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The perspective of Latvian flax (*Linum usitatissimum*) for biofuels

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Abstract. Flax is a culture that can be used fully, not only for fibre and seed, but also for other purposes. In Latvia fibre flax is grown, but in recent years emphasis is increasing on oil flax, which is used for the production of oil and seed cake for animal feed and energy. The largest areas of flax are located in the east of Latvia, where there are more suitable conditions for flax growing. The aim of this paper is to describe ten Latvian flax oil hybrids and eleven Latvian fibre flax accessions. Lithuanian variety 'Vega2' was used as a standard for fibre flax, but 'Lirina' was used as a standard for oil flax, and the trial was organized into three replications. The main objective of the research is to assess yield and quality of the oil flax hybrids. The quantity of flax fibre and seed yield depends on many factors. Several qualitative and quantitative traits, resistance to lodging, vegetation period, and yield of seeds, oil content and quality were evaluated. The highest seed yield was in 2007 – 169.2g m^{-2} and 2009 – 300.6g m^{-2} from which on average 2.1t ha^{-2} seed can be obtained. Seed yield obtained of seven samples of oil flax (70%) was higher than the standard. The oil content is higher in the standard sort of oil flax and it reaches 48.6%, whereas 'Vega' reaches 42.3%. Some samples of flax have a high perspective to use the surplus of oil for biofuel.

Key words*:* *Linum usitatissimum*, seed yields, oil content.

INTRODUCTION

Flax growing is strategically important, as raw materials for many economic sectors are obtained from them. One of the oldest and main raw materials of flax is fibre that is used in textile industry, but nowadays flax has a great importance as a raw material in the production of food, medicaments, building materials and other sectors of production (Ivanovs & Stramkale, 2008; Nandy & Rowland., 2008).

Flax is a cultivated plant which can be fully used not only for fibre and seeds but also for other purposes. In Latvia mostly fibre flax is grown, but in late years emphasis is increasing on oil flax, which is used for the production of oil and seed cake for animal feed and energy. The largest areas of flax are located in the east of Latvia, where there are more suitable conditions for flax growing (Stramkale et al., 2008).

Biofuel is an alternative sort of fuel which is obtained from rapeseed oil and methanol. On the Earth the resources of the fossil fuel are shrinking. One of the most important characteristics of biofuel is its high oil content. The use of vegetable oil in diesel engines has been known for a long time. Serious research into the usage of vegetable oil as motor fuel started in the beginning of the 70-ies and 80-ies influenced by economic crisis of those times. Rapeseed, linseed, sunflower, cotton seed, soya-been, ground-nut, coconut, palm oil, and oil of other plants were tested as fuel for diesel engines in different countries. Vegetable oil after culinary processing has also been tested with positive results. Research proved that vegetable oil can be used for driving engines (Tenekov, 2009) both in pure form and mixed with diesel oil, and in form of special biodiesel fuel, which is obtained by re-esterification of vegetable oils with alcohol (methanol or ethanol) in presence of catalytic agents (Galkin et al., 2008).

Oil suppressing is simpler than extracting, but extracting allows increasing the yield of oil from 37% to 43%, for instance, producing it from sunflower seeds (Shpaar, 1999). Biotechnological oil extraction from seeds is being developed as an alternative, the basis of which is a ferment fulldown from seed-coat. Ferments are working in water environment. Therefore, all components of seed- protein, oil and polysaccharides are in water. In the succeeding process of separating two products oil and oil cake are obtained. At present this so- called bio refining method has passed only the test of pilot hardware. It follows from the above mentioned that in small production units presses should be used, in particular for the reason that the oil surplus in cakes is valuable nutritive for domestic animals. In large companies combined technology is recommended: presses plus extraction (Antifeev, 2005; Permyakov, 2006).

Around 1978 the Carter Administration consolidated all federal energy activities under the support of the newly established U.S. Department of Energy (DOE). The DOE initiated research on the use of plant life as a source of transportation fuels (Antifeev, 2002; Permyakov, 2006). Biodiesel production in the world of recent years is characterised by considerable increase and is summed up in Figure 1. In the EU biodiesel production started in 1992. It was mainly due to its basic producer - European Union, where Germany is a leader (Fedorenko & Kolchinsky & Shilov, 2007). In 2007 the development dynamics and biodiesel production reached 2.681 million tonnes. In 2009 the largest producers of biofuel were Germany (2,359 thousand tonnes), Italy and France with up to 2,000 thousand tonnes.

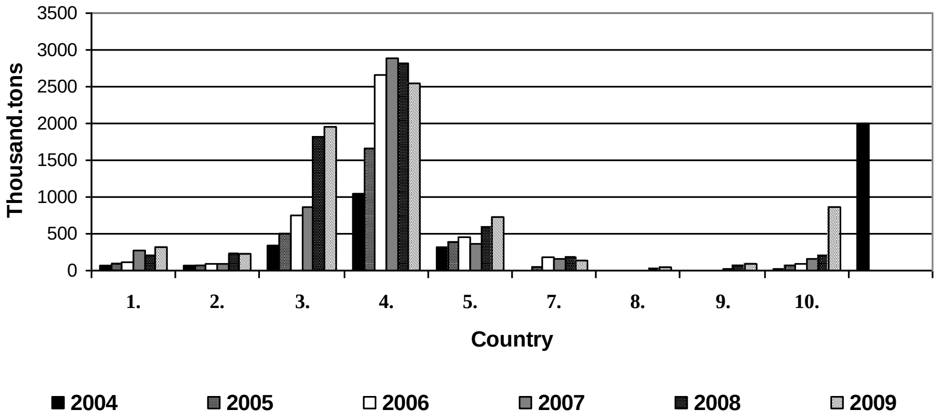

Figure 1. Biodiesel Production in 2004–2009.

Countries: 1. – Austria; 2. – Denmark; 3. – France; 4. – Germany; 5. – Italy; 6. – England; 7. – United Kingdom; 8. – Latvia; 9. – Lithuania; 10. – Spain

According to UFOP (Union for Assistance in Utilization of Oil and Protein Containing Crops) data, biodiesel is capable of replacing up to 5–10% of the total need for diesel fuels in Germany, and up to 10% in the EU (Bouleward, 2010). Cultivation of rape is subsidized from the federal budget of authorities in Germany and the EU. At present 90% of biodiesel fuel in the USA is obtained from soya-bean oil, but the rest from other sorts of oil, including animal fat. In 2004 about 80% of European biodiesel was produced from rapeseed oil and approximately one third of rapeseed yield in 2004 was used just for biofuel production. In 2005 the world produced more than 30 million tons only biofuels. But there also exists an opportunity to use linseed oil for biofuel production. Oil flax as well as its transition forms has more oil in seeds than fibre flax (Zivitin & Ginzburg, 2000). Oil content in seed varies according to climate, fertilization, sort, etc. Appearance of oil occurs also after flax harvesting. The sooner flax is harvested, the bigger is its impact of after- ripening on oil accumulation (Ivanovs & Stramkale, 2008). Biodiesel can be put into circulation, using it for farming the land, creating new jobs in agriculture, engineering, construction, etc. The aim is to determine the oil content of Latvian fiber and oil flax and to assess their prospects for biofuels.

MATERIALS AND METHODS

The trial was carried out at Latgale Scientific Centre of Agriculture, Ltd. in 2007–2009. Within the framework of this work eleven sorts on Latvian fibre flax and ten oil flax hybrids were analysed. Lithuanian variety 'Vega 2'was included as a standard in a trial, but 'Lirina' was used as a standard for oil flax, and the trial was organised in three replications.

There is putrefactive podzolic gley soil in the trial field. The agrochemical characteristics of the soil in the year of the trial: the content of organic substances in soil 3.0–3.5%, pH 6.4–7.0, the security of potassium K_2O–118–124mg kg^{-1} soil. The previous plant was spring wheat. After the first soil cultivation in spring time complex chemical fertilizer NPK 6–26–30 (300kg ha^{-1}) was worked into the soil. Seed was sown by hand on May 7, distributing 170 germinated seeds per meter for fibre flax and 70 germinated seeds per meter for oil flax. The distance between the rows was 10cm; the depth of sowing was 2–3cm. In the 'spruce' phase of fibre flax development the dose of additional fertilising was 15g m^{-2} N in clear substance and for oil flax 30g m^{-2} N in clear substance.

The samples of flax were harvested manually in the phase of early yellow ripeness. The plants were sheaved and were left in the field for 7–8 days. Seeds were cleaned by sample cleaner MLN, they were weighed and the seed yield was calculated at 100% purity and 9% humidity. The mass of 1,000 seeds was stated for samples; the amount of oil was stated by corn analyzer *Infratec* 1241^{tm,} which has a special built-in hardware for measuring linseed oil content.

The MS Excel program was used for statistical processing of data. The ANOVA method (LSD_{05}) was implemented.

RESULTS AND DISCUSSION

Ten samples of flax hybrids were selected according to different criteria: the length of vegetation period, seed yield, number of seed-vessels for one plant, number of seeds in one seed-vessel, and mass of 1,000 seeds. Qualitative seeds were obtained, they were sleek and smooth. The results of seed yield of the trial field are summed up in Fig. 2.

The seed yield of ten fibre flax samples was higher than of the standard sort ‘Vega 2’, but better seed yield in 2007 could be observed in three samples: 'Blue di Riga'–182.3g m^{-2}, 'Riga Freis'–183.5g m^{-2}, 'S64–17'–169.2g m^{-2}; better seed yield in 2008 could be observed in two samples: 'Blue di Riga'–258.2g m^{-2}; 'Ošupes 30'–253.3g m^{-2} and in 2009: 'Priekuļu 665'–300.6g m^{-2} , 'Ošupes 30'–253.1g m^{-2} and 'Blue di Riga'–250.3g m^{-2} ($LSD_{05} = 5.0$). This means that samples with a yield higher than the standard and not dependent on the year or meteorological conditions of their cultivation can be used not only for fiber, but also for seeds and oils. These varieties: 'Blue di Riga', 'Ošupes 30' and 'Priekuļu 665' can be used for biodiesel.

The oil flax in trial was sown on May 7, 2010 and it sprouted in 12 days. The weather conditions in 2010 were satisfactory for flax growing. The drought in the whole vegetation period had inimical effect on the straw yield. All oil flax has the persistence of lodging. The vegetation period for oil flax samples in the time of three years was 83–90 days.

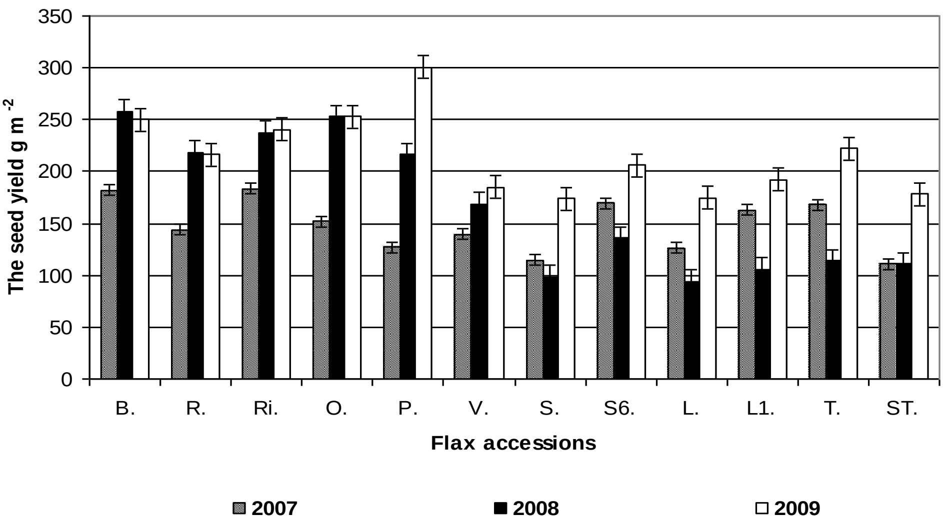

Figure 2. Seed yield g m^{-2} of flax in 2007–2009.
Names of varieties and accessions: B. – 'Blue di Riga'; R. – 'Rigaer LIN 748/82'; Ri. – 'Riga Freis'; O. – 'Ošupes 30'; P. – 'Priekuļu 665'; V. – 'Vietējais 1'; S. – 'S53/8–3'; S6. – 'S64–17'; L. – 'L11/11–11'; L1. – 'L19/6–15'; T. – 'T36–26/4–8' and ST. – 'STVega 2' (n=12, $LSD_{05} = 5.0$)

Seed yield depends on the number of seed-vessels in one plant, therefore it is important to clarify, how many seed-vessels can be obtained from each flax hybrid.

The number of seed-vessels in oil flax can be different: 9–38. Seed yield of seven oil flax samples was higher than that of the standard 'Lirina', but the best seed yield was in three samples: 2–210.3g m^{-2}, 7–188.7g m^{-2}, 10–199.3g m^{-2} (LSD_{05} = 6.0). The largest increase in seed yield in 2010 was found in oil flax hybrid 2–19.8%, 10–15.4%. The lowest seed yield in 2010 was found in flax sample 5–163.7g m^{-2}. These oil flax samples: 2, 7 and 10 have perspective for biodiesel. The seed yield of trial field is summed up in Fig 3.

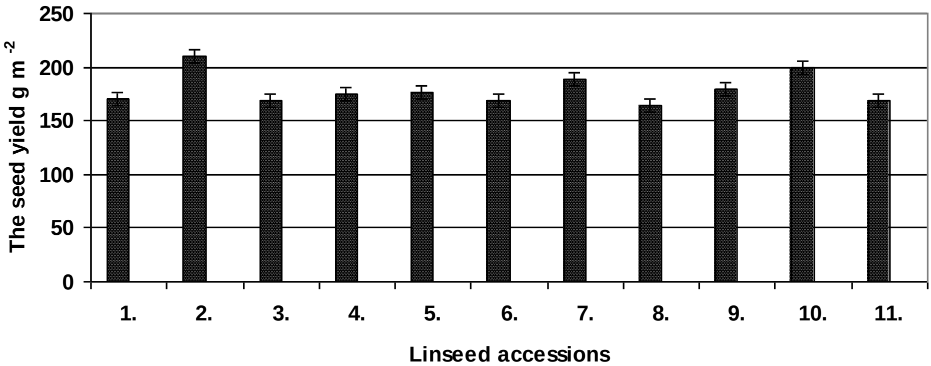

Figure 3. The yield of seed g m^{-2} of linseed in 2010.
Names of accessions: 1. – '37–1'; 2. – '37–2'; 3. – '37–5'; 4. – '37–9/1'; 5. – '37–10/1'; 6. – '37–28'; 7. – '37–34'; 8. – '37–49'; 9. – '37–50'; 10. – '38'; 11. – 'ST Lirina' (n=11, LSD_{05}= 6.0)

The oil content in fibre flax samples was determined in two years 2008 and 2009 and is summed up in Fig. 4. In 2008 the oil content in seven flax samples was higher than in the standard 'Vega 2', but the highest oil content in 2008 was in three samples: 'Vietējais 1'–44.7%, 'S64–17'–44.0%, 'T36–26/4–8'–44.0% (LSD_{05}=0.2). In 2009 eight fibre flax samples exceeded 42.5% of oil, that was fixed in the standard 'Vega 2', and the best oil content is fixed in five fibre flax samples: 'Blue di Riga'–44.4%; 'Riga Freis'–44.4%; 'Vietējais 1'–45.4%; 'L19/6–15'–44.7% and 'T36–26/4–8'–45.0% (LSD_{05}=0.2). In 2009 oil content in fibre flax was higher than in 2008. This means that the meteorological conditions in 2009 had good effect on flax seed and oil formation, and oil content of fiber samples was insignificantly different in 2008 and 2009, which means that they are resistant to adverse weather conditions.

Oil content of oil flax is used in 2010 and the results are summed up in Fig. 5. The weather conditions in 2010 were favourable for obtaining seeds and oil. The lowest oil content in oil flax is 41.9% (hybrids 3, 5 and 7), (LSD_{05}= 0.5). Oil content differs substantially in all the samples. The largest oil content in 2010 was in two samples: (44.3%) '37–50' and '38', but none of the samples exceeded the standard 'Lirina'; it had high oil content of 48.6%. The oil variety 'Lirina' is not only a good prospect for oil, but also for biodiesel.

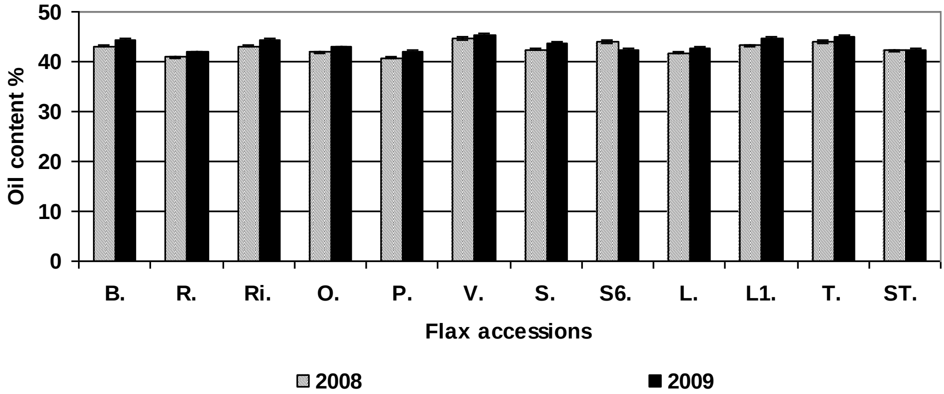

Figure 4. Oil content % of fibre flax in 2008–2009.
Names of varieties and accessions: B. – 'Blue di Riga'; R. – 'Rigaer LIN 748/82'; Ri. – 'Riga Freis'; O. – 'Ošupes 30'; P. – 'Priekuļu 665'; V. – 'Vietējais 1'; S. – 'S53/8–3'; S6. – 'S64–17'; L. – 'L11/11–11'; L1. – 'L19/6–15'; T. – 'T36-26/4–8' and ST. – 'STVega 2' ((n=12, LSD_{05}= 0.2)

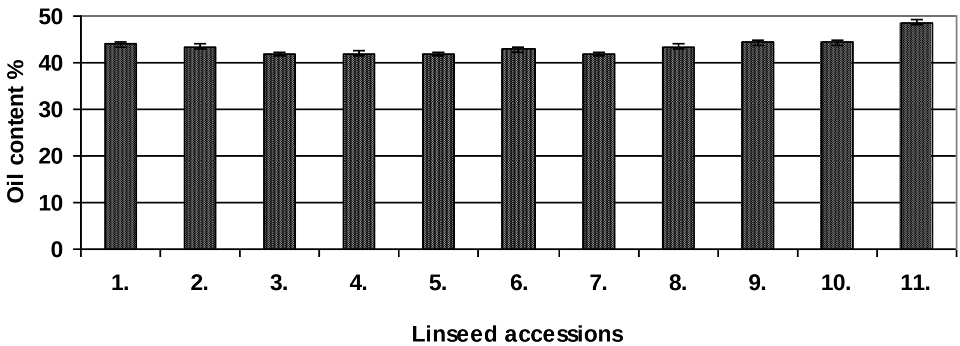

Figure 5. Oil content % of linseed in 2010.
Names of accessions: 1. – '37–1'; 2. – '37–2'; 3. – '37–5'; 4. – '37–9/1'; 5. – '37–10/1'; 6. –'37–28'; 7. – '37–34'; 8. – '37–49'; 9. – '37–50'; 10. – '38'; 11. – 'ST Lirina' (n=11, LSD_{05} = 0.5)

CONCLUSIONS

1. Seed yield depends not only on weather conditions, but also on flax genotype and its vegetation periods.
2. There is no substantial increase in seed yield obtained from Latvian flax hybrids in comparison with the standard ‘Lirina’.
3. In 2010 the seed yield of Latvian oil flax hybrids was 163.7–210.3g $m^{-2,}$ but seed yield of fibre flax was 144.1–300.6g m^{-2}. This year the largest increase in seed yield was observed in flax hybrids '37–2'; '37–34'; and '38'.

4. The vegetation period of oil flax hybrids lasted 83–90 days. The vegetation period of fibre flax lasted 86–90 days. The seed yield of seven oil flax samples (70%) was higher than that of the standard, but fibre flax exceeded it for 70–80%.

5. A higher oil content is in oil flax standard and it reaches 48.6% in three oil flax samples. There is a wide perspective to use the surplus from oil flax samples '37–50' and '38' and fibre flax 'Vietējais 1'; 'L19/6–15' and 'T36–26/4–8' for producing biodiesel fuel.

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