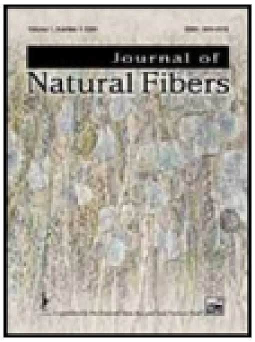

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New Methods for the Improvement of Flax Dew Retting

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ABSTRACT. In Lithuania, the flax production area was close to 10,000 hectares in 2003. Raw material for the flax fibres industry is prepared only as dew-retted flax straw. Improved methods of how to improve and control this very important and complex process, which is largely dependent on the weather conditions, are always welcomed. Joint research on how to refine flax straw dew-retting process was carried out by the Institute of Botany and the LIA Upyte Research Station in 2003. Two mixtures of the fungi, which take part in the flax dew-retting process in Lithuania, were developed and tested in the laboratory and field conditions. These mixtures were spread on flax straw once just after pulling on the swathe and once just after returning of swathe and twice–after pulling and after later turning over the swathe. According to the data of flax straw scutchability (fibre separation index defining degree of retting), the best results were obtained when applying first and second mixtures once just after pulling on the swathe, and once again just after turning the swathe. A double application of the fungal mixtures was not more efficient than a single application. doi:10.1300/J395v03n04_05 *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-HAWORTH. E-mail address: <docdelivery@haworthpress.com> Website: < http://www.HaworthPress.com> © 2006 by The Haworth Press, Inc. All rights reserved.]*

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INTRODUCTION

Over 1 million hectares of Lithuania's soils are suitable for flax growing, and Lithuanian flax growers could grow 150,000 hectares of flax every year (Endriukaitis, 2001). Now the area under flax in Lithuania is relatively stable: from 1999 to 2003 it was close to 10,0000 hectares (Farm crops, 1999, 2000, 2001, 2002), However, subjective factors also have an impact on flax fibre production each year.

Until 1993 half of flax was prepared as unretted straw to be water retted at scutching factories in the tanks, and the other half was dew retted in fields. Since 1993 only dew-retted straw has been produced in Lithuania (Endriukaitis, 2001).

Dew retting is carried out by spreading the stems thinly on the ground (in swathes) after harvesting and threshing off the seed capsules. Flax straw on the field is influenced by exposure to dew, rain, wind and sunlight (Van Sumere, 1992). Flax dew retting consists of a breakdown of the pectin compounds of the middle lamellae by micro-organisms starting from the cambium layer, which binds the cortex to the central woody core, following phloem parenchyma, which covers the inside of the fibre bundles, the parenchyma between the bundles and outer parenchyma, which cements the bundles to the thick-walled epidermis. During the last stage of retting, the bundles are split lengthwise into fibres (Van Sumere, 1992).

During dew retting, the stems are dampened by dew at night, and then dried during the day. Various fungi (*Alternaria alternata*, *Alternaria linicola*, *Aureobasidium* spp., *Cladosporium herbarum*, *Cephalosporium* spp., *Colletotricum* spp., *Epicoccum nigrum*, *Fusarium nivale*, *Mucor* spp., *Rhizopus* spp.) colonise stems, and their hydrolytic enzymes degrade polysaccharides in cell walls (Krauzlys & Mockapetris, 1963, Sharma et al., 1992, Van Sumere, 1992). *Aspergillus niger*, *A. foetidus*, *Penicillium expansum*, *Fusarium moniliforme*, *Botrytis cinerea*, *Verticillium dahliae*, *Trichothecium roseum* and other fungi, existing on the flax stems or in the upper layer of the soil may be also ascribed to active pectin rippers. Main varieties of pectin ripper can be considered *Cladosporium* spp. fungi (Mirchink, 1976; Lugauskas, 1988).

From more than 100 micro-organisms, taking part in flax dew-retting process, Russian scientists point out *Alternaria alternata* and

Cladosporium herbarum as important for dew-retted fibre colour (Belova & Savinova, 2000).

The properties of fungi isolated from dew-retted flax do indeed very considerably affect both retting efficiency and resulting fibre quality (Henriksson et al., 1997).

The improvement and control of dew retting, an important and complex process, which is largely dependent on the weather conditions, is to be encouraged.

The aim of the investigation, described in this paper, was to test fungal mixtures, developed specially for the improvement of flax dew retting.

MATERIALS AND METHODS

Some joint research on how to improve flax straw dew-retting process was carried out by the Institute of Botany and the LIA Upyte Research Station in 2003.

Selection of active fungi strains able to grow actively on the flax stems under laboratory conditions was carried out in the laboratory of Biodestructor Research, Institute of Botany. For the selection of fungi taking part in the processes of retting the fungi isolated from flax stems under natural conditions were used. The following criteria for the selection of active fungal strains were used: growth intensity on the flax stems, their influence on the fibre separation, and their antagonistic properties.

Two mixtures of the fungi, taking part in the flax dew-retting process in Lithuania, were developed and tested in the laboratory and then in the field conditions.

The first fungal mixture consisted of *Cladosporium tenuissimum* 2-1U-20, *Cladosporium herbarum* 8-5U-10 and *Cladosporium cladosporioides* 9-7U-50; the second mixture consisted of *Alternaria alternata* 1-4U-kl, *Cladosporium herbarum* 8-5U-10, *Chrysosporium merdarium* 11-6U-30 and *Trichothecium roseum* 15-8U-40.

The trial was conducted on a Eutri-Endohypogleyic Cambisol (Buivydaite et al., 2001). The content of P_2O_5 in the soil plough layer was 160 mg kg^{-1}, content of K_2O 193 mg kg^{-1} (determined in A-L extraction), pH_{KCl} level 7.0 (potentiometrically), humus content 1.74% (by Thurin method). In the field rotation flax followed winter wheat. Flax record plot was 10 m^2. Four replications were employed. Randomised plot design was used.

Flax cv. Hermes was sown at the beginning of May by a sowing machine SL-16 at a seed rate of 22 million viable seeds per hectare with 10 cm row spacing. Insecticide Fastac 10 EC (alfa-cipermetrine 100 g l^{-1}) 100 ml ha^{-1} was applied at seedling stage, herbicide Glean® 75 DF (chlorsulphurone 750 g kg^{-1}) 7 g ha^{-1} + Kemiwett™ S (ethohilate alcohol) 0.1%–when flax was of 6-10 cm height. Insecticide (Fastac), herbicide (Glean) and fungal mixtures were sprayed by a knapsack sprayer Hardy RY-2, nozzle type 4110-12, spray volume 400 l ha^{-1}, pressure 2.5 bars.

The Flax was harvested at early-yellow ripening stage (on August 13). The fungal mixtures were sprayed on flax straw once just after pulling (on August 14) on the swathes and once just after turning over the swathes (on August 21), and twice–after pulling (on August 14) and after turning the swathes (on August 21) (see trial design).

Trial design:
1. Check (water was sprayed).
2. First mixture sprayed once: during flax harvesting.
3. Second mixture sprayed once: during flax harvesting.
4. First mixture sprayed once: during flax swathe turning.
5. Second mixture sprayed once: during flax swathe turning.
6. First mixture sprayed twice: during flax harvesting and swathe turning.
7. Second mixture sprayed twice: during flax harvesting and swathe turning.
8. Suspension of *Cladosporium herbarum* sprayed once: during flax harvesting.
9. Suspension of *Cladosporium herbarum* sprayed twice: during flax harvesting and swathe returning.

The weather conditions were suitable for flax dew retting for three weeks after harvesting, but during this period the dew-retting process was not complete. At the beginning of September the weather became dry, and so the dew-retting process continued throughout September.

When flax straw became grey (because of the dew retting) fibre separation analyses were started with a tool OOV (Patarimai linininkui, 1975). A sample of 100 dew-retted straws was tested in 4 replications from each treatment. Fibre separation was measured in three places of the flax stem (top, middle and foot) cutting out 10 cm length segments and processing them with tool OOV. The samples were analysed 4 times with a weekly interval (starting from the first of September).

The data were analysed by computer software ANOVA, and means of LSD at P = 0.05 are presented (Tarakanovas, 1999).

RESULTS AND DISCUSSION

Usually dew retting is uneven along the stem because of the stem diameter and chemical composition. When pulling flax, the middle part of flax straw is crushed by the straps of the pulling machine, and the dew-retting process is more active in this part of the straw. Thus we investigated fibre separation dynamics not only following time, but also checked the dynamics in different places of the stem (top, middle and foot).

The dynamics of fibre separation index at the top of the stem. When investigating the dynamics of fibre separation index, we can see that the highest increase of the index in the check treatment was obtained from September 1-8 (first week of testing). Later on dew-retting proceeded more slowly. In most cases (treatments) fibre separation index at the top was higher when applying fungal mixtures, but the differences were not significant, except for treatment 8 (suspension of *Cladosporium herbarum* sprayed once–during flax harvesting) on the last sampling date, however, this effect might have been caused not by spraying of fungal suspension, but later by the processes following it (Figure 1).

From the graphs 1-3 in Figure 1 we can see that during the experimental period the lowest fibre separation index was at the top of the stem (from 2.6 to 6.9).

The dynamics of fibre separation index at the middle of the stem. At the beginning of tests, fibre separation index in the middle part of the stem was the highest (5.4-6.9) compared with that at the top or at the foot.

When investigating the dynamics of fibre separation index in the middle part of the stem (Figure 2) we can see, that the fibre separation index in the check treatment was gradually increasing during the testing period.

The data from the flax straw samples taken on September 1 (19 days after flax harvesting) show significant differences in fibre separation in the treatments where the second mixture had been sprayed during flax harvesting (treatment 3) and suspension of *Cladosporium herbarum* was sprayed during flax harvesting and swathe turning (treatment 9).

Significant differences were not found while testing samples from September 8-22, but on September 15 fibre separation index at the mid-

FIGURE 1. The dynamics of fibre separation index at the top of the stem–Upyte, 2003. (LSD_{05} for 09.01-1.45; LSD_{05} for 09.08-1.67; LSD_{05} for 09.15-1.52; LSD_{05} for 09.22-1.17)

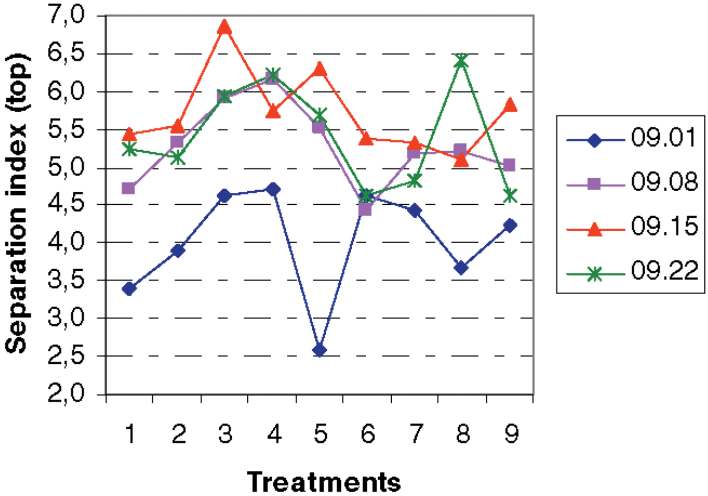
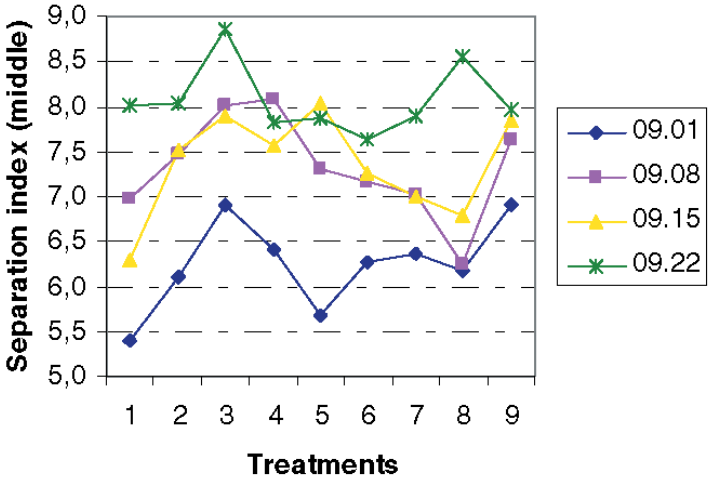


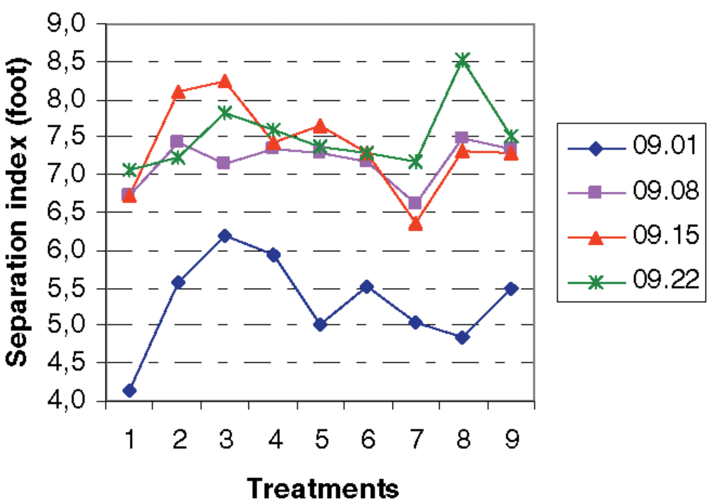
FIGURE 2. The dynamics of fibre separation index at the middle of the stem–Upyte, 2003. (LSD_{05} for 09.01-1.04; LSD_{05} for 09.08-1.39; LSD_{05} for 09.15-1.08; LSD_{05} for 09.22-0.88)



dle of the stem was significantly higher (compared with the reference check) in the treatments 2 (first mixture sprayed once: during flax harvesting), 3 (second mixture sprayed once: during flax harvesting), 4 (first mixture sprayed once: during flax swathe turning), 5 (second mixture sprayed once: during flax swathe turning) and 9 (suspension of *Cladosporium herbarum* sprayed twice: during flax harvesting and swathe returning).

The dynamics of fibre separation index at the foot of the stem. The highest increase of fibre separation index was noticed during the first week of testing, later on it was increasing much slowly (Figure 3). On the first sampling date (September 1) significant differences (compared to the reference check) were found after spraying the second mixture once: during flax harvesting (treatment 3) and after spraying the first mixture once: during flax swathe turning (treatment 4). On the second sampling date no differences were identified. On the third sampling date, the best results were given by application of first mixture once: during flax harvesting (treatment 2) and of second mixture once: during flax harvesting (treatment 3), on the fourth sampling date–application of suspension of *Cladosporium herbarum* sprayed once during flax harvesting (treatment 8).

FIGURE 3. The dynamics of fibre separation index at the foot of the stem–Upyte, 2003. (LSD_{05} for 09.01-1.54; LSD_{05} for 09.08-1.00; LSD_{05} for 09.15-1.36; LSD_{05} for 09.22-1.10)



The dynamics of the mean fibre separation index. The mean data of fibre separation index are presented in Figure 4.

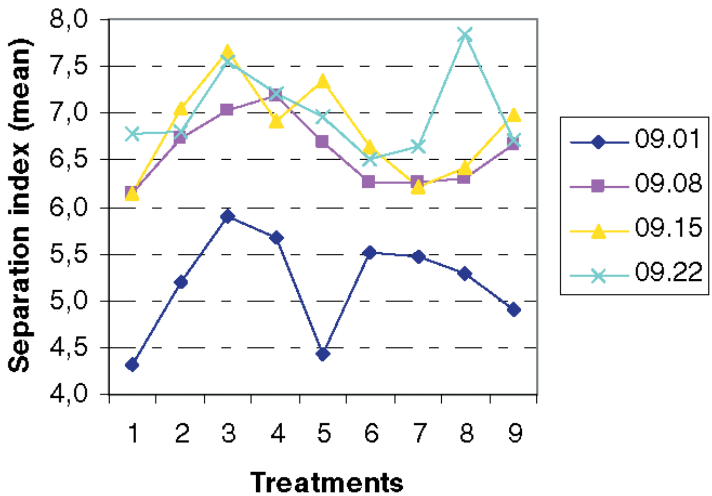
The data from the flax straw samples taken on September 1 (19 days after flax harvesting) suggest significant differences in fibre separation in the treatments where the second mixture had been sprayed during flax harvesting (treatment 3); the first mixture was sprayed during flax swathe turning (treatment 4); the first mixture was sprayed twice: during flax harvesting (pulling) and swathe turning (treatment 6) and suspension of *Cladosporium herbarum* was sprayed during flax harvesting and swathe turning (treatment 9).

From the samples taken on September 8 we found that fibre separation index was significantly higher only after spraying of the first mixture during flax swathe turning (treatment 4).

Data from September 15 showed that fibre separation index was significantly higher after spraying of the second mixture during flax harvesting (treatment 3) and the second mixture during flax swathe turning (treatment 5).

On September 22, fibre separation index was significantly higher only after spraying of suspension of *Cladosporium herbarum* during flax harvesting (treatment 8).

FIGURE 4. The dynamics of fibre separation index (mean)–Upyte, 2003. (LSD_{05} for 09.01-1.15; LSD_{05} for 09.08-0.99; LSD_{05} for 09.15-1.12; LSD_{05} for 09.22-0.80)



Therefore, the data of fibre separation index varied markedly during flax straw dew-retting process. The best results were obtained by application of the first and second mixtures during flax harvesting (pulling) or returning as well as application of suspension of *Cladosporium herbarum*. Double application of the fungal mixtures in many cases was not more efficient than a single application.

CONCLUSIONS

The fibre separation index varied markedly during the flax straw dew-retting process. The highest increase of the fibre separation index was obtained during the period from September 1-8 (first week of testing). Fibre separation index in the middle part of the stem was higher as compared with that at the top or at the foot. The best results were obtained by application of the first and second mixtures during flax harvesting or turning as well as application of suspension of *Cladosporium herbarum*. Double application of the fungal mixtures in most cases was not more efficient than a single application. Subsequent investigations could give more detailed suggestions on how to improve dew retting.

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