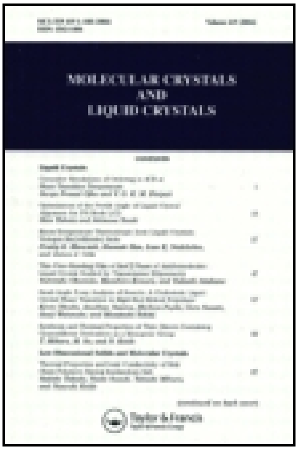

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

The Effect of Frost on Fibre Plants and Their Processing

Antti Pasila [a]

[a] University of Helsinki, Department of Agricultural Engineering and Household Technology, P.O. Box 27 FIN-00014 University of Helsinki, Finland

Version of record first published: 24 Sep 2006

Mol. Cryst. and Liq. Cryst., 2000, Vol. 353, pp. 11-22
Reprints available directly from the publisher
Photocopying permitted by license only

The Effect of Frost on Fibre Plants and Their Processing

ANTTI PASILA*

University of Helsinki, Department of Agricultural Engineering and Household Technology, P.O. Box 27 FIN-00014 University of Helsinki, Finland

Harvesting of flax and hemp fibres in normal time in autumn often meets with special problems in the Nordic circumstances. These are mainly due to the short growing period and the cold and rainy period in autumn. The risk of formation of mold spores inside the harvested fibre plant bales is obvious (1). Even though the bales are dried in bale driers there is enough time for the molds to destroy the quality of the raw material. This is caused by both the slow drying process and the high microbiological activity of the moist material (3). This is the reason why the new **Dry-line-method** (2) is under research. Briefly the dry-line-method means:

- harvesting the seeds in autumn which are at that time the driest parts of the plant
- harvesting the straw in spring which is the driest time of the year
- benefit from the good friction and processing properties of dry plant material

The frost affects fibre plants in Northern circumstances. In springtime the temperature is changing daily above and below the zero. This leads to the enlarging movement which is resulted from the frozen water and which is varying in different plant cell structures. When this takes place repeatly several times the movement also loose the bast fibre from the stem. Also the fibre yield was measured after processing raw material with different methods.

The demand for energy when processing of the plant material was being reduced drasticly when compared to unretted or dew retted material. For the second, the yield of the processed fibre from the plant raw material was higher compared to material which was not frozen. The latter is due to both the higher loss of shives before and during the processing as well as the better separation of fibre and shives during and after the processing.

Keywords: fibre; flax; frost-line; harvesting; hemp; northern; processing

* Antti.Pasila@helsinki.fi

1. INTRODUCTION

In Finnish climatic circumstances there are harvesting problems with fibre plants and especially with fibre hemp. The long daylength delays the maturing of hemp (4). The moisture content of hemp in normal harvesting time can be up to 70 % w.b. which is too high for mechanical drying. The Ministry of Agriculture financet a research to measure the energy consumption in flax and hemp drying. IN FIGURE 1 there is a summary of the results of fibre hemp drying.

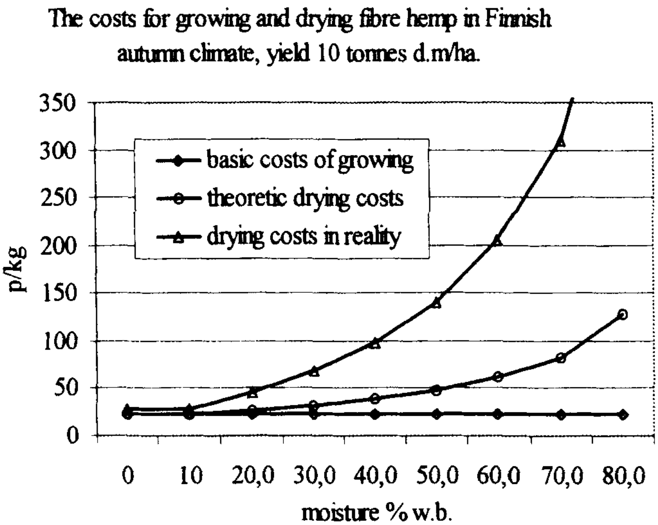

FIGURE 1. The costs for growing and drying fibre hemp in Finnsh climate the yield is 10 tonnes d.m./ha

There is an exponential growth of drying costs when the moisture content climbs up. The special problem is the slowly movement of water inside the stalks which causes up to four times higher drying costs compared to e.g. flax straw.

THE LOGISTICS OF PRODUCTION

As to the end products it is quite usual that only one fraction from a fibre is required. This means that the yield has to be separated to different fractions. However the problem is that e.g. the drying of the yield has to be completed before it is possible to separate the fractions. This is a very expensive stage in production chain. This stage is also often unknown for the end user of fibre and the economical response is the farmers or fibre producers. In FIGURE 2 the cost allocation problem of flax is dealt with.

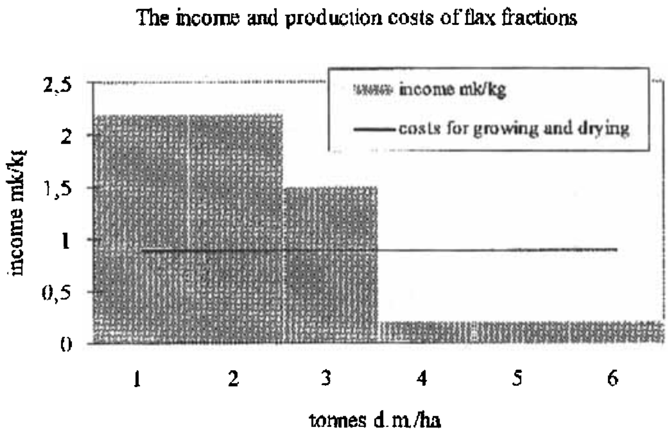

FIGURE 2. The income and growing costs for flax using normal harvesting time in autumn (Euro = 6 Fmk).

The moisture content of straw in FIGURE 2 has been appr. 35 % w.b. The flax variety in question was Norlin-linseed, total yield was 6 000 kg/ha, of which seeds 2 000 kg (pillars 1 ja 2, 2,2 mk/kg), fibre 1 000 kg (pillar 3, 1,5 mk/kg), shives 3 000 kg (pillars 4, 5 ja 6, 0,22 mk/kg). The cost for growing and drying has been appr 4 500 mk/ha. At the figure you can immediately read the economical result of the growing which is in this case reasonable good. No subsidies are calculated.

THE PROBLEMS WITH HEMP

In FIGURE 1 there were results of hemp drying. When the costs for growing were calculated together with the costs of drying in normal autumn conditions the result was a finacial disaster. In FIGURE 3. the logistic diagram shows that the economical result is not very good if you have to dry the hemp yield.

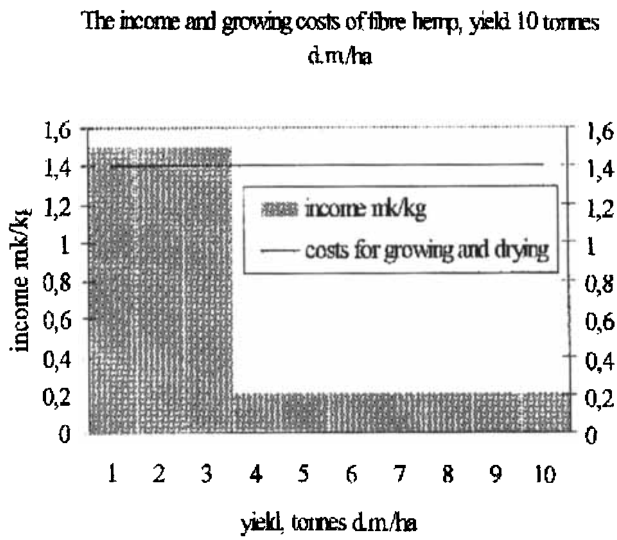

FIGURE 3. The income and growing and drying costs of fibre hemp when harvested in autumn (1 Euro = 6 Fmk).

The moisture content of the hemp straw is appr 50 % w.b. The yield is 10 000 kg d.m./ha. The basic cost for growing is 2 800 mk/ha (1 euro = 6 mk). The pillars in the chart describe immediately the economical result of the growing. Pillars 1, 2 and 3 are short fibre, price appr 1,5 mk/kg, pillars 4 - 10 are shives, price 0,22 mk/kg. The income from fibre is not high enough to cover the costs which are caused from the drying and processing of shives. Even though we add all the possible subsidies to cover the costs it is not enough.

DRY-LINE®-METHOD IN HEMP HARVESTING

In the dry-line-method the harvesting process is divided in two parts. First the seeds of flax or hemp plants are harvested in autumn. Secondly the standing stubble which in this case is the major part of the plant is harvested in spring after the winter. The machinery which is used in this method consists of the modified harvester which is used in autumn and the hay harvesting machinery used in spring (5) FIGURE 4.

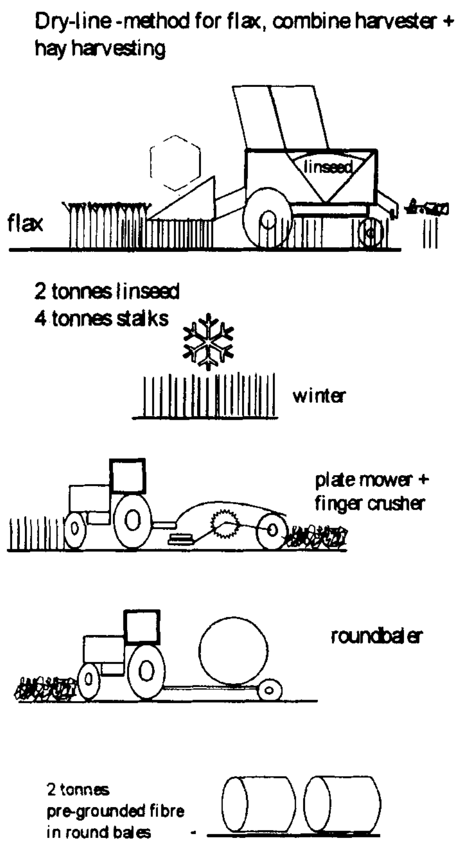

FIGURE 4. Dry-line method in flax harvesting (2).

The spring period in Finland is very dry and the yield needs no drying. The measured moisture content of yield was e.g. in May 1999 8 - 10 % w.b. If the data of dry-line harvested hemp is put in FIGURE 3. the economical result of harvesting changes totally FIGURE 5.

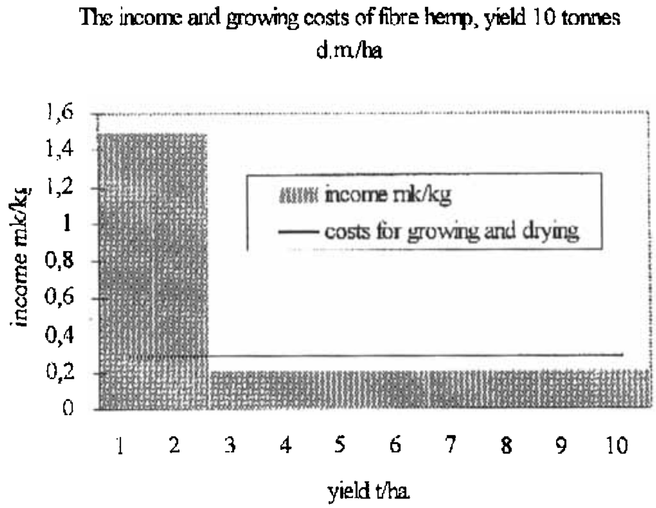

FIGURE 5. The income, the growing costs for hemp as in FIGURE 3 before, but no drying costs when the yield is harvested with dry-line -method in spring. (1 Euro = 6 Fmk).

The losses of yield in spring harvesting are remarkable for the moment. The measured losses are up to 40 % of the biological yield in spring. The harvesting machinery is not yet very developed. The harvesting losses consists mainly of hemp shives. However there are no drying costs which is critical for the economy of hemp growing in Finland. The income from the short fibre is high enough to cover the costs which are caused from the processing of low price shives.

2. THE EFFECTS OF FROST

In Finland the climate is cold and wet in autumn. The average temperature is so low late in autumn that the growth of molds is impossible. In spring the relative humidity decreases down quite early and again prevents molds from growing in plant material. In FIGURE 6 there are the average curves of temperature and relative humidity round the year.

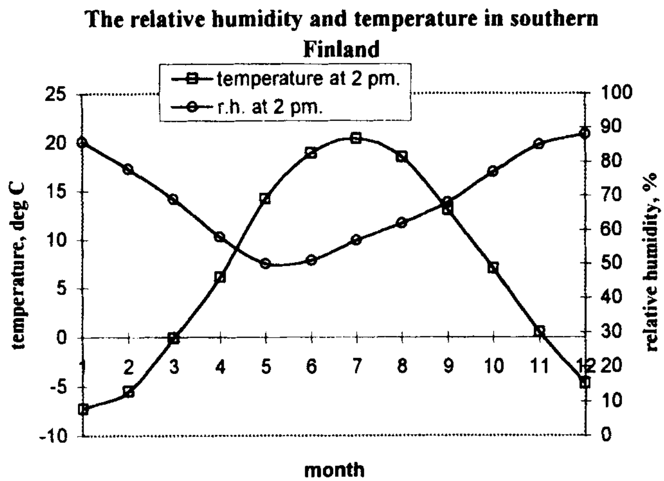

FIGURE 6. Temperature and relative humidity curves in southern Finland (6).

In FIGURE 6 the peak of the temperature curve is situated in July. The zero level is reached in November and in spring in March. The lowest relative humidity is reached in May. In these climatological conditions it is possible to reach a wet - cold - dry -chain which conserves the fiberplants over the winter. But more important for the structure of fibre plants are the repeated changes of temperature. Especially in spring the plant material is freezing and melting daily. In FIGURE 7 some temperatures measured in the fibrehemp areas are shown.

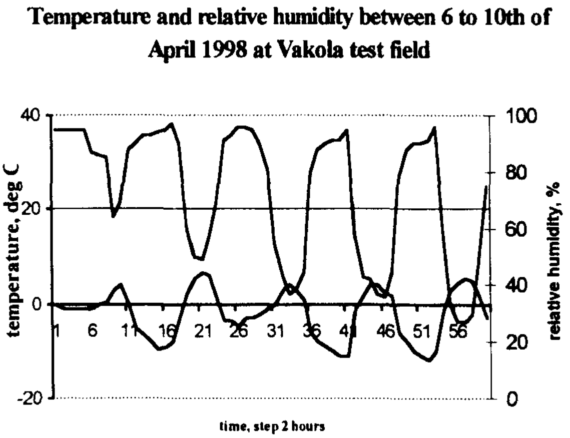

FIGURE 7. Daily variations of temperature and relative humidity.

The curves in FIGURE 7 meet each other during dry and warm days. It is obviously possible to forecast a suitable time for harvesting e.g. in times when the curves are making an intersection. There should be more empirical information about the properties of the harvested plants to adjust the curve levels.

The harvested fibre yield is overretted in spring and it is obviuosly not suitable for traditional textile production. The elementary fibres are separated from the stem and each others. The strength of the spring harvested fibre bundles is weaker than those fibres which are harvested in autumn and which are less retted (2).

There are however end products in which the loose elementary fibres are suitable. These are e.g. thermal insulation materials, different pulps and composites with PE or PP plastics. In FIGURE 8. there is a scanning microscope photo from the autumn and spring harvested fibres.

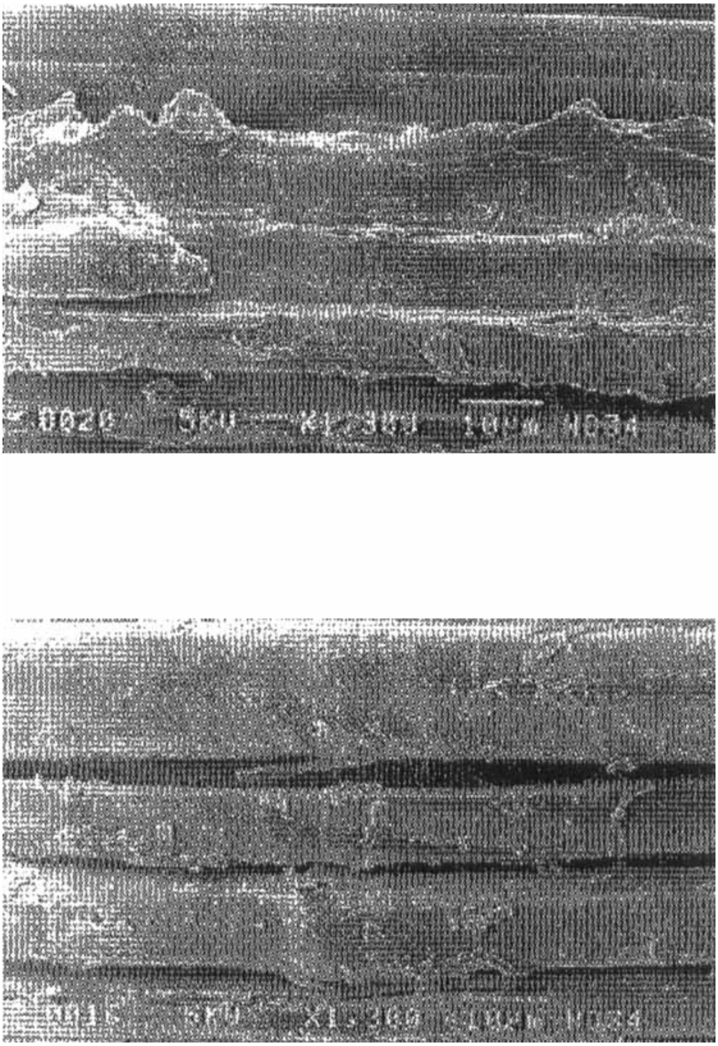

FIGURE 8. Autumn harvested flax, upper photo and spring harvested flax, lower photo.

3. FIRST RESULTS FROM PROCESSING OF DRY-LINE HARVESTED YIELD

Fibre hemp and flax stems were harvested both in autumn and in spring. The yield was dried in a special drier in aututmn until the moisture content was 12 - 15 % w.b. Spring harvested yield needed no drying. The flax seeds were harvested with a modified combine harvester in autumn. Hemp has producted no seeds during the 3 year tests. Flax stems were cut in spring with a mower conditioner and baled with a round baler. Hemp stems were cut with amodified cutter bar mower and baled with a round baler.

The bales were hammermilled with a KAMAS 30 kW mill with a 20 mm Ø screen. The milled raw material was separated to fiber and shives with a cyclone and a rotary screen combination. In FIGURE 9 the results are shown.

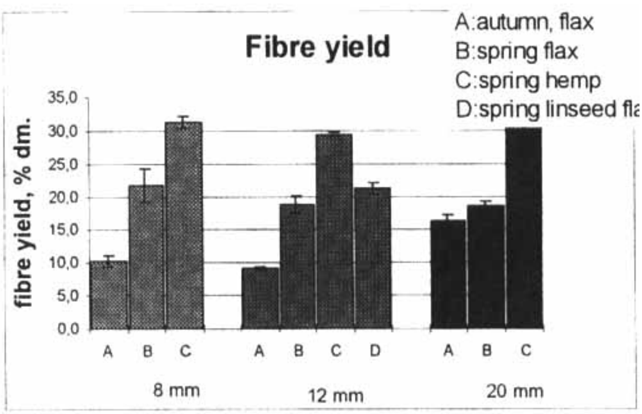

FIGURE 9. The results of the hammer mill test, 8 mm , 12 mm and 20 mm are the sizes of sieves.

These are the first results of the Frost-line-fibre (pat. pend.) production method for harvesting bast fibre plants in northern conditions. The total production chain is not calculated in this presentation. The results in FIGURE 9 must be taken in wiew of the fiber prosessor.

4. DISCUSSION

Dry-line - and Frost-line-fibre - methods could be applied in northern areas where non-wood pulp and paper are produced. When flax or double flax are used in pulp production it is also possible to produce food at the same time (linseed). Dry-line method is superior in pulp production compared with rice straw because it is possible to separate the bast fibre in dry conditions. Bast fibres do not contain very much lignin. Low lignin concentration in pulp production is an advantage because that kind of raw material pollutes the environment less.

If Chinese paper factories choose bast fibre plants and dry-line method they can multiply their fibre production and reduce the lignin in effluent. However the dry-line -method works only in areas where the winter freezes the fibre yield.

5. CONCLUSIONS

It is clear that bast fibre plants are overreted during the northern winter. The elementary bast fibres are loose when the daily temperature changes. The lignin content of bast fibre is lower than the lignin content of shives. This means that the bast fibres could separated in an industrial process in a simple and cheaper way than e.g. wood fibres.

The properties of suitable pulping process is an unknown area because the earlier researches have shown hemp and flax to be very expensive raw materials.

The spring harvesting is obviously possible also some other parts of the world as well as Finland. This "nature design" process should be researched more.

FOR FURTHER INFORMATION AND COMMENTS PLEASE CONTACT:

Antti.Pasila@helsinki.fi

This is a part of a research project "The production chain from field to the end product of plant based insulation materials", in cooperation with Helsinki University of Tecnology, the Dep. Of Structural Engineering and Building Physics. The research is financed by Ministry of Agriculture and Forestry and TEKES (Tecnology Development Centre of Finland) and several Finnish firms which are members of the research program.

References

[1] Ritschkoff, A. C. & Viitanen, H. *The Critical Moisture and Temperature Conditions which are Causing the Mold Formation.* VTT research report no 688. Espoo, Finland (1990).

[2] Pasila, A., Pehkonen, A., Lalli, J. Pehkonen & T. Sihvola, J. *The Machinery in Processing the Plant Base Insulation Materials.* Publications of the Department of Agricultural Engineering 23. University Press, Helsinki (1998).

[3] Sitkei, G. *Mechanics of Agricultural Materials.* Elsevier Publishers, Amsterdam, 487 p. (1986).

[4] Werf van der, H. M. G. 1994. *The effect of daylength on yield and quality of fibre hemp.* Doctor thesis. DLO Research Institute for Agrobiology and Soil Fertility (AB-DLO). Wageningen, Netherlands.

[5] Pasila, A. 1998. *New method for Harvesting Flax and Hemp.* Nordflax I, The 1st Nordic Conference on Flax and Hemp Processing 10 – 12. 08.1998 Tampere, Finland.

[6] Anon, 1991, *Climatological statistics in Finland* 1961 – 1991, Supplement to the meteorological yearbook of Finland. Vol 90 part 1 - 1990. Helsinki.