Heike Gottschalk, Einbeck

Short fibre flax

Strategies for optimising production and utilisation as well as material characteristics of technically usable short fibre flax

The motivation for an economically viable production of natural fibre in Germany, i.e. in climatically suitable latitudes, lies in the recognition that there exists a substitution requirement for synthetic fibres which are only conditionally environmentally supportable. These synthetic fibres are traded at prices which appear to offer profitable production of agricultural fibres.

Dr. Heike Gottschalk works as production coordinator in the maize division of KWS-Saat AG and from May 1993 to December 1996 was project manager at the Chair of Agricultural Engineering, University of Bonn (director: Prof. Dr.-Ing. K.-H. Kromer); e-mail: *h.gottschalk@kws.de*

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A research group's aim was development of an optimising strategy for the production and utilisation of technically usable flax fibre and for the recycling of the compound work material thus produced. The fibre was to substitute environment polluting and health-endangering synthetic fibres, and not mineral fibre which can be recycled, and also enable a closed material cycle to be achieved.

Required for this were scientific bases towards economically competitive and environmentally friendly production of a high quality technical fibre and the processing of this to environmentally acceptable compound working material with later suitability for the manufacture of recycling products.

The research group, from companies and research institutes for plant breeding, agricultural engineering, fibre processing and the automobile industry, helped to identify through rapid retro-coupling of post and pre-harvest production stages influences on material quality and processing potential as well as resulting product quality through continuing analyses and evaluations of the important influential factors. This also comprised immediate translation of new knowledge into the selection breeding programme so that parallel to industry research results, new varieties can be developed.

From the economical aspect, the new genotypes are especially valuable because through further improvement of the ripening synchronisation between fibre and seed, not only can the fibre be utilised as glassfibre substitute (trade price around DM 4/kg) but also through simultaneous utilisation of high quality seed a level of gross margin can be achieved allowing a subsidy-free cultivation of the crop in agriculture.

A broad genetic basis was available for previous projects (work from the Institute for Plant Production, Chair of Special Plant Production and Plant Breeding, University of Bonn, Prof. Heyland) and from this through information exchange with the processing industry new genotypes could be bred to meet the special quality demands of industrial – non-textile and high-quality – application areas.

Arranging the procedure

The harvest of fibre and seed where flax is to be used as industrial fibre can take place at a single date. At time of biological maturity the straw moisture content is 50 to 60% thus drying is required to achieve a storable product [11]. Traditionally this takes place in separated operations of turning in the field and delignifying in a machinery shed.

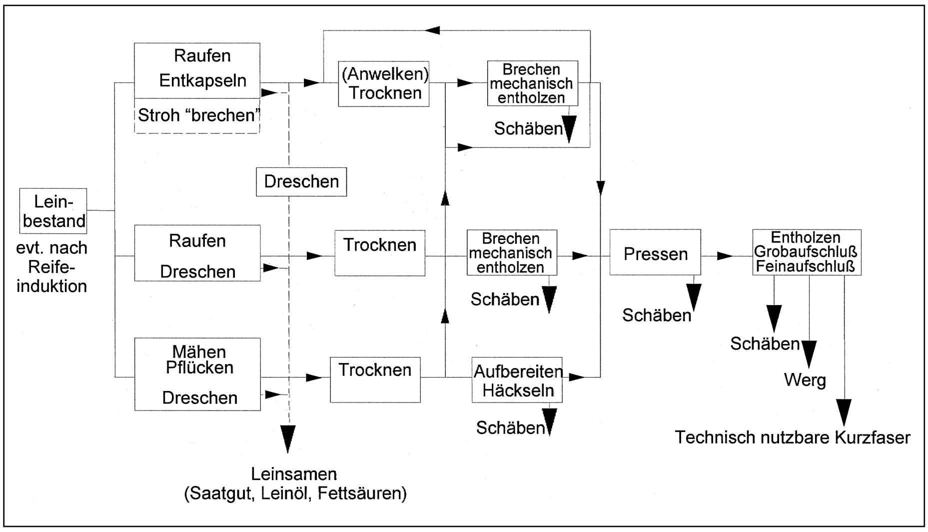

Fig. 1: Fibre and seed production process phases with flax

Straw drying can be expedited as in feed harvest by using straw conditioning machinery (field flax conditioner) and maturity can also be chemically or thermally induced [7].

The process phases of fibre and seed production for technically usable flax fibre are illustrated in *figure 1*.

Modern harvesting machines integrate mowing or plucking with threshing whereby a combine is fitted with standard or special cutter bar or plucking header for flax plucking with decapsulating and threshing equipment [13]. For cutting costs through reducing work operations and minimising losses through reduction of harvesting risk, the three processes plucking, decapsulation and mechanical delignification were combined in a prototype and tested. *Table 1* shows a comparison of the fibre yields involving the conventional retting process and modern field delignification.

The straw mass is reduced by up to 50% through delignification. Here the plucked and swathed material is twice processed by a Bahmer flax field delignifier. This field operation increases the fibre content in the straw and reduces transport weights. Further the „breaking“ and multiple delignification in the field expedites the drying process (*fig. 2*) and thus reduces risk of harvest losses through bad weather (with traditional flax fibre a total harvest loss is reckoned with every fifth year. In retting (biological decomposition of fibre coating) the material stays out in the field for around six weeks, so that the retted straw cannot then be taken-in under continuously wet conditions. According to the economical value required for the end product, more or less coating can be separated from the fibre through field delignification. Through the new harvesting method (plucking with decapsulation, straw conditioning and field delignification) a storage-suitable, technically usable short fibre with around 13 to 15% moisture content can be harvested within a single day in a typical August harvesting date (fig. 2). Targeted processing of the straw enables the production of fibre of defined and high quality.

Because all secondary fibres can be used in industrial utilisation, yields of up to 3.8 t/ha of technically utilisable fibre can be achieved with industrial fibre flax with up to 1.9 t/ha linseed harvested as well as the straw.

In Germany the production of high quality natural fibre is possible, but must be considered critically. Achievable producer prices and their variations have to be calculated with, and it must be recognised that the separate operation areas can in part achieve only limited returns (geo-textiles and insulation material: only minimal demands on the mechanical properties of the fibres). Viable production under such preconditions is unlikely in that, long-term, current levels of area compensation and set-aside payments cannot be depended upon. The aim, therefore, must be the production of high quality ware for high technical demands.

A great potential is seen in fibre for plastic compound reinforcement if it is possible to break into this sector which up until now is filled by glassfibre. In a first step, up to 30000 t natural fibre could be applied here and, in a second, up to 250,000t.

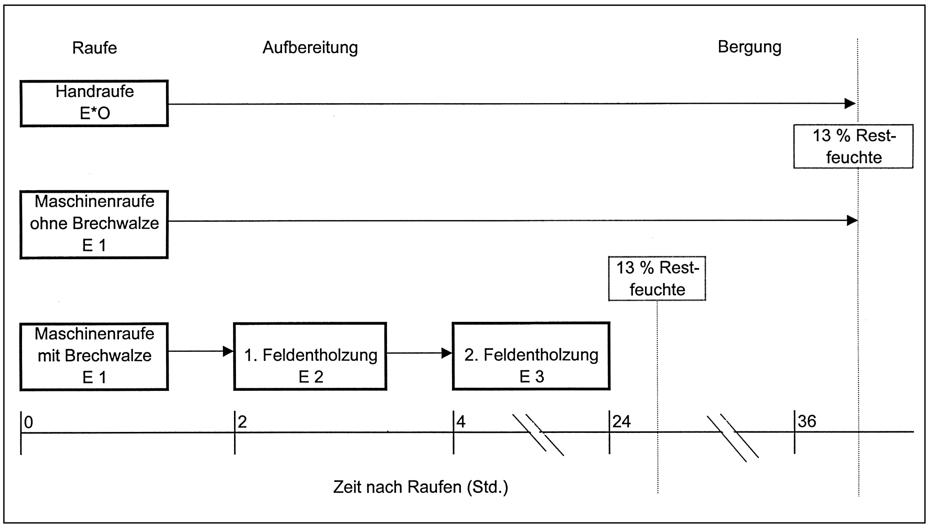

Fig. 2: Flow chart of field drying during delignification [8, altered]

Quality of industrial fibre flax

The technical use of flax fibres as substitute for synthetic ones requires only short fibres of >10 mm, as far as possible in the region from 30 to 100 mm. This means there is no need for a consistent, bundle-protecting, release of the fibre, e.g. through retting, and that time can be saved through mechanical delignification. This has led to the development of short fibre, or industrial fibre flax, technology through which the loss of the quality criterion breaking resistance can be reduced [5, 9, 11]. The interaction of biological properties (fibre characteristics of different varieties in interaction with environment influences), process technology and quality criteria require creation of a suitable system-technology [3, 6, 10]. The biotechnological criterion drying behaviour (absorption isotherms) of fibre bundles and flax straw in association with variety (genotype) and air temperature shows, with limited varietal influence, the advantages of processing for a rapid drying [1] through breaking of the flax straw (fig. 2).

The quality descriptions of natural fibre have oriented themselves on textile requirements. There are no exact quality values available for technical utilisation. Thus, it is important to develop new methods and to adjust existing methods to meet the demands of technical utilisation of natural fibres.

The fibre quality can be described through physical material properties divided into eight groups as far as agricultural material is concerned [14]. *Table 2* illustrates the importance of these material properties for differing utilisation possibilities [2].

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Table 1: Comparison of straw and fibre yield in association with harvesting and delignification procedures [4]

	Traditional method (n=25) Plucking Retting Drying Flailing (long fibre)	New method (n=18) Plucking Rolling to break-up lignin Wilting/drying Delignifying process (industrial fibre)	Difference (%)
Straw yield (dt/ha)	64,4	74,4	+16
Fibre content (%)	24,6	33,0	+34
Fibre yield (dt/ha)	16,0	24,7	+54

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Table 2: Importance of material characteristics of natural fibre for differing uses [2]

Utilisation: / **Material properties**	**Textiles**	**Technical textiles**	**Geotextiles**	**Nonwoven fabric**	**Compound industrial material**	**Lining**	**Building (insulation material)**	**Paper-industry**
Geometric properties of the fibre								
Length	++	++	++	++	++	++	++	++
Curl	++	++	++	++	++	++	+	+
Diameter and Cross sectional area	++	++	++	++	++	++	++	++
Gravimetric properties of the fibre								
Fineness	++	++	++	++	++	++	++	++
Density	++	++	++	++	++	++	++	++
Dry matter proportion, moisture proportion	++	++	++	++	++	++	++	++
Moisture absorption and release	++	++	++	++	++	++	++	++
Mechanical properties of the fibre								
Fineness-linked maximum breaking resistance	++	++	++	++	++	++	-	++
Breaking resistance	++	++	++	++	++	++	-	++
Flexibility	++	++	++	++	++	++	-	++
E-module	++	++	++	++	++	++	-	++
Bending resistance	++	++	++	++	+	+	-	++
Thermal properties of the fibres								
Heat resistance	++	++	++	-	++	++	++	-
Heat conductivity	++	-	-	-	-	++	++	-
Heating and burning value	-	-	-	-	+	-	-	+
Optical properties of the fibres								
Colour	+	-	-	-	+	-	-	-
Lustre	+	-	-	-	-	-	-	-
Acoustic properties of the fibres								
Sound reflection and absorption	-	-	-	-	+	-	+	-
Aero and hydrodynamical properties of the fibres								
Flow resistance	-	-	-	++	-	-	-	-
Air-suspension velocity	-	-	-	++	-	-	-	-
Electromagnetic properties of the fibres								
Elektrostatic build-up	++	+	+	-	-	-	-	-
Other properties of the fibres								
Fibre matrix co-adhesion	-	-	-	-	++	++	-	-

++ important, + less important, – not important