BAST FIBER CROPS
HARVESTING

by Luigi Pari
CRA-ING
Introduction to bast fiber crops

Existing harvesting systems for the following species:
- Flax (*Linum usitatissimum* L.)
- Hemp (*Cannabis sativa* L.)
- Kenaf (*Hibiscus cannabinus* L.)

Some basics of harvesting for the following species:
- Jute (*Corchorus olitorius* L. and *C. capsularis* L.)
- Nettle (*Urtica dioica* L.)

Concluding remarks

Future activities
What is the bast fiber?

The bast fiber comes from the phloem tissue of the plant. It provides support to the conductive cells of the phloem and strength to the stem.
Harvesting bast fiber crops is a delicate task for the following reasons:
1) High heterogeneity among crops that require different harvesting technologies
2) Difficulties to preserve the fiber quality during the harvesting operation
3) Ensuring the fiber separation at the processing facility.

Generally, the separation of the bast fiber from the xylem tissues is possible after the retting process, which takes place in the field once the plant are pulled or mowed and left in windrows.

Through the combined action of bacteria and weathering (sun, air, moisture), this phenomenon allows the degradation of the stem material (mainly pectines) surrounding the fibre bundles. Once the retting is completed, the plants are ready for bailing.
Harvesting flax: main steps

1) Pulling and windrowing
2) Retting
3) Turning: the plants are turned to ensure the uniform retting. Mainly used for producing fibers of high quality.
4) Baling parallel stems

Dehondt single puller

Union double turner

Dehondt self-propelled baler
1st step "pulling and windrowing"

**Machines**: flax pulling machines are mainly produced by Western European companies such as Dehondt (French), Union, and Depoortere (Belgium)

**Purpose**: plants are pulled from the ground and arranged in windrows. The stems are pulled and not cut in order to preserve the length of the fiber.

<table>
<thead>
<tr>
<th></th>
<th>Company</th>
<th>model</th>
<th>Weight</th>
<th>Engine</th>
<th>Working width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>Union</td>
<td>GE200</td>
<td>4700kg</td>
<td>Deutz BF4M1013E 124 hp</td>
<td>144cm</td>
</tr>
<tr>
<td>Double</td>
<td>Union</td>
<td>GE220</td>
<td>7150 kg</td>
<td>Deutz TDC 2012- 200 hp</td>
<td>240-260 cm</td>
</tr>
</tbody>
</table>
2nd step "turning"

**Machines:** Carried out with turning machines (single turner or double turner) mainly developed by Union, Dehont, Depoortere, and Agromash (Belarus).

**Purpose:** ensuring a uniform retting in order to make easier the fiber extraction

<table>
<thead>
<tr>
<th>Company</th>
<th>Model</th>
<th>Weight</th>
<th>Engine</th>
<th>Working width</th>
<th>Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single turner</td>
<td>Dehondt T3R</td>
<td>2300kg</td>
<td>Deutz F3L1011F – 50 hp</td>
<td>100 cm</td>
<td>1Ha/h</td>
</tr>
<tr>
<td>Single turner</td>
<td>Agromash OL-140</td>
<td>980kg</td>
<td>(semi-trailed)</td>
<td>140 cm</td>
<td>0.85ha/h</td>
</tr>
</tbody>
</table>
3rd step "baling"

**Machines**: self-propelled or trailed balers produced by Vlamalin, Union, Dehondt

**Purpose**: the balers are designed to form regular flax layers within rolls of parallel stems. The regularity of layers will ensure an easier processing in the next steps.

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<th>Engine</th>
<th>working width</th>
<th>Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baler</td>
<td>Dehondt</td>
<td>EAS-EASC</td>
<td>not disp.</td>
<td>John Deere 4045DF270 – 60 kw</td>
<td>100cm</td>
<td>1ha/h</td>
</tr>
<tr>
<td>Baler</td>
<td>Union</td>
<td>GE250</td>
<td>5200kg</td>
<td>Deutz F6L914- 130hp</td>
<td>100 cm</td>
<td>Not. disp.</td>
</tr>
</tbody>
</table>
Flax scutching plant
Harvesting hemp

Hemp can be cultivated to obtain long and short fiber. The material produced, which can be used in different production chains, requires in turn different harvesting techniques.

For this reason, the hemp harvesting can be divided in two categories:

1) Longitudinal harvesting: for obtaining long fibers for textile production
2) Disordered harvesting: for obtaining short fibers for technical uses
Problems with longitudinal harvesting

Nowadays, the traditional hemp processing lines are considered very old and inefficient, since they require a lot of handiwork and high processing costs. To solve in part this problem, the cultivation or the harvesting techniques for long hemp fiber production have to be adapted to that of flax in order to use modern flax scutching lines also on hemp stems.

However, the harvesting systems capable to furnish processable material to the flax scutching lines are still limited. This is because the features of the hemp plants differ from those of flax; the main limit is given by the height of the plants that in hemp is generally twice than flax.
The CRA-ING experience on longitudinal harvesting

The past experience of CRA-ING demonstrated that flax turner and balers can be utilized to collect windrowed hemp

Depoortere single turner tested on windrowed hemp

Dehondt baler tested on windrowed hemp
Depoortere single turner tested on windrowed hemp

Dehondt baler tested on windrowed hemp
The CRA-ING experience on longitudinal harvesting

The workability of the hemp baled material at the flax scutching lines was verified.

<table>
<thead>
<tr>
<th>Hemp scutching performance</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long fibre</td>
<td>8,82</td>
</tr>
<tr>
<td>Short fibre</td>
<td>17,03</td>
</tr>
<tr>
<td>Tow</td>
<td>3,18</td>
</tr>
<tr>
<td>Pith</td>
<td>70,97</td>
</tr>
</tbody>
</table>

The tests indicated that the flax scutching machines can process hemp with acceptable yields.
The CRA-ING experience on longitudinal harvesting

However, our study has shown a missing link in the hemp harvesting chain as well.

In fact, it is still to be developed an hemp harvester/windrower machine that may produce and arrange in ordered swaths the hemp stem sections to be turned and baled with flax machines.
Disordered hemp harvesting

In the disordered harvesting the plants are cut in pieces generally smaller than 1 m. These are arranged disorderly in windrows and then baled with traditional balers. There are three systems that are basically used to harvest hemp.

cutting bars

rotary header with one-knife cutting drum

counterrotating drums with cutting disks
1st system: rotary header with cutting drum HempCut 3000 or 4500

The HempCut machine consists of a row independent rotary header made by Kemper (Stadtlohn, Germany) combined to a Claas Jaguar 830 presenting an one-knife cutting cylinder developed by HempFlax. The hemp stalks are mowed by the header and fed lengthwise into the chopping drum, cut into 600 – 700 mm long pieces, and placed onto the field directly under the drum.

Limits: repeated swath turning is necessary to ensure a uniform retting process
2nd system: counterrotating drums with cutting disks “Bluecherho 02/03”

Developed in 1990’s by the company Kranemann (Germany).

The basic idea of the Bluecherho is to preserve the original array of the hemp plant until it is cut into pieces of 600 – 700mm.

Initially, the conveyor elements maintain and collect hemp stalks in a vertical position. Then the cutting units (discs), located at fixed positions on the drum, cut the stalks kept upright in their natural position several times before setting them in a swath.

Limits: imperfect forms of the swaths generated which may influence negatively the retting and drying phase.
3rd system: Cutting bars "Clipper 4.3 MMH"

Developed by the company Tabeco (Czech Republic), the system is composed by simple cutting bars mounted at three different height onto a metallic frame driven and powered by tractor. The three cutting bars are 4 m long. They cut the stems down into parts of 1000 millimeters about. In this case the cut material occupy the full field area (wide swath), this makes faster and more homogenous the retting and field drying.

Limits: it requires repeated turning and windrowing
Resuming table of the machine performances and characteristics

<table>
<thead>
<tr>
<th></th>
<th>HempCut 3000/4500</th>
<th>Bluecher 02/03</th>
<th>Clipper 4.3 MMH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power requirement (Kw)</td>
<td>250</td>
<td>100</td>
<td>74</td>
</tr>
<tr>
<td>Working speed (Km/h)</td>
<td>5 to 10</td>
<td>5 to 12</td>
<td>12.5 to 16.6</td>
</tr>
<tr>
<td>Area Performance (ha/h)</td>
<td>2.1-3.4</td>
<td>2.9</td>
<td>4 to 5</td>
</tr>
<tr>
<td>Swath width (mm)</td>
<td>800</td>
<td>800</td>
<td>(no swaths, uniform layer)</td>
</tr>
<tr>
<td>Maximum working width (mm)</td>
<td>3000 or 4500</td>
<td>3500</td>
<td>4000</td>
</tr>
</tbody>
</table>

Studies show that among the existing commercial machinery above described, the multiple level cutter bar system has improved the retting behavior of the stems. However, there is still a need to improve the harvesting systems in order to cut and prepare properly the hemp stems for subsequent storage and processing.
Baling hemp

The baling can be done with any kind of baler. Large round, soft-core balers may be most satisfactory in allowing bales to dry more quickly in storage. Bales must be stored indoors under dry conditions to stop the retting process before the fibers become rotted. Stalk moisture should be less than 15% at time of baling, and should continue to dry to about 10%
Kenaf harvesting

According to the end use of the crop, kenaf can be harvested as green or dry material. The first is harvested during flowering, while the dry material during winter, when the death plans are still erect in the field, leafless, and present the stems degraded by atmospheric and biologic processes.

There are advantages and disadvantages in using a product respect another; in any case it is widely accepted that fibers coming from green material are more valuable and can be used for more purposes.
1) Sugarcane-type Harvesters.

2) Jute/reed-type harvesters

3) Forage-type Harvesters and Baling Equipment.

4) F.lli Bassi
Sugarcane-type harvesters.

These are unmodified or slightly modified sugarcane harvesters that use rotating knives or circular cutting blades to chop off the base of the kenaf stalk and to separate the low fiber from foliage and top portions of the plants. The long stalks then pass through the equipment upright and then are laid down in long windrow to field-dry.
A prototype of modified sugarcane harvester was tested in Japan in 2003. The machine with a modified rotating knives system has shown a good productivity, being able to harvest green and dry stems. Beside the modified cutting system, the machine was equipped with a chopper system producing green-stem, leafless, 20-22 cm long. The leaves, removed with rollers during the machine progress were then blown out with a fan. The stem portions were then collected in net bags or loaded onto a trailer.
Jute/reed-type harvesters

Model 4GL-180II developed by the Chinese company Yucheng Yatai Machinery Manufacturing Co. The machine designed for harvesting jute and reed can be used for kenaf as well. It has a cutting bar system that chops off the stalks in the first 5cm above the ground. After cut the entire plant is directed in the rear part of the machine and left upright onto a metallic support by conveying organs. During the machine progress, the stalks are gradually accumulated on the metallic support and finally laid in windrows.

The machine is powered by a 52 hp engine, the net weight is 2000kg, the working efficiency is 0.68-1 ha/h and the working width is 1800mm.

https://www.youtube.com/watch?v=NatjqxDD46E
Forage-type harvesters and baling equipment.

Forage-type harvesters and baling systems have been widely evaluated for use in kenaf production, harvesting, and processing. It has been demonstrated that standard forage cutting, chopping and baling equipment can be used for harvesting kenaf as either a forage or fiber crop.

Kenaf can be baled in both small and large square bales or in large round bales.
Jute harvesting

The model 4GL-180II of the Chinese company Yucheng Yatai Machinery Manufacturing Co. can be utilized for the jute harvesting. The machine (already described in the kenaf section) has an area performance of 0.7ha/h and requires two operators.
Nettle harvesting

Studies show that machines with cutter bars can be adapted for harvesting fiber nettle, but improved harvesting technology for nettle has not yet been developed. Since the morphological characteristics of nettle stalks are similar to those of hemp, one can assume that the same harvesting machine could be used for both crops. However, problems, such as the wrapping of fibers around axles of rotating pieces of equipment and breakdown will occur if the machines are not adapted to the harvest of fiber crops.
Concluding remarks

• Promoting the development of fiber crops can help the local economic development, create new jobs, and generate positive environmental benefits, thus contributing to the sustainable development of urban fringe and rural areas.

• Technological innovation will be essential to make the existing harvesting machineries suitable for multiple crops, improve fiber quality, and increase the profitability of the chain.
References


Thank you for your attention!

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