GROWING FIBRE HEMP FOR PAPER PULP: A NEW APPROACH TO HARVESTING AND PRESERVATION

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INTRODUCTION

In the Netherlands many arable farmers are searching for alternative ways of farming. Costs get higher but prices for farmer's products get lower. A good investment in the future would be to do some research into the production and processing techniques of non-food crops. Hemp as an annual fibre crop for paper pulp could have both agricultural and environmental benefits. It is a non-food crop with a short growing season and it does not infest the soil, it saves forests and during cultivation there is no demand for chemicals. It is also expected that the processing of hemp into paper pulp is less polluting than the processing of soft wood.

In 1990 the Dutch government initiated a 4-year research scheme into the technical and economical feasibility of cultivating fibre hemp for paper pulp. All conceivable aspects were considered, from breeding varieties for the Dutch climate to pulp processing and paper making. As a part of this research programme the DLO Institute of Agricultural and Environmental Engineering (IMAG-DLO), together with the Department of Agricultural Engineering and Physics of Wageningen Agricultural University, investigated some aspects of drilling, harvesting and preservation up to the separation of bark and core as a preprocessing operation before paper pulping.

AVAILABLE TECHNIQUES FOR HARVESTING

Fibre hemp normally would be grown for rough textile fibres. With retting, bacteria remove non-fibre components such as resinous and rubber components. Because of the decrease in fibre demand, in many areas the mechanization of fibre crops is not much advanced. The evolution of harvesting equipment stopped with mowing-bundling machinery (Berger, 1969; Kirby, 1963).

In France the cultivation of fibre hemp and the processing into paper pulp is a fact. Two harvesting systems are used, depending on wether the seed is to be harvested (FNPC, 1985).

TEST RESULTS

Drilling and weed control

Hemp seed is sown best with a grain drilling machine at a row distance of 12 cm. The number of plants after germination should be about 90 plants/m^2 (van der Werf, 1994). Precision drilling does not improve crop regularity. Hemp grows quickly, soon covers the ground and chokes out the weeds. So weed control is not neccessary. Under humid growing conditions fungi, such as *Botrytis cinerea*, can cause considerable damage to the crop. However because of the height of the crop, it is not possible to control fungi by chemical curative spraying. Preventive spraying is both economically and environmentally not attractive. Breeding a fungus-resistant variety would be the best solution.

Defining a harvest technique

Different machines which were developed for other crops, were investigated to harvest hemp. These were mowers, mower conditioners, balers and choppers. In the total research programme the objective was to cultivate a crop with a maximum fibre yield. This means that harvest has to wait until September. To supply a pulp processing plant with fibres for a whole year, it is necessary to store the hemp. The Dutch climate in September does not make it possible to let the crop dry in the field after mowing. The stems in the bottom part of the swaths would be dew-retting so the fibre quality would get very inhomogeneous. Artificial drying is too expensive. As dry storage does not seem to have opportunities, tests were done to store and preserve the fibres anaerobically wet. Then the hemp should be baled or chopped. Because of the enormous bulk of dry matter, baling is expensive and does not compact the hemp well enough for a good preservation process. So chopping and preserving the wet hemp anaerobically do have the best feasible prospects.

Defoliation

At harvest date 1 kg of rough plant dry matter (dm) contains about 0.20 kg of dm of leaves, florescences and seed (foliage). Because there is no cellulose in the foliage, it is useless as a source for paper pulp. So it better can be removed in the field to reduce transportation costs and to diminish pollution in the processing. By stripping off the foliage in the field also some nutrients are brought back to the soil. At the end of the growing season, most of the foliage is situated at the upper part of the stem. A defoliating process was simulated with results of measurements of crop mass at different heights. After defoliation, 1 kg of rough plant material contains approximately 0.05 kg of foliage dm. Fibre losses are about 0.02 kg/kg. A good indication for the height above which a crop should be defoliated is 2.6 m. This depends greatly on harvest date, variety and plant density.

In tests using a rotating brush, the content of foliage averaged 0.04 kg of dm per kg rough plant dm. The loss of stem material was about 0.05 kg/kg at a defoliation height of 2.3 m. Simulating the defoliation, a better stripping efficiency was achieved than the one that could be realized in the field tests. It became clear that besides the defoliation height, the result is influenced by variety and plant density. A flail mower and a rotating brush can be used. Using a brush the safety is higher and the fibre losses will probably be lower because the leaves are stripped off, while a flail mower is beating the stems.

Harvest: chopping

Chopping is a well-known technique in the harvesting of green fodders such as grass and maize. The product can be handled easily (to be mixed or compressed) because of its flow behaviour. The tough bark of the hemp stem sometimes caused troubles with harvesting using a field chopper. First of all the header must be row-independent (with rotors) to avoid wrapping of stems around chains. Flywheel-type choppers, with the rotating axle parallel to the input, are more sensitive to technical troubles due to wrapping than drum-type choppers. Badly chopped bark easily can get to the axle, wrap around it and destroy the bearings. To avoid blockages the crop chute must be smooth and without any augers or blind areas. The knives have to be sharp and the chopping length has to be small (6 mm). The length of the elementary bast fibres is longer though (with an average of 20 mm), but it seemed that the bark is not cut at the adjusted chopping length. In field tests the length of the chopped bark varied from 1 cm to more than 20 cm. The field capacity of a field chopper in hemp is expected to be somewhat lower than in maize (because of more technical troubles) and is estimated at 0.9 ha per hour.

Preservation

As a raw material for paper pulp it is neccessary to preserve and store the harvested fibres for a whole year. This can be done by ensiling (wet anaerobic preservation). This technique is commonly used to conserve green fodders. In silage, in an anaerobic climate, lactic acid bacteria consume free sugars and produce lactic acid until the acidity is that low (pH 4.2) that even these bacteria cannot survive. Then the silage is in a stable condition in which the quality of the fodder does not change. Because there are not enough sugars in hemp, fermentation will hardly succeed spontaneously. Therefore, it is necessary to use additives for a successful ensiling process. Results of measurements of fibre strength indicate that the best preservation environment is acidic (pH<4.5) or alkaline (pH>12). But even under these circumstances the strength decreased by 18% after a silage period of 3 months (compared to dry-stored fibres). The course of the fibre strength during the preservation period is not quite clear. Results indicate that the strength is slowly decreasing in a stable acidic or alkaline environment. It is not known how much that decrease is and whether it can be stopped.

Separation of bark and core

Bark and core can be separated best after storage, just before the processing (integrated in the washing operation). The prospects of the decortication in the field are not good because the separation results were not satisfactory and this operation would be very expensive (approximately 110 Dfl per ton dry matter). When the hemp is harvested with a field chopper, the bark is loosened from the core because of a tearing action. This makes it possible to separate bark and core by flotation after the hemp has been taken out of storage and transported to the pulp plant. In water the bark sinks and the core floats. The costs of this operation would be substantially lower (approximately 5 Dfl per ton dry matter) and the separation results would also better.

CONCLUSIONS

In the examined system to cultivate, harvest and store fibre hemp, the wet anaerobic preservation is the most uncleared factor for the supply of a good and equal quality of fibres throughout the year. Field choppers with a row-independent header can harvest fibre hemp but the sharpness of the knives and throughput of the chopped fibres need special attention to prevent wrapping or blockages. More research is needed into the preservation processes with special attention to the decrease in fibre strength. An option may be to cultivate an early ripening variety. Then the crop can be mowed at the end of July to be dried in the field. Accepting that the fibre yield is lower, also seed can be harvested. Dry storage is the best guarantee for the highest quality of fibre.

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