The Cultivation of Hemp at Riswick House

Experience from the 2005 and 2006 Crops

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Fig. 1: Hemp textiles

Hemp is a very old plant, with the origins of its dissemination going back many thousand of years in India and China. Hemp has also been cultivated in Europe over the past few centuries as well. In the 17th century, almost all ships' sails, hawsers, ropes, flags, paper and even sailors' uniforms were made out of hemp. Hemp was an important source of raw material for making rope, textiles, paper and oil products. Even Johannes Gutenberg printed his first Bible on paper made from hemp and Henry Ford impressed the world in 1941 with his "hemp car", a car whose bodywork was made of hemp fibres and whose motor was powered by methanol obtained from industrial hemp. However, in the years that followed, the cultivation of hemp in Germany gradually declined in significance as a result of progress in the manufacture of artificial fibres and from 1982 to 1996 was banned completely due to the risk that a narcotic could be obtained from it. However, since then, hemp is being rediscovered as an "industrial plant". Today, hemp growers have ensured that only species low in tetrahydrocannabinol (THC) are available for the cultivation of industrial hemp, as these hemp plants produce no narcotics. To date, the hemp cultivated in Germany today is processed in particular into environmentally friendly insulating material and sealants. The processing of hemp into textiles is still not yet possible, as the mechanical technology has not been developed, although a potential market for these domestically produced natural textiles may be expected, as hemp textiles guarantee a high level of wearing comfort.

In the Euregio Rhein-Waal many farms, companies and research institutes have therefore got together to establish a regional hemp textile chain. Even the Chamber of Agriculture of the German state of North Rhine Westphalia (NRW) is participating in this cross-border project. The partners taking part in the project are as follows:

BRUT (EWIV) Kleve (applicant)
Kleve Technology Centre, Germany
Plant Research International BV Wageningen UR (NL),

NRW Chamber of Agriculture / Riswick House Agricultural Centre, Germany
Biological Products Manufacturers Association, Achterhoek (NL),
German Textile Research Centre Northwest (Inc.) Krefeld, Germany
Trützschler GmbH & Co.KG, Germany
VRISIMA BV Laren (NL),
Food Valley Foundation, Wageningen (NL),
Research Promotion and Transfer Centre (FFT), University of Duisburg-Essen, Germany

As part of this project a large number of partial aspects of fibre harvesting, spinning technology and textile manufacturing must be further developed in order to optimise the manufacturing process. For example, the usual wet-and-dry spinning technologies are not suitable for spinning hemp from Western Europe. In order to be able to use the highly technical short-fibre spinning system, an additional improvement is necessary. This can be achieved with the use of the so-called steam-explosion technology (STEX) in which hemp fibres are treated with high-pressure steam and blown into a centrifugal separator. The resulting fibres can be spun in a short-fibre spinning system (in combination with cotton if required) and the yarns can be processed into fashionable and environmentally friendly clothing, functional textiles for the health system and into home textiles. The Chamber of Agriculture in the state of North Rhine-Westphalia is also involved in this project. In 2005 and 2006 it cultivated the hemp required for the project development on the experimental fields at Riswick House in Kleve that provides the raw materials for developing manufacturing and further processing. Cultivation for a similar project has also been carried out just across the border in the Netherlands.

Experience from the 2005 and 2006 Crops in Kleve:

Fig. 2: Rapid, even growth

Fig. 3: A dense crop on 9 June, 6 weeks after seeding

Sowing took place on 26 and 27 April 2005 by means of Säkombination combined sowing with a front-end rotary harrow. The chameleon species of hemp cultivated at Plant Research International BV Wageningen UR (NL) was sown in both years. This new variety is characterised by a soft, fine fibre which makes it easier to use the hemp fibres for manufacturing textiles. The variety contains a low level of THC, which is a basic requirement for official permission to cultivate it. Fertilising was carried out in solely organic form, i.e., with the use of liquid cattle manure and/or dung. Any weed-killing measures were not necessary, however. Due to their rapid initial growth, the plants provide shade for the ground very rapidly and suppress all weeds. Thus, in both years the hemp demonstrated no signs of diseases by the time it came to be harvested. The cultivation of hemp has therefore proven to be attractive for ecological farming as an addition to the crops used in rotation.

The cold snap in mid-May 2005 blemished the crop slightly by making it somewhat light-coloured in a short time but did not cause any long-term damage, as the plants showed astonishing increase in length following the subsequent rise in temperature. The second year of cultivation (2006) was characterised by an extended period of dry weather due to a lack of rainfall in June and July. Under these extreme conditions, the hemp itself showed no damage as a result of the dryness. On the contrary, it showed that, with its deep root system, it was capable of surviving such dry spells.

Fig. 4: At harvesting, the crop had reached 3.80 m in height.

However, in spite of very rapid initial growth in 2005 the hemp reacted very markedly to obvious soil differences in the experimental cultivation area. On a 1.8 ha area of ground with a good soil structure, the plants noticeably grew more robustly with thicker stalks and longer to a height of some 4 m. However, growth was reduced to 73 plants per square metre in density: It was thus markedly more robust than the crop on a second, smaller, partly more compact 1.1 ha area of ground, where the weaker individual hemp plants only grew to about 3.25 m in height but with a greater density of 105 plants per square metre.

Harvesting was carried out in both years with the Hemp Cut 3000 on the Jaguar 840 maize chopper as the carrier system. In the process the hemp stalks were shortened to about 60 cm in length. In 2005 the harvest was carried out on 24 August, 34 days after the female plants had started flowering on 21 July 2005; in 2006, flowering did not start until 26 July 2006, five days later. However, flowering started this year at the same stage of development as in 2005, which meant that the harvest could begin 16 days after flowering had started, i.e., on 11 August 2006. After being mown the hemp must first lie on the ground for a few weeks for the so-called retting. During this period the fibres are supposed to detach themselves slightly from the stalks. Due to the changeable weather during this period, the retting in both years took a relatively long time – about four weeks. To dry the harvest out in 2005, the straw was turned once before pressing but in 2006 it was turned a total of three times and then pressed into square-shaped bails on 22 September 2005 and on 11 September 2006. On average 77,75 dt/ha (decitonnes per hectare) of pressed hemp material were harvested in 2005 and 68,03 dt/ha in 2006. The smaller harvest in 2006 was very obviously attributable to the more intensive drying which caused the fibres to separate very well while still on the ground, so that a considerably greater number of the stalks remained lying on the ground.

Fig. 5: Coming into flower. Left: a male flower, right a female flower

Fig. 6: Demonstration of the structure of the flower by the breeder

Fig. 7: Harvesting the hemp with the Hemp Cut 3000

Fig. 8: Shortening the stalks to 60 cm in length

Table 1: The influence of sowing density on plant growth, yield, quality and nutrient removal of the hemp plant in 2006 at Riswick House, Kleve,

Part of Plant	Leaf		Stalk		Entire Plant		Net Nutrient (55% of the Stalk Removal)	
Sowing Density, Seeds/m²	**170**	**230**	**170**	**230**	**170**	**230**	**170**	**230**
Sowing Density, kg/ha	**33**	**45**	**33**	**45**	**33**	**45**	**33**	**45**
Plantings								
- % Field Emergence Rate					0,82	0,79		
- No. of Plants/m² after Emergence					140	182		
- No. of Plants/m² at Harvest					88	119		
- m Growth Height					3,47	3,10		
Dry Mass Yield								
- dtTM /ha	22,8	18,7	127,9	105,4	150,8	124,1	70,4	58,0
Fibre Yield								
- XF-kg/ha	307	269	7940	6345	8246	6614		
- NDF-kg/ha	776	569	10085	8366	10861	8936		
- ADF-kg/ha	453	374	7920	6502	8374	6876		
Removal of Minerals								
- N-kg/ha	84,7	63,4	79,9	58,3	164,6	121,7	43,9	32,1
- S- kg/ha	8,0	6,1	7,1	4,5	15,1	10,5	3,9	2,5
- Ca-kg/ha	54,2	40,5	69,5	59,0	123,7	99,5	38,2	32,4
- P-kg/ha	9,0	7,9	25,2	22,5	34,2	30,4	13,9	12,4
- K-kg/ha	72,0	59,7	292,0	229,9	363,9	289,6	160,6	126,4
- Mg-kg/ha	10,2	8,8	10,5	9,1	20,7	17,9	5,8	5,0
- Na-kg/ha	1,0	0,7	2,6	2,4	3,6	3,2	1,4	1,3
% Ingredients								
- % TS	83,3	83,4	86,0	85,8				
- % Crude Ash	17,7	16,7	6,2	6,0				
- % Crude Protein	23,1	21,2	3,9	3,5				
- % Crude Fibre	13,5	14,4	62,2	60,2				
- % NDF	33,9	30,4	78,8	79,4				
- % ADF	19,9	20,0	61,9	61,7				
- MJ NEL/kgTM	6,1	6,1	4,2	4,3				
Raw Nutrient Formula								
- % S	0,35	0,32	0,06	0,04				
- % N	3,69	3,39	0,62	0,55				
- % Ca	2,36	2,17	0,54	0,56				
- % P	0,40	0,42	0,20	0,21				
- % K	3,17	3,19	2,28	2,19				
- % Mg	0,45	0,47	0,08	0,09				
- % Na	0,05	0,04	0,02	0,02				

The differing sowing density and crop/plant density obtained in spite of a uniform sowing density of 36.7 kg/ha in 2005 was the reason for systematically investigating the influence of the sowing density on crop/plant development once again in 2006 in order to assess the possible influence of crop/plant density on the quality of the fibres. In 2006 4.29 ha of field were sown with a density of 170 seeds/m² and 33 kg/ha respectively and 1 ha was sown with a density of 230 seeds/m² and 45 kg/ha respectively. After rising the number of plants and the number and length of the plants at harvest was determined and the yields of the stalks, leaves and the entire plant and its composition were analysed. These results have been summarised in Table 1.

The various seeding intensities with a rising rate of approximately 80% resulted in crop densities of 140 and 182 plants/m². By harvest, the number of plants was each reduced by about 35 % so that the number of plants at harvest was 88 plants/m² and 119 plants/m². At 3.47 m in height, the thinner plants were clearly taller with considerably stronger individual stalks than the thicker-stalked

Fig. 9: Lower sowing density: 88 plants/m²

Fig. 10: Higher sowing density: 119 plants/m²

With a lower sowing density and 127,9 dt/ha (decitonnes per hectare) dry mass, the stronger individual plants achieved a considerably higher stalk yield than with a higher seeding density of 105,4 dt/ha. With a dry mass of 22.8 and 18.7 dt/ha, there were only negligible differences in the leaf yield. While this is of no significance when making textiles, it is, however, significant for calculating the gross nutrient removal by the hemp plants until they are harvested; this is because the nutrients in the leaves of the plants themselves have to be provided with nutrients so that the plant will grow. The removal of minerals in Table 1 show that a well-developed hemp crop, as has been established with the low sowing density if 170 seeds/m² , has very large gross nitrogen and mineral requirements. When producing hemp to make textiles, however, the entire leaf and the stalk parts remain on the ground after separating from the stalk while drying out after the harvest. This percentage may very well depend on the intensity of this drying process. But only the actual harvest physically removed from the field is relevant for the nutrient balance because, on the one hand, the drying leaves separate from the stalks while drying out on the ground but so, too, do the non-fibrous parts of the stalks to a considerable extent. The nutrients in the leaves and a large percentage of the ingredients from the stalks therefore remain on the ground after drying out. In 2006 as a result of the intensive drying-out, which made it necessary to turn the hemp straw three times, a very large share of the dry mass of the stalks (almost 45%) remained on the ground. This meant that, all told, an average, only 68.03 dt of dry mass/ha hemp straw from the entire sowing area was pressed. The quantity harvested corresponds to slightly less than the quantity of crude fibre analysed in the hemp stalk. This customary analysis parameter borrowed from feed investigations seems to indicate a close correlation to the quantity of pressed hemp straw.

Fig. 11: Gross yield from the harvest

If one takes into consideration the fact that in 2006, only 55% of the dry stalk mass was removed from the field, we arrive at the net nutrient removals shown in Table 1 for this year, which only make up a fraction of the gross removals. This requirement can be covered quite sufficiently by the addition of liquid manure. It did not prove necessary to fertilise the entire gross removal of the hemp plants. If the ground is in good cultivating condition with a [illegible] egory C), the hemp plant, with its strong root system, is quite obviously capable of temporarily obtaining its nutritional requirements from the reserves in the soil. However, after the harvest, most of these nutrients remain on the ground. For the nitrogen compounds in particular, there is a risk that they may be mineralised from the warm, damp exposure to the elements by late autumn and then be washed out over winter. The earlier the hemp is harvested, the more important it is that the harvest is followed by planting a fast-growing follow-on crop which is capable of absorbing the released nutrients and protecting it before being transferred over winter. Fast-growing intermediate crops such as mustard as inter-tillage appear particularly suitable, or even cold-resistant winter plants such as Italian rye grass or green rye, which develop quickly before the onset of winter.

Fig. 12: Net yield after retting on the ground

If one were to make a preliminary summary of these initial results, it could be said that the cultivation of hemp to obtain its fibres for the textile industry constitutes a complex enrichment of the sequence of plantings. Lower susceptibility to disease, reliable suppression of weeds and low nutrient and water requirements also make growing hemp attractive for ecological farming. Because of its deep, fine roots, hemp helps improve the soil structure. However, to improve the nutrient balance in the soil, a fast-growing follow-on crop should be planted immediately after the hemp has been harvested.

Fig. 13: Hemp bales ready to be taken away

Fig. 14: The first jeans made of hemp grown at Riswick House

Since then, the hemp fibres from the 2005 harvest were successfully made into the first swatches of material samples with various percentages of hemp content and the first jeans made from hemp were also displayed. At the moment efforts work is going on to optimise processing techniques in this regional hemp chain. The objective of having "5,000 jeans per hectare" produced in the Rhein-Waal region seems within reach.

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