Report of a visit to the All-Union Scientific and Research Institute of Bast Crops, Glukhov, Ukrainian SSR

5-14 July 1991

S. Hennink (CPRO-DLO), E.P.M. de Meijer (CRPO-DLO),

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cpro-dlo

Dienst Landbouwkundig Onderzoek

Centrum voor Plantenveredelings- en Reproduktieonderzoek

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PREFACE

As a result of the renewed interest for hemp cultivation in the Netherlands many aspects of hemp became subject of a comprehensive feasibility study. Technological aspects of the Dutch programme are maybe unprecedented, but the agronomic and breeding research is certainly not. Hemp has a long history as a fibre and oil crop in a large part of Europe and Asia and a lot of useful information about this crop can be obtained from breeders and agronomists abroad, especially in Eastern Europe and the Sovjet Union. Therefore we were very pleased to have the opportunity to visit the All Union Scientific and Research Institute of Bast Crops in Glukhov.
Probably our trip was the first one in its kind to the Sovjet-Union since the mission of Friederich c.s. in 1964*. We were impressed by the hospitality of our Sovjet colleagues, interpreters and everybody else involved in our visit. We hope that a continuation of this contact in what ever form will be possible in the future.
In this report our impressions of the activities and strategies of the institute are summarized. We hope that it will be of use to researchers involved in the hemp programme in the Netherlands, and that it gives evidence of a correct understanding from our side to the Sovjet colleagues.

Wageningen, December 1991

PROGRAMME

05/07 Flight from Amsterdam-Schiphol to Moscow-Sheremetyevo,
(van der Werf).
Journey by night-train to Glukhov, (van der Werf).
06/07 First acquaintance with staff of the institute. (van der Werf).
07/07 Flight from Amsterdam-Schiphol to Moscow-Sheremetyevo,
(Hennink, de Meijer).
Journey by night-train to Glukhov (Hennink, de Meijer).
08/07 Morning:
First acquaintance with staff of the institute, general introduction (Hennink, de Meijer).
Visit to agronomic field trials (van der Werf).
Afternoon:
Visit to department of technology and quality standards.
Visit to department of harvest mechanization.
Evening:
Meeting with mayor and local authorities of Glukhov.
09/07 Journey by car from Glukhov to Kiev.
Visit to the Ukrainian Pulp and Paper Research Institute, Kiev.
10/07 Sight-seeing Kiev.
Return to Glukhov.
11/07 Visit to selection field trials.
Departure and return to Moscow, return flight to Schiphol (van der Werf).
12/07 Visit to department of selection and genetics.
Excursion to Forestry department Sumy-region.
13/07 Sight-seeing Glukhov, return to Moscow.
14/07 Return flight to Schiphol (Hennink, de Meijer).

*Reported by Friederich J.C. and H. Sparrenberg (1967): "Teelt en verwerking van vlas en hennep in de Sovjet-Unie en Polen."

INTRODUCTION

Hemp in the Sovjet-Union

Currently the basic product of hemp in the Sovjet Union is the bast fibre which is used for the production of tissue (canvas) and rope. The woody core of the stem is mainly used for the production of chipboard. Also the seeds are harvested for their content of edible oil, the oil cakes are used as fodder. Depending on the primary product of the crop (seed or fibre), different methods of cultivation are practiced (plant density and harvest time are different), while the same varieties are used for both purposes.
About 30 % of the total hemp area is primarily used for the production of seed (seed reproduction and oil seed). Also the stems of these crops are harvested but they are of inferior quality.

Before the revolution an area of 960.000 ha of hemp was grown on the present Sovjet Union territory. Average straw yield was 3-4 tonnes/ha. Fibre yield did not exceed 0.3 to 0.45 tonnes. (Reported weights of straw and fibre include respectively 20% and 13% moisture). Average seed yield was 0.7 to 0.8 tonnes/ha. Hemp was cultivated for the production of rope and many kinds of tissue which were exported to Western Europe. A sufficient quantity of hemp seed oil, mainly used as edible oil and for production of paint, was produced to supply the domestic needs.
At present an area of about 60.000 ha of hemp remains, mainly in the Ukraine and western parts of Russia.

The All Union Scientific and Research Institute of Bast Crops.

The All Union institute of Bast Crops was established by the Sovjet government in 1931. During the 60 years of its existence the institute has investigated breeding, agronomy, mechanization, processing and economy of fibre hemp. Primary processing of hemp is one of the most recent subjects.
The institute consists of five departments:

1 - The department of selection and genetics deals with the subjects: Establishment and maintenance of a collection of landraces, evaluation methods, breeding, elite seed production, heredity studies (especially heredity of fibre characteristics and sexual type) and bio technology.
2 - The department of agricultural technology, studies the agronomy of hemp: fertilization, crop rotation and plant density.
3 - Department of mechanization and harvesting. Subjects: Design, construction and testing of machinery, production of prototypes.
4 - Department of technology and quality standards. Subjects: Retting processes, post harvest conservation, environmental effects of retting, quality standards for factories, price level proposals for hemp products, organization of labour.
5 - Department of large scale processing. Main subject: design of machines for the hemp industry.

Besides these departments which concentrate on hemp there is also a laboratory for selection of flax connected with the institute.
The institute owns an experimental farm of 100 ha for the implementation of new techniques.

SOVJET HEMP VARIETIES

The collection of Sovjet hemp varieties

In the past the institute gathered the local hemp varieties of the Sovjet-Union, selected landraces were introduced for cultivation in other territories than the region of origin and/or used in breeding programs.
Accessions are multiplied under outdoors conditions, a space isolation of at least 1 km is taken into account. The "most typical" plants according to date of maturity, shape of flowers, bract morphology, stem diameter and stem length are selected. Seeds of at least a 100 female plants are harvested to guarantee the populations integrity. Accessions are regenerated every two years.

Landraces

In former times, between 32° and 60° Northern latitude, hemp was a common crop in large parts of the present Sovjet territory, several local forms (landraces) existed. The characters of the local varieties are the result of a long process of unconscious selection by peasants during harvesting and threshing. This selection was favourable for the early maturing plants in the population.

At present the commonly used classification of Sovjet hemp varieties is still based on geographic origin:

- Northern hemp (from the Leningrad region), characteristics: adapted to short day length and low temperatures, height not more than 70 cm, vegetation cycle 70 days, production about 2 tonnes straw/ha and low seed yield. The fibre content is natural which means 12 - 15 %. This group of hemp is of no practical use at present and was only grown by peasants before the revolution. It was cultivated for the production of tissues for clothing and the production of oilseed.
- Middle Russian Hemp, (central Ukraine) characteristics: 110 to 125 days from sowing to seed maturity. The yield of straw is 5-6 tonnes/ha, seed yield 0.5 - 2 tonnes/ha (average of 1 ton). At present fibre content and fibre yield of the selected varieties derived from this group are respectively 30% and 2 tonnes/ha.
- Southern Russian hemp (South Ukraine, Caucasus and Asiatic republics, also including far eastern hemp). Vegetation cycle of 140 to 160 days. Yield of straw is usually more than 8 tonnes/ha, stem length sometimes reaches 7m. Fibre content 25 %. Seed yield poor, usually less than 0.5 tonnes/ha.

The Siberian local variety Yermakovskaya, belonging to the middle Russian group, is still used in field trials as a standard because of its excellent fibre quality. Characteristics are: A short vegetation cycle of 105 days, a yield of 4-5 tonnes straw/ha and 0.7 tonnes of seed. Fifteen % of fibre of high textile quality (thin). The content of the narcotic compound THC in this variety is higher than 0.2 % which is the tolerated maximum content in the Sovjet Union.

Modern varieties

The main objectives of the hemp selection and breeding programme are: High stem yield, seed yield, fibre content and fibre quality, monoeciousness, low narcotic potency, and acclimatization of southern hemp types to northern conditions.
Besides the forementioned landraces a so called intermediary group of varieties was created. This group of varieties combines a long vegetation period, and a good yield of straw, fibre and seed. Although this hemp is late flowering (southerly maturing), it is adapted to cultivation in areas where originally only middle Russian landraces were cultivated. Intermediary varieties were bred by hybridization of selections of southern and middle Russian hemp and afterwards family group selection. Senchenko bred US-1 (Krasnodarskaya x Northern hemp) which combined good fibre and

seed yield, resistance, and earliness. In the nineteen-seventies US-6 was the main variety, characteristics were: 24% fibre of good quality, 120 days vegetation cycle, good straw yield, 0.8 ton seed yield. Initially the intermediate varieties were dioecious like the landraces where they were derived from.
Nowadays dioecious varieties are completely replaced by monoecious varieties. Although dioeciousness has biological advantages it is considered to be undesirable from the economic point of view. Monoecious (in Russian "Odnodomnaja") varieties are preferred above dioecious because they are homogenous which allows a more easy harvest mechanization.
Another strategy, already attempted before the second world war was to create dioecious varieties in which maturation of male and female plants takes place simultaneously. Although these attempts were successful the desired character disappeared after two or three cycles of multiplication. Classification and genetics of the several sexual types which occur in monoecious *Cannabis* populations have been subject of intensive study by Dr. Migal in the last decennia.
US-9 was the first monoecious Sovjet hemp variety. It contained a fibre content of more than 30%, but suffered from an insect plague called *Psylliodes attenuata* (hop flea beetle) and also from *Orobanche ramosa*. Resistance was introduced by back crossing with Southern hemp. Resistance is always acquired from the female parent.
Currently dioecious populations are only used for breeding purposes.
The most important selections at present are several types of so called Yuzhnaya (abbreviated: USO). Average yields of these varieties are 6-8 tonnes straw and up to 30% bast fibre. Higher fibre content (up to 40%) is supposed to be possible but causes lodging and a decrease of fibre quality. Hybrid F1 varieties are only used for breeding purposes. Hybrid seed production for large scale cultivation as is common in Hungary, is considered to be too complicated and too expensive.

Selection for low narcotic potency was started in 1973 by Dr. Virovets. Before that time THC contents of 2% were common, at present contents of 0.1% and even of 0% occur, also the content of CBD decreased very much as a result of this selection. Varieties with low THC content are: USO14, USO31, USO16, Dneprovskaya, Zolotoskaya and Kuban.

SCREENING AND EVALUATION METHODS

In selection fields, plants are widely spaced in a density of 30 plants/m^2 with row distances of 45 cm. Fibre content and quality, seed yield, stem yield, stem length and diameter, infection by *Fusarium*, *Botrytis* and *Sclerotinia* and the concentration of narcotic compounds are the most relevant characters that are evaluated.

Stem quality

Traditionally, textile quality parameters of stems and fibres were judged. Important fibre quality criteria are: Durability against biological and mechanical agents, flexibility, ability to splice, large breaking strength, absence of impurities and an easy extraction of fibres in retting processes.
A general problem in textile hemp breeding programs is that an increase of stem fibre content causes a decrease of fibre quality.
The improvement of evaluation methods of stems in order to accelerate the selection procedure is the general aim of the research of the department of technology and quality standards.
Recently a new approach in judging stem quality has been introduced, because of the possible utilization of hemp for non traditional purposes like paper pulp production.
The clarification of the relationship between plant morphology and fibre quality would allow indirect screening methods. Results of these investigations are patented and therefore not published. Although details were not discussed, we were told that only 2-3 minutes per stem is sufficient to characterize the most important parameters.
In recently developed evaluation methods fibres are treated as a complex of elementary fibrils located in an amorf lignin and pectin complex. One of the methods measures the density of anastomose connections between elementary fibres. Also a method for estimating fibre lengths exists.
The characters of the xylem core are also part of the programme, especially the level of adsorption and desorption are evaluated as measures for cellulose quality.

Stem parameters mentioned as being relevant to judge the quality for paper pulp production are: stem maturity, cellulose quality, level of maturity of individual fibres and uniformity of fibre length. Additionally it would be desirable if primary and secondary phloem contained the same amount of lignin (which is not the case). The higher lignin content of secondary fibres compared to primary fibres hampers a cheap production of paper pulp.
We were told that patented techniques can be bought, in the past several patents dealing with flax were bought by French companies or institutes.
Although the main theoretical problems concerning the determination of stem quality are solved and although prototypes of the required equipment exist, the department showed interest in collaboration in the field of technical improvement of the equipment.

According to staff members of the Ukrainian Pulp and Paper Research Institute in Kiev the ideal composition of hemp stems depends on the kind of paper which is desired. In general the lignin concentration should be as low as possible and the lignin should be as easy as possible to remove. Also the xylem core should be as small as possible especially because of its difficult delignification. Although secondary bast is less desired because it causes heterogeneity in the bast pulp this problem can technically be solved. In general as much bast fibre as possible is desired. There was general agreement that it is a problem to find useful purposes for lignin and for the woody core of hemp.

Narcotic compounds

The collection of landraces was evaluated to obtain populations with low narcotic potency. An indirect criterion for the content of the main narcotic compound delta-9 tetrahydrocannabinol (THC) is smell and stickiness of the female inflorescences. Indeed a selection lacking THC and with very low content of the other major cannabinoid cannabinol (CBD), shown to us in the field, did not possess the typical resinous smell of normal *Cannabis*. Evaluation of THC content takes place at the stage of initial seed maturity. Ten plants out of a family group of 50 are gathered in a mixed sample and THC content in the leaf dry matter is analyzed by gas chromatography (GC).

An indirect method to predict THC content was described by Gorskhova. The density of a specified type of resin glands is used as a parameter for indirect screening of THC content. Glands are not stained while using this technique. Microscopic observation shows a dominating density of cystolithic hairs in plants with low THC content, and a domination of iron colored trichomes in plants with high THC content. This indirect technique together with thin layer chromatography (TLC) is used only in the first stages of selection. At final stages gas- liquid chromatography GLC is necessary to determine THC content. Gorshkhova's technique is suitable for selection of individual plants, for large numbers of plants it is to elaborate.

Diseases

Susceptibility for fungal diseases is solely observed in the field and never *in vitro*. *Botrytis* and *Sclerotinia* are not very important in the S.U. due to the continental climate. Breeding for resistance does not have high priority.

Resistance to low temperatures is not taken into account. The usual sowing time is the second half of april and damage of seedlings by late frost does not occur.

Nematodes or other soil borne diseases do not play any role in the breeding programme. Hemp is believed not to suffer from these organisms. A field trial exist with a history of 60 years of hemp cultivation without rotation. If fertilizers, insecticides, organic fertilizer, micro-elements and Calcium are supplied, no yield depression can be observed after such a period.

Fibre yield

In order to increase the yield of straw and fibre two strategies were followed: 1; Introducing Southern varieties (long vegetation cycle) and 2; increasing fibre yield per individual stem by a selection for long thin stems. In the second case important parameters are; diameter of stem base and stem length. Selection aims at increasing length without increasing the stem diameter. Parameters are: A coefficient calculated out of the diameter of a lower stem section and the diameter of an upper section, and a coefficient calculated out of the diameter of the stem base and the stem length. It was concluded however that a direct determination of fibre content is a more effective criterion for selection than calculated indirect parameters.

The present protocol to treat individual stems is a combination of both approaches: Measurement of stem length, diameter and weight. Subsequently determination of fibre content of a representative segment of the stem and a calculation of fibre content and fibre weight of the complete stem.

GENETIC RESEARCH

Sex expression

Existing classifications of the sexual types of hemp are not suitable for practical use in genetics and breeding. Therefore a new classification is developed. This classification is based on the theories of Grishko (1940) and Neuer (1943). Deviating from existing classifications of sexual types, male and female plants segregating from monoecious hemp are not classified as dioecious male and female type.

According to Migal's theory, sex type in dioecious hemp is determined by two genes on the sex chromosomes, which are tightly linked. Both genes have two alleles, the Y chromosome carrying allele M for male flowers and allele I for loose inflorescence. The X chromosome carrying allele F for female flowers and allele i for compact inflorescence. Allele M dominates over F and I over i. The genotype of diploid cells carried by the sex chromosomes is ♂ IiMF and ♀ iiFF.

Besides these genetic factors of sex chromosomes, all plants of dioecious and monoecious hemp have a complex set of sex determining genes on autosomes. These genes come into force when genes controlling sex on the sex chromosomes become inactive. Autosomal factors control the sex type of monoecious hemp. Inbreeding of monoecious hemp leads to 100% monoecious offspring. Crosses between dioecious and monoecious hemp give mainly dioecious (female) hemp with a small percentage monoecious hemp.

In wild dioecious hemp monoecious plants occurs in a frequency ranging from 0.003 to 0.01 %. Since monoeciousness is recessive and heritable a third allele besides F and M should exist. The frequency of this allele ranges from 0.5 to 1 %. It is possible that the sex chromosome becomes inactive when both chromosomes carry this allele. Inactivity of the sex chromosomes is probably not caused by mutations.

The autosomes in monoecious hemp are determined by two pairs of alleles.

A the factor causing differentiation of male sex organs

G the factor causing differentiation of female sex organs

The strength (valency) can be written as AG Ag aG ag where A>a and G>g.

aaGG aaGg	♀♀♀♀	100% female flowers
AaGG	♀♀♀♂	predominance of female flowers
AAGG AaGg aagg	♀♀♂♂	50% male, 50% female flowers
AAGg	♀♂♂♂	predominance of male flowers
AAgg Aagg	♂♂♂♂	100% male flowers

It is not explained how loose or compact inflorescence type is determined in monoecious hemp.

Leaf arrangement

Normally leafs on the vegetative part of the stem are arranged in opposite pairs (decussate). In the generative part leafs are arranged spirally (alternate).

Occasionally trifoliate plants appear (three leafs on one node). Selection of trifoliate plants is possible. Populations with 82% trifoliate plants were obtained. In these populations plants occur with 4 leafs per node, even plants with five leafs where found. In the trifoliate populations the percentage of male plants was higher than in the original population, 55% vs 45%.

In the original populations also plants appear with one leaf per node. This form is not heritable.

Apomixis

At rare occasions two seedlings germinate from one seed. One of them is an apomict. Often one of the two seedlings is very small. These plants appear to be haploid.

BREEDING PROGRAMME AND TECHNIQUES

The programme has three major goals. The maintenance of existing varieties, the selection of new varieties and the production of elite seed.

History

Before breeding started hemp yielded about 3-4 tonnes of straw per hectare and 0.7-0.8 tonnes of seed. One ton of straw gave about 0.1-0.15 ton of high quality fibre. In the beginning (1930's) landraces where collected. The best landraces were selected. There were to ways for increasing fibre yield. Improving the straw yield by use of Southern Hemp or selecting for a longer vegetation period. The second method did not give the wanted result, seed production declined. After a few years the progress also stopped with the first method.
The selection for a higher fibre content started. The ratio length/diameter of the stem was used as a indirect measure for fibre content. Later the fibre content was determined by retting the stem. Fibre content increased from 15% to 30%. In breeding material even 40% was obtained.
By increasing the fibre content, the quality of the fibre declined. Therefor tests where developed to determine fibre quality, such as purity, durability and strength. These new tests determine fibre content in a mechanical way, so that retting was no longer needed. During autumn and winter 30,000 till 40,000 plants can be evaluated.
In the 30's a problem occurred with the mechanization of hemp harvest. Dioecious male plants started retting on the field while female plants where still green. Italian scientists and Grischko developed equal maturing hemp. In these varieties male plants have a habitus like female plants, but these varieties where not stable. A few years later they started the development of monoecious hemp. Nowadays most of the Russian hemp varieties are monoecious.
In former days conventional mass selection was used. The last decade family selection is used.

Selection of new varieties

The Institute selects hemp for fibre and seed production. One variety may be used for both purposes. As a seed hemp it must be early maturing and as a fibre hemp the bast fibre content must be high, with a good fibre quality. About 30% is the maximum fibre content, higher fibre content decreases quality and plants become sensitive to lodging.
The main breeding objective last decade has been decreasing THC content. The maximum content according to Sovjet law is 0.2%. Most varieties have a content of about 0.1%. The institute has recently created varieties without THC. Variety Nr 42 yields 10 tonnes of straw or 1 ton of seed, has a fibre content from 25 to 28% and no THC. For the selection of families and populations in an early stage thin layer chromatography is used. In a later stage gas liquid chromatography is used. Individual plants are scored with the trichome method.
As basic breeding material landraces from varying origin are used. These landraces have a high fibre quality. Southern early maturing hemp is used for its high straw yield and its resistance against *Psylliodes attenuata*. New dioecious material is crossed with a monoecious variety. This hybrid contains only few monoecious plants so the hybrid population is backcrossed with a monoecious variety. This population contains enough monoecious plants for further selection. This procedure is standard for the production of basic selection material. Selection takes place on a family basis. It is not clear whether full sib- or half sib families are used as a basis. Families are evaluated and selected during 10-11 years on the field. During the evaluation of the families all male plants are removed. The selections are evaluated on different locations in the country. By doing this different varieties are created for different regions.
After the period of selection a selected family becomes a variety and the variety will be multiplied for cultivation. Super elite seed is sown on an area of 0.3 hectare, selection takes place against male and inferior plants. Next year elite seed is sown on an area of 0.6 hectare, again selection

takes place. Two further years of multiplication is board out to a Sovchos or Kolchos without selection. The seed then produced is used for cultivation.
Existing varieties are maintained under continuous selection. Without selection a variety will deteriorate and become dioecious in a few generations.

AGRONOMY

Fertilization and rotation

In most cases fertilization of hemp in the Soviet Union carried out with chemical fertilizers only. Depending on the soil and the expected yield, 60 to 120 kg of N and P_2O_5 and 80 to 140 kg of K_2O are applied. Fertilization affects fibre quality by its effect on plant density. The more N fertilizer is applied, the smaller the number of plants at harvest and the larger mean plant size will be. Large plants have a lower bast fibre content than small plants.
In the Glukhov region hemp may be grown after each of the crops in the rotation (cereals, potatoes, maize, clover). Hemp is considered to be self-compatible, it sometimes is grown for 5 to 10 years continuously on the same field, with no apparent effect on yield. Fertilizer requirements however are said to be higher when hemp is grown continuously. In a field experiment as Glukhov hemp has been grown continuously for 60 years. The experiment contains fertilization levels ranging from no fertilization (yield 880 kg of stem/ha) to 40 tonnes of manure/ha (yield 7000 to 8000 kg of stem /ha). Reported weights of straw and fibre include respectively 20% and 13% moisture.

Sowing

Hemp is usually sown in the second half of April. In most cases hemp seed is treated with TMTD. On good soils 450 seeds/m^2 are sown for fibre hemp, on poor soil 500 to 550 seeds/m^2 are used. Row width is 7 to 12 cm. In a good crop of fibre hemp 300 plants/m^2 will be present at harvest. When hemp is grown for seed production, plant density at harvest varies from 30 to 180 plants/m^2, depending on the variety.

Weed control

In fibre hemp weed control is not necessary. In seed hemp, which is sown at a lower plant density, herbicides are used. Against monocotyls: Nabu, Targa (quizalo-fop-ethyl), Zellek (manufactured by Dow), Fusilade (fluazifop, 1.5 to 2.5 l./ha) and Iloxan (diclofop, 2 to 3 l./ha).
Against dicotyls: Ballan (benefin), Dual (etolachlor), Lenacil (venzar), Pyramin (pyrazon). A mixture of Dual (1,5 l/ha) and Lenacil (1.2 l/ha) is often used.

Pests and diseases

Two insect species (*Lepidoptera*) may cause damage to hemp: *Grapholita delineata* and *Ostrinia nubilalis*. Against both insects, *Bacillus thuringiensis* and *Trigogamma spp.* are used. Against *Psylliodes attenuata*, the hop flea beetle, a seed treatment is available, the composition of which is secret.

Harvesting and processing

About 70% of the hemp area of the Soviet Union is harvested for fibre only. Harvest takes place at "technical maturity", that is, when the male plants are shedding pollen. At Glukhov this stage generally is reached by the end of July or early in August. Seed ripeness occurs one month later. By the end of July a hemp crop will yield 7 to 8 tonnes of stem (20% humidity)/ha and 1.7 to 2 tonnes of bast fibre (13% humidity)/ha.
Prior to harvest, the crop will be defoliated, either by mechanical means or by spraying Magnesium chlorate. Most of the hemp is dew retted, depending on the whether, dew retting may take 10 days to one month. Other common techniques are warm water retting and chemical retting. In some factories hot steam is used to separate the bast fibre from the rest of the stem. The best fibre quality is obtained from warm water retting. High quality hemp stems are typically 1.50 to 2.00 m long, their diameter (at half height) will be 5 to 7 mm.

HARVEST TECHNOLOGY

The department of mechanization and harvest technology develops prototypes of new machines for hemp. The machines shown to us are listed here:

* Harvester. This machine mows the hemp and ties it into bundles without damaging (breaking or crushing) the stems. Careful handling of the stems is important when the fibre is used for textile. For hemp which is used for pulp this is less important. The machine leaves the bundles in the field to dry. This machine can handle hemp of a length of up to 3.5 m.
* Mechanical defoliator. Research into mechanical defoliation has started in order to find an alternative to chemical defoliation.
* A machine which turns hemp stems in the course of dew retting.
* A machine which picks up hemp stems after dew retting and makes bundles.
* A big baler which picks up hemp from the field while driving diagonally across the stems.
* A machine which is used to unroll big bales in the processing factory.

We were told that the lack of harvesting machines is the main factor limiting the area of hemp grown in the Soviet Union. In the republic of Uzbekistan 20.000 ha of kenaf is grown. Mechanization is similar to that used for hemp.

PULP AND PAPER TECHNOLOGY

Among other topics, the Ukrainian Pulp and Paper Research Institute at Kiev investigates pulping, paper making, composite materials and paper recycling. A paper in English, listing in full the activities of the institute can be obtained from the authors of this report. The institute also investigates the use of annual crops (flax, hemp, reed, rice straw) as a raw material for paper making.
Currently two pulp plants are operating in the Ukraine, both use aspen wood as raw material, they produce paper and board. The feasibility of a third pulp plant is being studied. One of the product lines of this new plant might be based on hemp bast fibre. Hemp bast pulp might be used for three paper grades:

* Cigarette paper. At present cigarette paper is imported. The required technology is available in the Ukraine, the pulp would consist of 50% hemp bast fibre and 50% wood.

* Document paper (high strength, bank notes). This paper usually is produced using the polluting Kraft method. The quality of document paper does not depend so much on fibre lengths but on the pulping and bleaching techniques used. Dr. Krotov proposes a new non-polluting method for making document paper from bast fibre. When used on the woody core this material will yield a relatively good pulp. The method is described in a paper (in English) which can be obtained from the authors of this report. This new method is not yet used, as the machines which are required cannot be built in the Ukraine.

* Reinforced paper for the sausage industry. This type of paper is currently bought from the Dexter company. The technology required for making sausage paper is being developed at the Leningrad (St. Petersburg) pulp and paper institute. For this paper grade the fibres should be as long and strong as possible.

Dr. Krotov thinks that the conservation of wet hemp stems ("ensiling", as is considered in the Dutch hemp programme) prior to processing in the pulp factory is a viable option, as appropriate conservation products are available. These chemicals will conserve the hemp stems and initiate the pulping process. The institute would be interested to cooperate with Dutch researchers on this topic. In order to be best suited for paper production, hemp stems should contain as much bast and as little wood as possible. The woody core of the hemp stem is relatively hard to delignify (relative to aspen). A lower lignin content in the wood would therefore be desirable. Experiments carried out in cooperation with the research institute at Glukhov have shown that the crop development stage at harvest has little effect on the delignification process of the woody core.

CLOSING REMARKS

Literature, seed material and results will possibly be exchanged. For example CPRO-DLO has evaluated a collection of hemp accessions, including some Russian varieties. It would be interesting to compare results obtained in the Sovjet Union with those obtained under Dutch conditions.
This report will be handed to colleagues involved in the Dutch National Hemp Programme which will probably lead to contacts on other fields of research besides breeding and agronomy.
It would be a pleasure for us if a countervisit to Holland could be arranged in the future.

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