International Hemp Association

Dedicated to the advancement of *Cannabis*, through the dissemination of information

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Hemp seed oil: A source of valuable essential fatty acids

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Interest in *Cannabis* has largely focused on its content of psychoactive substances (cannabinoids) or its potential industrial use as a source of cellulose fibre. While the whole seed has long been used as a source of food, its potential health contribution has never gained much attention. Hemp seed shares with no other plant resource, both a high content of easily digestible complete protein and a rich endowment of oil providing a favorable ratio of the linoleic (C18:2w6) and linolenic (C18:3w3) essential fatty acids required for proper human nutrition, in addition to a significant contribution of *gamma*-linolenic (C18:3w6) acid of potential therapeutic efficacy. With a recently acquired knowledge concerning the importance of these fatty acids in the human diet, it is time to both intensify research on their variable occurence among varieties of hemp seed, and investigate methods of oil extraction and storage suitable for their preservation.

Introduction

Cannabis is probably one of the first plants to have been used (and later cultivated) by people (Schultes 1973). Throughout history and in separate parts of the world, hemp has often been an important plant revered for its psychoactivity and useful for medicine, as a source of fibre, and for the food provided by its seed. The seed oil is particularly nutritious and its properties and potentials are herein explored.

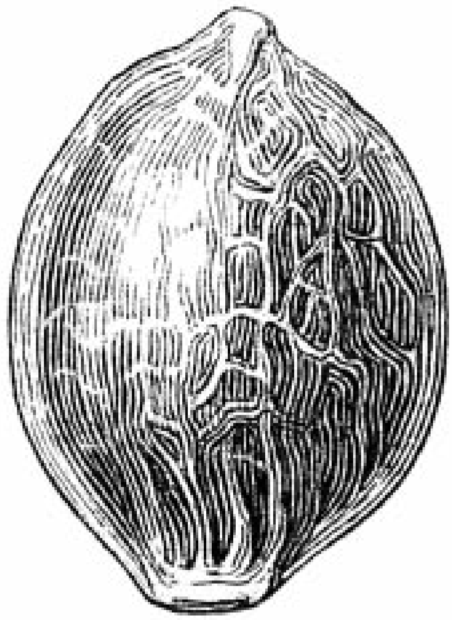

Figure 1. *Cannabis* seed, magnified (Courtesy of VIR.)

The fruit of hemp is not a true seed, but an "achene", a tiny nut covered by a hard shell (Small 1979, Paris and Nahas 1984). These are consumed whole, used in food and folk medicinal preparations (Jones 1995) or employed as a feed for birds and fishes. Whole hemp seed contains approximately 20-25% protein, 20-30% carbohydrates and 10-15% insoluble fiber (Theimer and Mölleken 1995, Theimer 1996), as well as a rich array of minerals, particularly phosphorous, potassium, magnesium, sulfur and calcium, along with modest amounts of iron and zinc (Jones 1995, Wirtschafter 1995), the latter of which is an important enzyme co-factor for human fatty acid metabolism (Erasmus 1993). It is also a fair source of carotene, a "Vitamin A" precursor, and is a potentially important contributor of dietary fiber. Most hemp seed also contains approximately 25-35% oil, although one variety grown in Russia called "olifera" reportedly contains 40% (Small 1979, *Continued on pg. 4*

DEAR MEMBERSHIP

The last issue of the Journal of the International Hemp Association proved to be our most popular yet, and we are seeing more small distributors carry it. Suggestions for additional venues would be appreciated. This issue was produced by Dr. Hayo van der Werf in Colmar, France. Peer review and editing was contributed by our members *via* telefax, the Internet and conventional post.

In mid-May, David Watson and Rob Clarke traveled to the Vavilov Research Institute in St. Petersburg to begin the VIR/IHA *Cannabis* Germplasm Preservation Project for 1996. The project has once again been supported solely by generous donations from IHA members Joyce Donoghue (US$10,000), Ohio Hempery (US$500), J. Craig Melville US$130), Dr. Andrew Katelaris (US$100) and Hemptech (DF100). The budget for the 1996 reproduction of about 90 accessions is US$17,500 and US$5,000 is still owed. The Vavilov now has refrigeration equipment and electrical generators for storing freshly reproduced seeds. Long-term refrigerated storage will allow reproductions every 5 to 10 years or more, rather than every 3 to 5 years, as with ambient temperature storage. This will enable us to complete the first round of reproductions in 1996 or 1997, and begin to characterize the accessions with the aim of building a core collection for use by hemp breeders. A *Cannabis* core-collection would contain only accessions with genes for unique agronomic traits, and duplicate accessions would no longer need to be maintained. Once a smaller core collection has been established, the work and expense of maintaining it will be much reduced, and it will be much easier for breeders to use. The VIR also supplied the IHA with 20 seeds from each of the approximately 400 accessions of its entire *Cannabis* collection for analysis of fatty acid content, to be performed by Roland Theimer and Helga Mölleken at Bergische Universität in Germany. Results of this survey will appear in a later issue of this journal.

The IHA "*Cannabis* Educational Package" offer appearing on the back cover of our last issue has been well-received by our members, and the first 25 have been distributed. Many of our members are involved in the hemp business and have made generous donations of their products and explanatory information. As a result, the contents of the *Cannabis* Educational Package has considerably increased from our original modest goal, and we hope that the assortment of hemp items and information will continue to grow. In the future, we would like to include additional supplementary transparencies and samples earmarked for the use of specific *Cannabis* specialty interest groups.

The bad news is that the Colorado bill was again (rather narrowly) defeated, primarily due to misguided intervention from the drug-enforcement lobby. Our condolences to those who have worked so hard on this project. Maybe later..... The good news is that the first American industrial hemp initiatives passed in Hawaii on April 12 and in Vermont on May 16. Both of these bills were less ambitious than the Colorado bill and that may have helped their passage.

With the German legalization of industrial *Cannabis* for this growing season, their situation is developing rapidly. Farmers with end-user contracts have planted and will be eligible to receive a subsidy of approximately DM1500/hectare. These recent developments will inevitably result in cheaper and logistically easier raw material sourcing for the German hemp movement.

The IHA has continued its policy of making small amounts (5 kg) of seed available to interested parties and presently has 12 varieties available. Some of these seed varieties are EC-approved for subsidy in European member countries. Those in the Southern Hemisphere may want to order soon for the September planting season. However, they should be aware that these varieties were developed for latitudes greater than 40 degrees and will flower prematurely in tropical environments.

It is not too early for a reminder that several hemp events are being held for this Autumn. Preliminary announcements have even been made for conferences scheduled in the Spring of '97, for details see page 45 of this issue.

Overall, this year promises to be one of steady progress. Members are invited to contact us if we can be of any assistance (and *vice-versa!*).

Irene Bijl	Robert Clarke	David Pate	David Watson	Hayo van der Werf
Treasurer	Projects Manager	Secretary	Chairman	Editor-in-Chief

COLOFON

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The International Hemp Association is a non-profit organization established in 1992 to promote the beneficial uses of hemp products worldwide. The organization encourages and facilitates the accumulation and exchange of information on *Cannabis*, sponsors projects in several countries and publishes this journal for its members. The IHA is supported by memberships and by donations from foundations, corporations and individuals.

Although many IHA members may feel that in light of the great economic potential of *Cannabis*, the current legal restrictions hampering *Cannabis* research and hemp cultivation should be reconsidered, the IHA does not endorse a political stance on *Cannabis* legislation, nor will it serve as a forum for the *Cannabis* legalization debate.

LETTERS

Breeding genealogies

To: Etienne de Meijer and the IHA

Let me compliment you on your thorough discussion of breeding genealogies in the December issue of the Journal of the International Hemp Association. You drew your discussion of Lyster Dewey's breeding from the 1927 piece, which means you did not mention the last cultivar which was his crowning accomplishment, ‘Chinamington’. Writing retrospectively after his retirement in 1935 (his program was terminated in '33), Dewey wrote of Chinamington: "The hemp breeding work, carried on by the Bureau for more than 20 years, was discontinued in 1933, but practical results are still evident in commercial fields. A hemp grower in Kentucky reported a yield of 1,750 pounds per acre of clean, dew-retted fiber from 100 acres of the pedigreed variety ‘Chinamington’ grown in 1934. This is more than twice the average yield obtained from ordinary unselected hemp seed. "

I was told by Dr. Bocsa of the GATE Research Institute at Kompolt in Hungary, that Dewey sent Chinamington to Fleischmann (the founder and director of the GATE Institute from 1918 to 1951) and that it was used as one side of the first hemp hybrid, the other side was Kompolti. Dr. Bocsa said that Chinamington was later than Kompolti and photoperiod manipulation was required to make the cross, so it was not amenable to large scale production, but the hybrid grew quite tall. Of course, ‘Chinamington’, as the entire Kentucky Hemp lineage, is lost.

Dr. Bocsa also informed me that the monoecious character, used by von Sengbusch in Germany in developing Fibrimon, was isolated by Greisko in Russia. He also brought to my attention that McPhee in the US had performed basic experiments on sexual variants earlier, in the twenties. [McPhee, H. 1925. The genetics of sex in hemp. J. Agric. Res. 31: 935-943.]

One last point: In his article (JIHA 2: 79-82), V. P. Sitnik says, "In the 1990's, to solve the problem of drug use, the Institute...obtained the highly productive and non-drug varieties..." This implies that previous fiber varieties had been used for drug purposes. The misinformation that hemp varieties have ever, anywhere, been divertible for drug use is something we have to deal with constantly. While in Russia last year, I was told by Russian hemp producers that they were told (by their superiors) that the crop's THC level increased with each reproduction and that was why they had to return regularly for new breeders’ seed. This is certainly untrue. Hemp does not become smokeable, no matter what you do to it. We must be careful not to give credence to the rampant worldwide belief that hemp is divertible, or ever was.

Sincerely, David P. West, Ph.D.

Membership

The IHA has three types of membership: Student (US $25/NLG 40 per year), Individual (US $50/NLG 80 per year) and Sustaining/Business (US $100/NLG 160 or more per year). In order to be listed by your business name you must join at the Sustaining/Business level. Members may order additional or previous issues for US $10 (postpaid), non-members pay US $ 15 (postpaid). Members joining after June may join for the next year and purchase the issues of the current year. Payments may be made by International Postal Money Order, American Express/Thomas Cook Money Order, AmEx credit card or personal check for US $.

Authors who contribute an accepted article to the journal will receive a year’s membership, including a subscription to this journal. Sustaining members can direct their contribution toward any specific project they prefer. A financial audit of income and expenditures is available to sustaining members.

Submission of manuscripts

The IHA Journal publishes original research, literature reviews and news items on hemp. Preferably, contributions should not exceed 10 double-spaced typed pages (ca. 4000 words). Longer contributions may be accepted if they can be serialized in two consecutive issues. Manuscripts can be submitted in triplicate to: IHA Journal, Editorial Office, Postbus 75007, 1070 AA Amsterdam, The Netherlands. Once a paper is accepted, the preferred medium of submission is on disk (Macintosh or MS-DOS format), preferably MS Word 5.0 or later, with accompanying manuscript. A guide for authors can be obtained from the IHA.

Production: INRA Agronomie, Colmar, France and bbp² prepress, Amsterdam, The Netherlands

Printed on 100% hemp paper.

Continued from pg. 1 Mathieu 1980) and a Chinese variety was claimed to slightly exceed this figure (Jones 1995).

This highly polyunsaturated oil has uses similar to that of linseed oil (e.g., fuel for lighting, printer's ink, wood preservative), but also has been employed as a raw material for soaps and detergents (Olschewski 1995) and as an emollient in body-care products (Rausch 1995). However, it is the nutritional qualities of the oil that are particularly important. The crushed seed by-product is suitable for animal feed as well as a human staple (Grinspoon and Bakalar 1993, Small 1979, Paris and Nahas 1984), due to its spectrum of amino acids, including all 8 of those essential to the human diet (Jones 1995, Wirtshafter 1995), as well as carbohydrates and a small amount of residual oil. Its protein is primarily edestin (St. Angelo *et al*. 1968), a highly assimilable globular protein of a type similar to the albumin found in egg whites and blood. However, heat-treating whole hemp seed denatures this protein (Stockwell *et al*. 1964) and renders it insoluble, possibly affecting digestibility.

An ideal seed hemp variety would produce a high yield of seed (normally 0.5-1.0 t/ha) containing a high percentage of good quality oil. Highly branched varieties are usually preferred. For seed production, male plants are sometimes removed after pollination has occurred, in order to leave more space for female plants. Mathieu *et al*. (1980) have noted that seed yield can be doubled using monoecious varieties, although this sexual type suffers some inbreeding depression. Cultivation of a monoecious strain in Switzerland yielded up to approximately 1.5 metric tons of seed per hectare in 1995 (unpublished data), but lower yields are generally reported (Mathieu 1980, Höppner and Menge-Hartmann 1994). Highest seed yields are obtainable with unisex female varieties, such as Uniko-B (Bócsa 1995). The number of flowers per plant and, therefore, the quantity of seed produced, can be increased by "topping" the plants when they are 30-50 cm high. Maximum seed yield requires that hemp be sown at a much lower density than for fibre (Reichert 1994). However, weeds can prosper if planting density is too sparse (*e.g.*, 25/m^2).

Extraction methods

Extraction of oil from hemp seed is not being carried out on a large scale at the present time. That being processed, is sometimes relatively unhomogenous, mature seeds mixed with green ones. This is due to the difficulty of finding the optimal time for harvesting, since not all seeds reach maturity simultaneously, especially in hemp undeveloped for seed production. The presence of unripe seeds not only increases seed crop moisture content, it also lowers oil yield and modifies its taste.

After harvest, hemp seed undergoes a drying process that reduces its moisture content to 10% or less, so as to prevent sprouting during storage. Batches of this material are then fed into a hydraulic screw press and a pressure of 500 bars is progressively applied, resulting in only a minor elevation in temperature. Best quality oil is obtained from the first fractions recovered. Approximately 35% of the available oil remains in the seed cake (Jones 1995). The pressing process is sometimes repeated with this crushed residue to obtain a small additional amount of oil, although quality is decreased.

This "cold pressing" does not allow an extraction yield equal to that of techniques employing solvents or high temperatures, but it has the advantage of minimizing degradative changes in the oil. A small amount of oil is also unrecovered during the subsequent filtration process. Further refining procedures should be avoided in order to preserve the native qualities of this product. Bottling must occur quickly and filling under nitrogen into opaque bottles, then refrigerating, offers significant protection against oil degradation due to oxidation and the action of light, although freezing is necessary for long-term storage. Addition of anti-oxidants extends shelf life of the product at room temperature (McEvoy *et al*. 1996).

Oil composition and properties

Non-refined hemp seed oil extracted by cold-pressing methods varies from off-yellow to dark green and has a pleasant nutty taste, sometimes accompanied by a touch of bitterness. The seed (and therefore the extracted oil) normally does not contain significant amounts of psychoactive substances (Paris and Nahas 1984, Vieira *et al*. 1967). Trace amounts of THC, sometimes found upon analysis, are probably due to contamination of the seed by adherent resin or other plant residues (Matsunaga *et al*. 1990, Mathé and Bócsa 1995), although reports to the contrary exist (*e.g.*, Patwardhan *et al*. 1978).

Analytical data reported for the fatty acid composition of hemp seed oil (Weil 1993, Kralovansky and Marthé-Schill 1994, Höppner and Menge-Hartmann 1994, Theimer and Mölleken 1995, Wirtshafter 1995), together with an analysis performed on an oil produced in Switzerland from a monoecious variety (unpublished data), reveals that it is unusually high in polyunsaturated fatty acids (70-80%), while its content in saturated fatty acids (below 10%) compares favorably with the least saturated commonly consumed vegetable oils (Table 1). This high degree of unsaturation explains its extreme sensitivity to oxidative rancidity, as the chemical "double-bonds" that provide such unsaturation are vulnerable to attack by atmospheric oxygen. This degradation is accelerated by heat or light. For this reason, the oil is unsatisfactory for frying or baking, although moderate heat for short periods is probably tolerable. It is best consumed as a table oil, on salads or as a butter/margarine substitute for dipping bread, similar in use to olive oil. Proper steam sterilization of the seed probably does not cause significant damage to the oil, but does destroy the integrity of the seed, allowing penetration by air and molds. If this procedure is required, it should be done at a legally bonded facility immediately before release of the seed for further processing. By the same reasoning, one should avoid eating whole hemp seed that has been

Table 1. Profile of hemp seed compared to common edible oils (% total fatty acids). Adapted from Erasmus 1993.

Less healthy/Chemically stable <----> More nutritious/Chemically unstable

	"Saturated"		"Monounsaturated"	"Polyunsaturated"	
	Palmitic (C16:0)	Stearic (C18:0)	Oleic (C18:1w9)	Linoleic (C18:2w6)	Linolenic (C18:3w3)
Hemp	6-9	2-3	10-16	50-70	15-25
Soy	9	6	26	50	7
Canola	0	7	54	30	7
Wheatgerm	0	18	25	50	5
Safflower	0	12	13	75	0
Sunflower	0	12	23	65	0
Corn	0	17	24	59	0
Cottonseed	0	25	21	50	0
Sesame	0	13	42	45	0
Peanut	0	18	47	29	0
Avocado	0	20	70	10	0
Olive	0	16	76	8	0
Palm	85	0	13	2	0
Coconut	91	0	6	3	0

subjected to any cooking process, unless reasonably fresh.

The two polyunsaturated essential fatty acids, linoleic acid (C18:2w6) or "LA" and linolenic acid (C18:3w3) or "LNA", usually account for approximately 50-70% and 15-25% respectively, of the total seed fatty acid content (Theimer and Mölleken 1995, Rumyantseva and Lemeshev 1994). Such a 3:1 balance has been claimed optimal for human nutrition (Erasmus 1993) and is apparently unique among the common plant oils (Table 1), although black currant seed oil approaches this figure (Table 2). *Cannabis* seed from tropical environments seems to lack significant quantities of LNA (ElSohly 1996, Theimer and Mölleken 1995). Temperate variety oils are less saturated, perhaps due to a natural selection in northern latitudes for oils with a higher energy storage capacity or which remain liquid at a lower temperature. It will be interesting to see if this trend continues for Nordic hemp varieties. The range of results found in some analyses may be attributable to differences in crop ripeness, since formation of polyunsaturated fatty acids is incomplete in immature *Cannabis* seed (ElSohly 1996). This suggests that a maximum ripening of the seed and the culling of immature seed are important considerations for the production of a quality oil. Likewise, proper seed sampling criteria are also crucial for representative analyses.

Table 2. Oil profiles of major GLA sources (% total fatty acids). Adapted from various sources.

	Palmitic (C16:0)	Stearic (C18:0)	Oleic (C18:1w9)	Linoleic (C18:2w6)	Linolenic (C18:3w3)	*gamma*-Linolenic (C18:3w6)
Hemp	6-9	2-3	10-16	50-70	15-25	1-6
Evening Primrose	4-12	1-7.5	4-12	65-72	0	3-15
Black Currant	6-7	1-2	9-11	45-60	12-15	15-19
Borage	~11	~4	~16.5	~37	<1	~23
Fungus (*Mucor*)	9-12	1-2	20-40	18-20	0	20-40

GLA sources and importance

Gamma-linolenic acid (C18:3w6) or "GLA" is found in minute quantities in most fats of animal origin (Horrobin 1990a, 1990b). Oats and barley also contain small amounts. Human milk contains some GLA (Carter 1988), but any significance is probably overshadowed (Erasmus 1993) by the greater presence of its metabolic derivative dihomo-*gamma*-linolenic acid or "DGLA" (C20:3w6).

GLA is available exclusively in health food shops or pharmacies, mostly as soft gelatine capsules, and is not found in oils usually consumed by most people. Good sources of GLA include the blue-green alga *Spirulina* (~1% of dry weight) and (Table 2) evening primrose oil, black currant seed oil, borage oil and some fungal oils. Black currant seed oil also reportedly contains up to 9% stearidonic acid (Erasmus 1993) or "SDA" (C18:4w3), although 2-4% is more usual (Clough 1996). Hemp seed oil from sterilised seed analyzed in the US contained 1.7% GLA (Weil 1993, Wirtshafter 1995), but higher levels (3-6%) have been measured by German investigators (Theimer and Mölleken 1995, Theimer 1996), although it is apparently rare in most tropical varieties of *Cannabis*

(ElSohly 1996). However, absolute amounts of GLA are not the only criteria for ranking the desirability of an oil. The particular arrangement of these fatty acids on glycerol (as the natural triglyceride), as well as differences in possible toxicity among the various oils, may be important (Horrobin 1994).

The potential physiological effects of GLA have been extensively investigated only recently. In the body, GLA is normally derived from LA and serves as an intermediary for the formation of longer-chain fatty acids and eicosanoids. Eicosanoids are short-lived hormone-like substances which fulfill numerous vital roles, ranging from control of inflammation processes and vascular tone to initiation of contractions during delivery. The metabolic conversion of LA to GLA is slow in mammals. Further, it has been suggested that due to stress, ageing or pathology (*e.g.*, hypertension, diabetes, *etc.*), formation of a sufficient amount or balance of eicosanoids may be impaired. This problem may be relieved by direct GLA supplementation (Horrobin 1990a, 1990b), although caution is warranted since overconsumption could be harmful (Phinney 1994). Its alleviating action on psoriasis, atopic eczema, and mastalgia are already well documented and GLA preparations are now frequently prescribed for the treatment of the latter two disorders. GLA has also been under investigation for its beneficial effects in cardiovascular, psychiatric and immunological disorders (Horrobin 1990a, 1990b, 1992).

If a favorable response to GLA supplementation does not occur, additional application of stearidonic acid (SDA) or use of black currant seed oil may be indicated, since the same enzyme (*delta*-6-desaturase) that converts LA to GLA is also responsible for converting LNA to SDA (Erasmus 1993). However, relatively few people suffer from a defect in this enzyme compared to the nearly universal lack of adequate LNA levels in the diet. A chronic LNA deficit is best acutely treated with flax seed (fresh linseed) oil, although it is unsuitable for prolonged consumption due to an imbalance in its LA (14%) to LNA (58%) content, a ratio approximately equal, but inverse, to that of hemp (Erasmus 1993).

Future prospects

Questions remain concerning the reasons which have so far prevented a more extensive consumption of hemp seed oil. It is possible that the historically significant uses of hemp (*i.e.*, fibre, medicine, whole seed, psychoactive drug) took priority over its potential utilisation as a source of oil. Secondly, many other plant sources of oil have been found more adequate in terms of yield and chemical stability of their oil, and the nutritional value of hemp seed oil was little known. Finally, the relatively recent "anti-drug" ban on hemp cultivation in many countries has prevented food scientists from investigating in more depth the wide range of potential uses for this seed.

Probably no other single source of oil offers a more favorable human dietary balance of the two essential fatty acids, LA and LNA. Even though hemp seed oil contains only relatively small amounts of GLA when compared to more established sources, this is probably sufficient for many of those who cannot efficiently convert LNA to GLA, and helps to prevent GLA overconsumption. In addition, because of its ease of cultivation, *Cannabis* may possess the potential to become an alternative raw material source for the production of isolated forms of GLA as a special dietary supplement.

Much work remains to be undertaken with the existing cultivars, as well as indigenous landraces and feral strains. A major research priority must be the full characterization of oils obtained from diverse hemp sources. There exists considerable potential for development of varieties providing larger yields of seed containing a higher oil content with a consistent fatty acid profile. Knowledge of environmental influences on seed quality and the development of improved agricultural methods will also contribute to the future success of this plant. In addition, important questions remain concerning this oil's physico-chemical properties, triglyceride structures, and physiological effect, as well as the methods of extraction and storage that are most economical and best suited to preserve its unique nutritional qualities.

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Report of Italian VIR/IHA *Cannabis* Germplasm Preservation Project - 1995

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Doubovskaja, A., A. Sonnino, U. De Corato, L. Rumyantseva and R. Clarke, 1996. Report of Italian VIR/IHA *Cannabis* Germplasm Preservation Project - 1995. *Journal of the International Hemp Association* 3(1): 7-9.

Fourteen accessions of *Cannabis* from the germplasm collection of the Vavilov Institute were sown at 7 locations in Italy in 1995 for germplasm maintenance and reproduction of seed reserves for distribution. Ten accessions yielded from 73 to 7,500 grams of seeds. The other 4 yielded no seeds. The plant pathogens *Phomopsis sp*. and *Macrophomina phaseolina* (Tassi) Goid. were reported on the hemp plants near Policoro.

Introduction

In 1993, the N. I. Vavilov Institute of Plant Industry (VIR), with the support of the International Hemp Association (IHA), began a program to preserve its *Cannabis* germplasm collection. In 1994 the project was expanded to the Ukraine and Italy. Accessions of Italian origin were selected for sowing in Italy in order to reproduce them in the most suitable conditions. Another goal of this project was to return to Italy its own hemp germplasm to conserve it not only in the VIR Gene Bank, but in Italian Gene Banks also. The VIR collection contains 8 Italian *Cannabis* accessions (Lemeshev *et al*. 1994), and most of them were of low viability. All Italian accessions in threatened condition were sown in Italy in 1995.

Accessions of a Chinese *Cannabis* group with long vegetative cycles were also chosen for sowing in Italy in 1995. It is difficult to reproduce them in northern Russia and the dissolution of the Soviet Union caused the separation of some southern VIR stations outside Russia.

Materials and methods

Fourteen accessions of hemp from the VIR Germplasm collection were sown at 6 locations in Italy (Table 1). This material was introduced to the collection from Italy, China, Turkey and Bulgaria, and represents varieties, lines and local populations (Table 2). For the purpose of germplasm maintenance three collection accessions with the origin from Italy and China were sown in two plots at the Trisaia Station of the Institute for New Technology, Energy and the Environment (ENEA) near Policoro. The distance between the plots was 850 meters and contained trees and high buildings. At one plot were planted a landrace accession from Italy (n.112) and 'Chain-Chgo' from China (n.182) with a difference in vegetative cycles of 22 days. The Italian early-ripening accession was sown 10 days before the Chinese late-ripening variety to avoid stray pollination. Shared plantings of temporally isolated varieties allows twice as many reproductions in the same amount of space. The Chinese accession Shan-Ma (n. 321) was planted at the second plot.

The first accession was sown on May 22. The seeds were sown in densely planted rows spaced 30 cm apart. The size of the plot varied from 5-8 m^2 depending on the number of seeds. The plots were irrigated after sowing and later on depending on plant conditions. The soil was predominantly composed of red clay.

The other 7 accessions were sown in order to look for

Table 1. Participants of the VIR/IHA *Cannabis* Germplasm Preservation Project in Italy - 1995.

Responsible Organizations	VIR Catalog No.
Experimental Institute of Industrial Crops of Bologna, Dr. Paolo Ranalli	278, 462
University of Bologna, University of Milan, Prof. Maria T. Amaducci	280, 282
Peasant Civilization Museum of Bologna, Mr. Ivano Trigari	195
General Agriculture and Grass Crops Inst., Sassari, Prof. Giuseppe Rivoira	184, 336
Institute for New Technology, Energy and the Environment:	
Casaccia Station of Rome, Dr. Andrea Sonnino	181, 279, 323, 340
Trisaia Station of Policoro, Dr. Alexandra Doubovskaja	112, 182, 321

the possible correlation between the contents of tetrahydrocannabinol (THC) and some clearly visible early developmental morphological markers. Five accessions with high-THC from the IHA, and variety 'Yellow stem' and line 'Foglia Pinnatofida' from VIR collection were investigated; but they did not show the yellow color of the stem and the pinnate type of leaf respectively. Six from the seven accessions were taken away at the phase of 6-8 pairs of leaves, before the first male flowers opened. The variety 'Yellow stem' was left at the plot to look for the stem color at a later phase of vegetation.

Four accessions were sown at the Casaccia Station of ENEA near Rome on two double plots: the Italian 'Bolognese' (n.279, vegetative cycle 140 days) together with the Chinese 'Sen-Ma' (n.323 166 days), and the Bulgarian 'J-3' (n.340 140 days) with the Chinese 'Sar-San' (n.181 190 days). The sowing method was similar of that at the Trisaia Station.

At the Peasant Civilization Museum of Bologna, the local Italian variety (n.195) was sown on April, 15 on a plot of 16 m^2. The distance to other hemp sowings was 5 km. The plants were covered with nets at the time of ripening to protect the seeds from birds. The plots were irrigated twice. The soil was clayish.

The accession 'Distretto di Fatza' (n.280) originally from Turkey was sown at the University of Bologna, and the Italian accession 'Carmagnola' (n.282) was sown near Milan. At the Industrial Crops Institute of Bologna two Italian accessions 'Napoletana' (n. 278) and 'Linea a foglia pinnatofida' (n. 462) were sown on April, 3 and May, 22 respectively. The distance between the plots was more than 70 km and the size of the plots were 48 and 60 m^2. The seeds were sown in the rows spaced 40 m^2 and 100 cm apart with the distance between the plants in the row 13 and 10 cm. The soil was clayish.

Two Chinese accessions 'Tin-Yan' (n.184) and 'Dun-Ma' (n.336) were sown at the General Agriculture and Grass Crops Institute of Sassari on May, 29 and on June, 9 respectively. The distance between the plots was more than 100 km. The seeds were sown in densely planted rows spaced 50 cm apart.

Agrometeorological conditions in Italy during 1995 were favorable for the growth of hemp. The spring, first half of summer and autumn were hot and dry. August was humid with frequent rainfall totaling 96 mm compared to the average of 12 mm. Because of this both early-ripening varieties and late-ripening varieties found good conditions for maturation.

The number of plants was calculated at the beginning of growth or at complete flowering (total plant number), and before the harvest (female plant number). The average height of plants for the plot was measured before the harvest. The vegetative cycle was calculated from the day of sowing to the day of complete maturation and/or harvesting.

Results

Ten reproductions yielded from 73 to 7,500 grams of seeds. The largest yields were obtained in the Industrial Crops Institute and in the Peasant Civilization Museum of Bologna from Italian hemp accessions (Table 2).

Four accessions (ns. 181, 280, 282, 340) yielded no seeds because of the poor germination or the absence of germination (Table 2). Accession n. 280 did not germinate in spring and was sown again with the remaining seeds. The plants were transferred into the greenhouse to obtain some seeds during the winter period.

The vegetative cycle varied from 119 to 176 days for the Italian accessions of hemp and from 115 to 144 days for the Chinese ones. The plant height varied from 90 to 350 cm for the Italian hemp accessions and from 95 to 195 cm for the Chinese ones.

The plants of the variety 'Yellow stem' developed different shades of the stem color from green to almost yellow. The seeds from two plants with the most yellow stem color were harvested for later experiments.

Two fungal diseases were identified on the plants at the ENEA Trisaia Station near Policoro. The "bad withering" disease became apparent as complete withering of the plant at the beginning of maturation. The seeds of infected plants were visibly normal and they ripened normally; 15-20 days earlier than the seeds of the healthy plants. Fourteen percent of the plants were infected in the plot of accession n. 321. There were black microsclerotia on the roots of infected plants (Figure 1). According to Ferri (1959) it was *Macrophomina phaseolina* (Tassi) Goid., which is usually transmitted by vegetative remains.

Another disease became apparent as numerous little black picnidia on the stem around the branch. The zone of infection was clearly distinct from the healthy tissue (Figure 2A) or it had no clear border (Figure 2B). The conidia of the fungi were unicellular with two nuclei,

Table 2. Results of Italian VIR/IHA *Cannabis* Germplasm Reproduction Project-1995.

VIR Catalog No.	Name/Origin	Total plants n	Female plants n	Plant height cm	Seed yield g	Veg. cycle days
112	Local, Italy	1277	519	90	634	90
195	Local, Italy	472	240	250	4,000	160
278	Napoletana, Italy	600	360	350	7,500	-
279	Bolognese, Italy	226	171	150	585	-
282	Carmagnola, Italy	4	0	- -	-	
462	Linea a foglia pinnatofida, Italy	922	377	180	5,400	-
280	Distretto di Fatza, Turkey	-	-	-	-	-
340	J-3, Bulgaria	-	-	-	-	-
181	Sar-San, China	-	-	-	-	-
182	Chain-Chgo, China	604	234	151	73	144
184	Tin-Yan, China	123	80	-	2,200	-
321	Shan-Ma, China	125	77	190	1,056	121
323	Sen-Ma, China	63	33	95	122	-
336	Dun-Ma, China	494	289	-	2,632	-

suggesting a classification as *Phomopsis sp*.. (Von Arx, 1981). This infection is usually transmitted by water (Goidanich, 1975). There are no data about the possibility of transmission of these two diseases by the seeds.

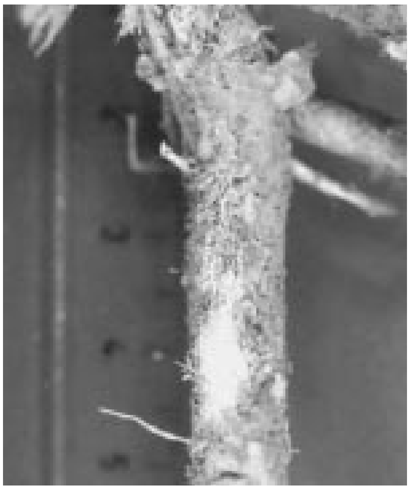

Figure 1. Microsclerotia of *Macrophomina phaseolina* (Tassi) Goid. on the root of the hemp plant at the ENEA Trisaia station in 1995 (Photo G. Mazzei).

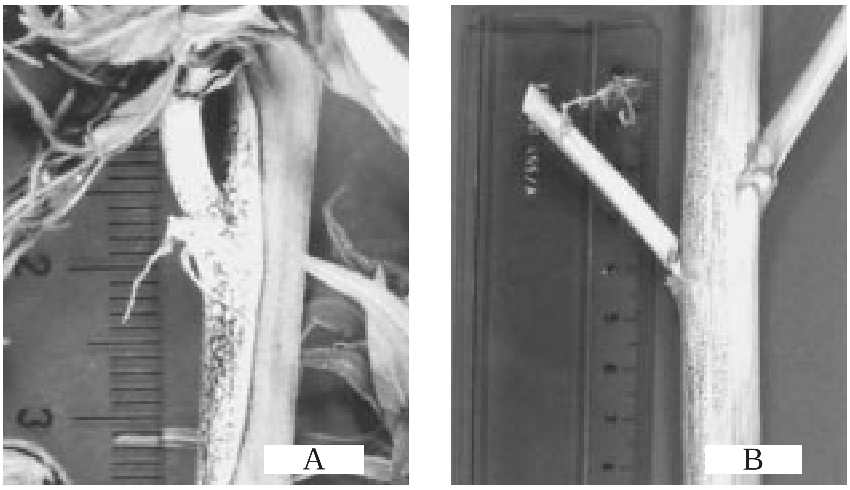

Figure 2. The picnidia of *Phomopsis* sp. on the stem of the hemp plant at the ENEA Trisaia station in 1995. A - the zone of infection is clearly located, B - the zone of infection is without border (Photo G. Mazzei).

Conclusions

In the first report of the VIR/IHA Cannabis Germplasm Preservation Program two key requirement were defined to consider an accession adequately reproduced: at least 1000 plants have to produce at least 200 g of seed (Lemeshev et al. 1994).

Due to poor germination only 7 from 10 sown accessions reproduced sufficient quantity of seed. Among these 7 accessions, only one had a sufficient population size.

All reproduced seeds of the Chinese accessions and a part of the seed of each Italian accession have been sent to the gene bank of the VIR. The remainder of the seed of each Italian reproduction will be preserved in Italy.

A sample of seeds of the Italian industrial hemp variety "Carmagnola" has been received by the National Flax and Hemp Industry of Vimercate (Milan). Part of the seeds will be preserved in Italy. The remaining seeds have been sent to the VIR.

Acknowledgment

This project was possible, thanks to support from the International Hemp Association and the participation of Prof. Maria Teresa Amaducci, Prof. Alessandro Bozzini, Dr. Giancarlo Messagi, Dr. Paolo Ranalli, Prof. Giuseppe Rivoira and Mr. Ivano Trigari.

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Maintenance of *Cannabis* germplasm in the Vavilov Research Institute Gene Bank - 1995

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Kutuzova, Sofia, L. Rumyantseva and R. C. Clarke., 1996. Maintenance of *Cannabis* germplasm in the Vavilov Research Institute Gene Bank - 1995. *Journal of the International Hemp Association* 3(1): 10-12.

Ninety-two samples of the *Cannabis* collection were planted on the isolated plots of Kuban, Ustimovka, Ekaterinino and Pavlovsk Experiment Stations of the VIR with the purpose of reproduction and maintenance of their viability. Reproductions were received from 74 accessions; 4 did not germinate, 5 were stolen, and 9 failed to mature seed.

Introduction

Hemp is a traditional and important industrial crop for Russian agriculture. However, in recent years the areas of its cultivation have sharply diminished. Only 8,000-10,000 hectares were cultivated in 1995. Since Russia became cut off from the major cotton-producing areas in the south, the demand of the national industry in the country's own natural fibers (including that of hemp) has grown considerably. Hence, there is again a tendency to develop and enhance cultivation and seed production technologies for commercial hemp cultivars as well as breeding new high-yielding hemp cultivars free from psychoactive substances.

In such a situation the significance of hemp genetic resources stored in the gene bank of VIR has greatly increased. However, these circumstances have made the process of germplasm viability maintenance much more difficult due to the separation of southern experiment stations where late-ripening thermophilous (heat requiring) hemp samples were formerly maintained, and also because of the increased risk of plant theft from isolated plots. Despite precautions each year a part of the planted samples fail to yield reproductions due to poor seed ripening and theft.

The target of this work was to maintain a set of hemp accessions from VIR's germplasm collection in order to revive their viability and confirm their identity for future use by plant breeders.

Materials and methods

In 1995, in order to maintain germination ability, 92 accessions were planted on isolated plots in different climate conditions at 4 experimental stations:

1) Pavlovsk (in the vicinity of St. Petersburg)
2) Kuban (in Krasnodar Region)
3) Ekaterinino (in Tambov Province)
4) Ustimovka (Ukraine)

The size of plots was dependent on the availability of seed and their germination rate. Methods applied were the same as in previous years: manual planting in rows with 20 cm intervals between the rows; hoeing and weeding of young plants; removal of atypical plants during budding and flowering phases; and manual harvesting (Lemeshev *et al.* 1994).

Results

On isolated plots of Pavlovsk Station 19 accessions of hemp belonging to the dioecious Northern and Middle Russian groups were planted. The minimum distance between plots was 2 km. The plots were protected by heavy forest cover and landscape relief providing additional isolation. Meteorological conditions in 1995 were even more unfavorable than in 1994. In May and June cold and rainy weather led to soaking of the soil, which caused delays in plowing and cultivation of isolated plots. Hence planting was also delayed. In June and August there was hot and dry weather with temperatures in excess of 30°C. All this produced negative effects on the development and productivity of the plants. Harvesting was started in mid-September. Of 19 planted samples, 15 yielded reproductions and 4 failed to yield mature seed (Table 1).

Twenty accessions were planted on isolated plots at Ekaterinino Station. Weather conditions in 1995 were not favorable: due to early spring drought many young plants grew sparsely and therefore produced poor seed yields. As a result, 17 accessions reproduced seeds, 1 did not germinate, 1 was cut and stolen and 1 produced very few plants (Table 2).

Twenty accessions belonging to the monoecious and dioecious Southern groups were planted on isolated plots at the Kuban Station. Planting was delayed due to a delay in settling financial issues. By the time of planting all other crops had already germinated. Soil moisture had already been exhausted, and therefore plants on many plots grew sparsely. Fifteen accessions were reproduced, 3 yielded insufficient number of plants and 2 were cut and stolen (Table 3).

Thirty-three hemp accessions were planted at the Ustimovka Station. Twenty of them were sown at the optimum time and produced good seed yield. Thirteen additional samples were sown a little later in dry soil. Because of that, 3 accessions did not germinate, and 5 did not yield mature seeds. Two accessions were stolen, so only 23 accessions were fully reproduced (Table 4).

Conclusion

Ninety-two hemp accessions were planted out with the intention of maintaining viability. Seventy accessions

Table 1. Results of 1995 VIR/IHA *Cannabis* Germplasm reproduction at Pavlovsk Experimental Station of VIR.

Catalog No.	Name/origin	Total plants	Seed yield (g)
317	U.S.S.R., Kirov Province	815	200
318	U.S.S.R., Komi Republic	450	150
80	U.S.S.R., Bashkirskaya	610	350
85	U.S.S.R., Tyumenskaya	700	600
99	U.S.S.R., Keshtovskaya	1100	420
100	U.S.S.R., Altaiskaya	250	130
148	U.S.S.R., Altaiskaya	300	180
151	U.S.S.R., Mariyskaya	420	250
156	U.S.S.R., Tatarskaya	180	120
355	U.S.S.R., Mariyskaya	120	160
357	U.S.S.R., Mariyskaya	160	240
415	U.S.S.R., Kazakhstan	230	110
416	U.S.S.R., Kazakhstan	205	130
423	U.S.S.R., Kazakhstan	180	100
424	U.S.S.R., Kazakhstan	160	200
220	Germany, monoecious	80	not ripened
227	Germany, monoecious	50	not ripened
263	Germany, monoecious	60	not ripened
251	Germany, monoecious	170	not ripened
Totals	19 accessions	6,240	3,340

were satisfactorily reproduced. Four accessions did not germinate, 6 were cut and stolen, 10 did not yield mature seeds, and 3 samples produced an insufficient number of plants.

Thanks to the implementation of the joint VIR/IHA project, in 1993-1995 a total of 252 hemp accessions were reproduced. All of the samples were either very old seed reproductions (before 1989) or had a small number of seeds. Successful reproductions were received from 134 threatened accessions. In 55 accessions very small number of seeds were produced, so it would be necessary to repeat regeneration. In addition, repeated regeneration is required for 65 accessions, which yielded insufficient seed quantities in 1991-1992 before the VIR/IHA project started.

On the basis of the accomplished works, it is obvious that in order to complete this project successfully it would be necessary to enlarge the number of isolated plots. This

Table 2. Results of 1995 VIR/IHA *Cannabis* Germplasm reproduction at Ekaterinino Experimental Station of VIR.

Catalog No.	Name/origin	Total plants	Seed yield (g)
508	U.S.S.R., Krasnodarskaya 56	150	394
139	Hungary, local	204	408
465	Turkey, local	92	92
444	Hungary, local	115	136
312	U.S.S.R., Chernovitskaya	35	84
147	U.S.S.R., Drogobychevskaya	120	206
400	France, Fibrimon	94	156
365	Hungary, B-7	65	106
363	Czechoslovakia, Shumperskaya	204	270
311	U.S.S.R., Yuzhnaya Cherkasskaya	86	160
399	France, Unya	15	42
296	U.S.S.R., Byelorusskaya	36	32
210	Romania, YCAR	267	682
122	U.S.S.R., Transcarpathian region	71	76
171	?, line 13/167	156	260
295	U.S.S.R., Yuzhnaya Chyiskaya	-	not germinated
168	U.S.S.R., Kavkazskaya	1	2
96	Portugal, local	10	38
398	France, Fatza	340	735
374	Romania, local	196	stolen
Total	20 accessions	2,257	3,831

Table 3. Results of 1995 VIR/IHA *Cannabis* Germplasm reproduction at Kuban Experimental Station of VIR.

Catalog No.	Name/origin	Total plants	Seed yield (g)
298	China, Keshal	3	15
185	China, Shan-van	2	2
297	China, Yhion	51	50
326	China, Lun-dzin	62	360
320	China, Bai-dzin-chun	9	23
284	China, local	10	10
180	China, Da-van-gru	70	260
181	China, Sar-san	5	20
436	Hungary, Fertody	70	405
395	Hungary, Kompolti	74	670
535	Hungary, local	153	stolen
437	Hungary, Szegedi 9	96	990
467	Romania, Fibrimulta	35	80
173	Hungary, Kompolti	98	stolen
18	Yugoslavia, local	10	200
377	Yugoslavia, Lescovashca	52	402
484	U.S.S.R., Alma-atinskaya	1	2
22	Yugoslavia	55	465
481	Hungary	19	125
538	France, Felina 34	60	360
Total	20 accessions	935	4,439

will require widening of the number of experiment stations participating in the project. In 1995 the project was expanded into Italy (see pg. 7). We hope to have cooperation with Italy again in 1996 and also initiate reproductions in Uzbekistan and Yugoslavia.

Reference

Lemeshev, N., L. Rumyantseva and R. C. Clarke 1994. Maintenance of the *Cannabis* germplasm in the Vavilov Research Institute Gene Bank 1993 *Journal of the International Hemp Association* 1(1): 1, 3-5.

Table 4. Results of 1995 VIR/IHA *Cannabis* Germplasm reproduction at Ustimovka Experimental Station.

Catalog No.	Name/origin	Total plants	Seed yield (g)
537	Yugoslavia, Carmagnola	168	360
378	Yugoslavia, Carmagnola	234	700
109	U.S.S.R., Proskurovskaya	640	1,035
471	U.S.S.R., Khorezmskaya	40	117
504	U.S.S.R., Yuzhnaya Odnovremenno Sozrevayush.24	274	470
138	Hungary, line	208	420
538	France	106	360
117	Hungary, Fleishmann	260	815
481	Hungary, Uniko B	204	500
449	Hungary, Szegedi	102	300
412	Hungary, local	296	55
172	Hungary, Fertodi	106	115
448	Hungary, Kompolti	276	1,270
447	Hungary, Fibrimon 24	54	110
407	Hungary, local	63	150
539	France, Fibrimon 24	76	stolen
463	Italy, CS	92	stolen
474	Poland, local	119	immature seeds
468	U.S.S.R., Kazakhskaya	106	160
469	U.S.S.R., Kazakhskaya	53	270
473	U.S.S.R., hybrid	-	not germinated
483	U.S.S.R., Tashkentskaya	95	265
511	U.S.S.R., Dneprovskaya 5	93	immature seeds
514	U.S.S.R., Irkutskaya	65	240
516	U.S.S.R., Armenia	-	not germinated
526	U.S.S.R., Armenia	58	immature seeds
529	U.S.S.R., Primorskaya	69	immature seeds
520	U.S.S.R., Sozrevayushchaya 28	75	immature seeds
554	U.S.S.R., Daghestan	-	not germinated
485	Yugoslavia, local	105	200
405	U.S.S.R., Arkhonskaya	122	475
228	Germany, monoecious	316	1,115
312	U.S.S.R., Chernovitskaya	96	500
Total	33 accessions	4,571	10,002

Selection for Non-Psychoactive Hemp Varieties *(Cannabis sativa L.)* in the CIS (former USSR)

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Virovets, V. G. 1996. Selection for non-psychoactive hemp varieties (*Cannabis sativa* L.) in the CIS (former USSR). *Journal of the International Hemp Association* 3(1): 13-15. Results of research on the creation of new non-psychoactive hemp varieties are presented. These hemp varieties are notable for their minimal cannabinoid content including tetrahydrocannabinol (THC), which excludes the possibility of the use of hemp as a drug. Some varieties were produced that contain no cannabinoids and represent valuable initial material for further selection.

Introduction

Hemp has been cultivated on a large scale as a bast crop because it allows relatively cheap fiber production. Traditional use of *Cannabis* for psychoactive purposes in the southeastern countries of the former USSR is locally limited and it is only used by some ethnic groups at their places of residence. As a rule, the industrial cultivation of hemp was excluded in these circumstances. Due to a growing demand for articles made of natural fibers and as a raw material for paper making prospects for hemp use were increasing, but were curtailed by an outbreak of drug use. In this connection, the Department of the Interior and the Department of Health and Agriculture of the former USSR in 1973 issued an ultimatum to the former All-Union Scientific and Research Institute of Bast Crops to either create non-psychoactive varieties or stop cultivating hemp.

Under these circumstances, selection was used as a method to solve the problem of creating non-psychoactive varieties. Because of the natural lack of varieties without cannabinoids, as well as a lack of a suitable selection method, we found ourselves in great difficulty. The theoretical premise for selection was a law on hereditary variability formulated by N. I. Vavilov. Successful selection to lower the levels of harmful substances had been successful in lupine, rape, tobacco, hops and other crops.

The creation of hemp varieties was preceded by working out a selection method and by additional study of the psychoactive cannabinoids. Three phenolic compounds prevail : cannabidiol (CBD), tetrahydrocannabinol (THC) and cannabinol (CBN), the first two existing predominantly as their carboxylic acid forms.

Cannabinoids accumulate in different amounts in all parts of the plant. Glandular hairs as well as cystolithic hairs are found on the upper leaves of the inflorescence. The heads of the glandular hairs serve as reservoir for the resinous fluid. The glandular hairs occur on the external surface of the bracts and up to 90% of their mass is cannabinoids (Clarke 1981, Hammond & Mahlberg 1973, Hammond & Mahlberg 1977).

Materials and methods

During the selection process, we used varieties which had been created earlier at the Institute of Bast Crops and other establishments, which represent mainly Middle-Russian and Southern hemp types. We used the middle-Russian hemp varieties Glukhovskaya 10, Starooskolskaya uluchshennays (SOU), Yermakovskaya local landrace and others. Southern hemp was represented mainly by the following foreign varieties and samples : Szegedi 9 and Kompolti (Hungary), Fibrimon 56 (France), Napoletana and CS (Italy) and Belobzhevskaya (Poland). The initial material was obtained mainly by the classical methods of selection and hybridization. The apical part of an inflorescence was taken from each plant to determine cannabinoid content by thin-layer chromatography (TLC). Controlled cross-pollination and field analyses of the plants for cannabinoids were made in separate plant nurseries,.

Results and discussions

At the beginning of the work, the maximum threshold for tetrahydrocannabinol (THC) content as the main cannabinoid component was 0.3 % and was then lowered to 0.2 %. Recently, this index has been lowered twice again to 0.1 %. The initial selection step was to study all of the known hemp varieties as well as samples from the world hemp collection. The results of our past researches into cannabinoid contents were rather broad (Zakharova 1973). There were no varieties that completely lacked cannabinoids. A rather high content of these substances was found in some varieties and hybrids was determined and they were excluded from cultivation (Table 1). The results obtained have shown that hemp cultivated in more northerly areas is naturally rich in cannabinoids, and that the only way of lowering their content is through selection.

We chose the method of family-group selection among highly productive varieties as a method of lowering cannabinoid content. Preliminary research was made with hybrids from the crossing of separate low yield hemp strains (collection of the All-Union Institute of Agriculture) with low cannabinoid content. However, the work with low productivity hybrids was discontinued because of the necessity to produce industrial varieties with high fiber and seed yields. As a result of this intensive selection work the first three highly productive hemp varieties, (USO-14, USO-16 and Dnepro-petrovskaya monoecious-6) containing less than 0.2 % THC (Table 2), were created and subsequently distributed

Table 1 - Cannabinoid Contents in Inflorescences of Hemp Varieties and Hemp Hybrids.
Strain Testing of the Institute of Bast Crops, 1976.

NN	Variety hybrid	Cannabinoid contents, %		
		Cannabidiol (C B D)	Tetrahydro-cannabinol (T H C)	Cannabinol (C B N)
1.	U S O - 1	4.273	0.775	0.147
2.	U S O - 4	4.290	0.630	0.223
3.	US - 6	4.493	1.961	0.258
4.	US - 8	5.333	0.736	0.158
5.	US - 9	4.808	1.780	0.234
6.	S O U	4.564	1.340	0.358
7.	Yermakovskaya mestnaya	5.133	0.720	0.344
8.	Glukhovskaya 10	4.968	0.529	0.144
9.	US - 12	4.790	2.326	1.070
10.	US - 22	4.351	1.206	0.434
11.	(CS Glukhovskaya-10 U S O - 1)	4.769	0.726	0.189
12.	US - 9 U S O - 1	4.913	1.258	0.299

(beginning in 1980) (Virovets *et al*. 1980). The monoecious hemp variety USO-16 was also characterized by high fiber and seed yield. Advanced hemp farms in the Cherkassy region harvested 1.7-1.8 t/ha of fiber and 0.7-0.8 t/ha of seeds. Expansion of the selection work was carried out simultaneously with the elaboration of a selection technique and a method for the determination of cannabinoid content.

Since hemp populations are characterized by panmixia, there was a tendency for spontaneous maintenance of heterozygosity of a given trait, in spite of repeated strict selection. However, on the whole the proportion of plants with a complete absence or minimal quantity of THC increased (Table 3).

Artificially excluding plants with high cannabinoid content from the population (before flowering) convinced us of the efficiency of controlled pollination. In 1980, only the population of individuals without THC were allowed to flower. The next year the number of cannabinoid-free plants in the population doubled from 39.9 % to 76.3 %.

As the demand for increased plant analysis throughput accelerated, the rather labor-intensive thin layer chromatography (TLC) technique was replaced by a simplified method that made it possible to determine cannabinoid content rapidly and easily. This provided an opportunity to divide plants on qualitative characters :

Table 2 - Productivity of Hemp Variety USO-14.
State Strain Testing in Glukhovski Strain Plots, 1976-1978.

Variety	Yield ($t\ ha^{-1}$)			Fibre Yield %		Long fibre quality		Vegetation period (days)
	Straw	Seeds	Fibre	Long	Total	Breaking effort, kgf	Count	
				Utilization for fibre and seeds				
USO-14	9.0	1.1	2.9	23.9	32.1	26.9	6.2	128
USO-1	9.3	1.2	2.6	20.1	28.2	26.2	5.8	127
				Utilization for fibre				
USO-14	11.1	-	3.3	28.8	30.3	26.3	6.1	106
USO-1	10.8	-	3.0	20.8	27.7	23.7	5.8	105

Table 3 - Differentiation of Elite Plants of Variety USO-29 Cannabinoid Content before Flowering, 1980.

	Plants with THC content (%)								
	Nought	Trace	1	2	3	4	5-7	8-9	> 9
Number of plants	1131	161	274	325	296	173	284	77	101
Proportion of plants (%)	39.9	5.7	9.7	11.5	10.5	6.1	10.0	2.9	3.7

varieties containing some THC and varieties without any THC (Sazhko *et al*. 1985). The rapidity of analysis of one plant (11 sec.) with simultaneous removal of undesirable individuals has made it possible to extend investigations and develop a method for effective selection of new initial material for breeding.

Simultaneous selection for both cannabinoids and productivity has made it possible for the new varieties to occupy great industrial areas in the Middle-Russian hemp sowing zone and in the Northern Caucasus. The variety USO-14 has been the best among the southern-maturing hemp varieties, with stem fiber content of 30 % or higher. USO-16 and Dnepropetrovskaya monoecious-6 are also examples of varieties with reduced cannabinoid content. According to data from the Central Laboratory of the State Commission on Agricultural Testing of the former USSR for 1978-79, the THC content of the variety USO-14 has been lowered to 0.08 % while in the initial variety USO-1 this index was equal to 0.44-0.49 %.

The accumulated experience of putting this selection method into practice, combined with a good choice of diverse initial breeding stocks, has made it possible to obtain a number of new varieties, among them the variety Zolotonoshskaya USO-11. In 1984, it was distributed in the Cherkassy and Poltava regions of the Ukraine to replace the variety USO-16. In 1987, in the Sumy region of the Ukraine, and in the Oryol, Penza and other regions of Russia, the new variety USO-31 has been distributed and is no less productive than the variety USO-14, which contains twice the cannabinoids. In the regions of the Northern Caucasus were distributed the new southern hemp varieties Zolotonoshskaya-13 (1986) and Zenitsa (1991). These are also characterized by high produc-tivity and lowered THC content (Goloborod'ko *et al*. 1993). In 1993, a decision was made to put the southern hemp Dneprovskaya monoecious-14 into production in the Ukraine.

The main achievement of the intensive selection work has been the creation of the two hemp varieties USO-42 and USO-45 with not only a minimal quantity of THC, or even its complete absence, but a considerably lowered content of the other cannabinoid components as well (Goloborod'ko *et al*. 1993). These new standard varieties also possess resistance to infections and pests.

Conclusion

We have studied the peculiarities of accumulation and localization of cannabinoids in plant organs, the inheritance of cannabinoid production and the modification of cannabinoid production depending on different factors. This has made it possible to elaborate a selection method and to obtain considerable lowering of cannabinoid quantity.

With further selection work, we foresee creation of new varieties with high yield indices, a stable minimum THC content (or complete absence of THC) and other cannabinoids, and resistance to pests and infections, with the aim of excluding hemp as a potential drug crop.

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Use of AAS pulping for flax and hemp shives

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Some plants such as hemp, flax and kenaf produce two types of fibres: long bast fibres and short woody core (shive) fibres. The bast fibres are used in the pulp and paper industry; however, the short core fibres do not produce good quality pulp using conventional pulping technology. Test results have shown that the alcohol-based ammonia-sulphite (AAS) pulping process has produced good quality unbleached pulp from flax and hemp shive; pulp which has a high yield, low Kappa number and good physical properties for papermaking.

Introduction

When flax and hemp stocks are processed, 70-80% of the initial raw materials are rejected as shive. Flax and hemp shive are not very suitable for utilization; however, sometimes it can be used for low-quality building materials (shive-containing fibreboards, gypsum, concrete); in agriculture as bedding for livestock and for soil mulching; and it can be processed into combustible briquettes.

Of the 56 mills processing flax and hemp in Ukraine, only 20 process a part of the shive. Of this number, 7 mills produce shive-containing fibreboards or building gypsum blocks and the rest make briquettes. A large part of shive is used as fuel for the boiler houses of the mills themselves but greater amounts are thrown out forming dumps which become a source of environmental problems and also create fire hazards near the factories.

The pulp and paper industry does not use flax and hemp shive, mainly due to the following factors:

•the difficulty of delignification which is determined by the composition of the raw materials i.e there are high lignin contents in fibre cell walls and, in particular, the lignin content of hemp shive approaches the lignin content in softwood and that of flax shive exceeds the lignin content in softwood;

•unbleached flax and hemp shive pulps produced using conventional pulping processes have lower yields and higher Kappa numbers as compared to hardwood pulps;

•pulps produced from flax and hemp shive have small length fibres which are 2 to 3 times shorter than hardwood pulp fibres;

•extremely low drainage rate of pulp produced from flax and hemp shive by conventional methods;

•low papermaking and mechanical pulp properties of pulp produced from flax and hemp shive by conventional methods;

•possible recovery problems due to higher ash content and silica compounds present in the ash.

All the above factors make the pulping of flax and hemp shive difficult if conventional or modified sulphite, kraft, soda or other known methods are used, but they are not of vital importance in the case of our pulping method based on water-organic solutions of ammonia (NH3) and sulfur dioxide (SO2) (Krotov & Lavrinenko 1984, Krotov & Lavrinenko 1985, Krotov 1994).

Alcohol-based Ammonia-sulphite (AAS) pulping

For AAS pulping, a wide range of organic solvents of different classes and their mixtures could be used including, but not limited to:

•monobasic alcohols (methanol, ethanol, etc.)
•polyols (diethylene glycol, glycerine, etc.)
•cellosolves (ethylene glycol monoethyl ether)

The major requirements of the organic solvents used is that they should mix with water at the pulping temperature and they should not degrade or undergo condensation reactions with lignin contained in the raw material. From economic and technical points of view, in the AAS pulping process preference should be given to ethanol or methanol.

A remarkable feature of AAS pulping is the possibility of the combined pulping of different raw materials, including those with considerably different morphological characteristics, structure and chemical composition. This feature would allow the development of the most efficient technology for pulping bast-fibre plant stalks such as hemp, kenaf and flax without their separation into bast (fibre) and woody (shive) fractions, as is the suggested current practice for kenaf pulping described in the technology of Ankal Proprietary Ltd. (Australia) (Kaldor *et al*. 1990).

Previous testing shows that AAS pulping results in high yield for long bast fibres with very low lignin contents. Thus, our studies in this paper of the processing of disintegrated bast-fibre plant stalks are directed at the delignification of the woody (shive) core part.

Methods

Raw materials were pulped using aqueous-alcohol (65:35 vol%) ammonia and sulfur dioxide solutions. Cooks were made in a 1 litre stainless-steel digester placed in a heated glycerine bath. All cooks were made at near isothermal conditions. To simulate a digester screw feeder, shive with a dry weight of 140-145 g was placed in

Table 1. Chemical composition of hemp and flax shiveas % of oven-dry raw material weight.

Characteristics	Hemp shive	Flax shive
Ash	1.00	2.55
Extractable substances (in a 1:2 ethanol-benzene mixture)	3.16	2.76
Lignin	25.52	30.11

a hydraulic press and compressed rapidly (5-10 seconds) using pressures of up to 8.5 Mpa. The shive was transferred to the digester, cooking liquor was added, and the digester was hermetically sealed. The digester was placed immediately in the heated glycerine bath and the contents were raised to cooking temperature within 2-3 minutes. The digester remained in the heated glycerine bath at the cooking temperatures and for the cooking times described in Table 2. After cooking for the allotted time, the digester was cooled using cold water. Then, the pulp was removed from the digester, placed on a 100 mesh screen and washed using warm water. The washed pulp was then analyzed. No shive and mass sorting was carried out. In the first run of experiments, the wastes of primary hemp and flax whole stalk processing mills were used. Soda and soda-anthraquinone pulping tests also were conducted with the same raw materials for comparison purposes with the AAS pulping tests. Soda pulping tests were performed under conditions typical for processing the nonwood raw materials in a Pandia digester apparatus.

The analysis of raw materials, preparation and refining of fibrous stock, making hand sheets and determination of physical-mechanical characteristics of pulp were performed to Ukrainian standards which mainly conform to ISO standards. Hand sheets of 75 g/m were made of the various fibrous stocks refined to 60 + 1 0SR.

Table 2. Pulping conditions and test results for three pulping methods (Soda, Soda -AQ and AAS).

		Hemp shive					Flax shive			
Characteristic	Units	Soda	Soda-AQ	AAS	AAS	AAS	Soda	Soda-AQ	AAS	AAS
Pulping conditions										
Chemical consumption, as % of oven-dry raw material weight:										
active alkali, Na_2O		18.0	18.0	-	-	-	18.0	18.0	-	-
anthraquinone, AQ		-	0.1	-	-	-	-	0.1	-	-
ammonia, NH_3 1--		-	-	15	15	15	-	-		
sulfur dioxide, SO_2		-	-	10	28	18				
Water to alcohol ratio		-	-	65:35	65:35	65:35	-	-	65:35	65:35
Liquor to shive ratio		4.0:1	4.0:1	4.0:1	4.5:1	4.5:1	4.5:1	4.5:1	4.5:1	4.5:1
Temperature	^{0}C	170	170	170	150	170	175	175	160	170
Time	min	45	45	75	180	180	45	45	180	180
Pulping results										
Yield	%	50.1	46.5	62.2	67.9	54.5	42.1	44.2	55.2	47.9
Kappa number		64.4	25.2	48.1	56.5	17.3	90.0	78.4	78.9	42.7
Physical properties of 75 g/m^2 hand sheets refined to 60 + 1 0SR										
Density	g/cm^3	0.62	0.62	0.67	0.68	0.75	0.59	0.58	0.64	0.64
Breaking length	m	6310	7150	8550	10140	12000	5130	5860	7860	8710
Tensile elongation	%	3.4	3.4	3.4	3.0	3.0	2.7	2.8	3.3	3.4
Folding endurance, double folds		320	680	1250	140	280	26	26	70	140
Burst index	kPa•m^2/g	3.56	4.17	5.58	5.58	6.24	3.05	2.59	4.07	4.42
Tear index	mN•m^2/g	3.19	3.28	3.33	2.65	3.71	4.10	4.28	3.78	4.47

Results and discussion

Characteristics of the raw materials are given in Table 1, and experimental conditions and results are summarized in Table 2. As is seen in Table 1, flax shive contains much more lignin and ash than hemp shive which means that hemp shive is the more preferable raw material for pulping.

The data in Table 2 demonstrate that shive pulp produced using the soda process is suitable only for low-grade papers and boards and that soda pulping is not very suitable for making bleachable shive pulp. The addition of anthraquinone (AQ) to soda liquor considerably improves the process giving bleachable pulp with a 46% yield for hemp shive and strength properties higher than those of soda pulp. However, soda-anthraquinone pulping did not produce hemp pulp which could compete with hardwood pulps.

As compared to hemp shive, flax shive is weakly responsive to the addition to anthraquinone to the soda pulping liquor. Soda-anthraquinone flax shive pulp displays low strength properties (excluding tear) which do not differ considerably from those of soda pulp. Despite higher yield and low Kappa number, soda-anthraquinone pulp made of flax shive will be difficult to bleach.

Based on the test conditions used, the test results of soda and soda-anthraquinone processes confirm that hemp shive is of little use and that flax shive is practically unsuitable for the production of pulp and paper if traditional pulping technologies are used. The AAS pulping process, however, offers entirely new potential for the use of hemp and flax shive in the pulp and paper industry.

The data in Table 2 show that AAS pulping can produce shive pulp which is not inferior in its properties to hardwood kraft pulps. In fact, AAS hemp shive pulp displays especially high yield and physical characteristics. The yield of easily bleachable AAS hemp shive pulp is at least 10% higher than that of the soda-anthraquinone pulp, and it is at the same level or exceeds the yield level of aspen kraft pulp. Of physical characteristics, the very high breaking length of AAS pulp deserves special attention. In the case of AAS hemp shive pulp, the breaking length is 12,000 m which is comparable with breaking length of high-strength softwood kraft pulps.

The high breaking length of AAS pulps may be explained by a higher selectivity of AAS pulping than conventional soda or soda-AQ pulping with the result that, in AAS pulping, the hemicelluloses are retained in the pulped stock. Also, it is especially valuable for AAS pulps that high breaking length is combined with high tear strength.

The characteristics of AAS flax shive pulps are somewhat lower than those of hemp shive pulps. However, an appropriate choice of pulping conditions can give stock comparable with conventional hardwood pulps, and such pulps can be used in the furnish of high-grade papers and boards.

Conclusions

The studies have demonstrated that our pulping method with aqueous-organic, in particular aqueous-alcohol ammonia and sulfur dioxide solutions, offers the potential to make hemp and flax shive valuable raw materials for pulps of different purposes, including possibly high-grade bleachable pulp which could compete with hardwood kraft pulps.

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Staminate inflorescence
(courtesy of VIR)

A review of *Cannabis* diseases

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Diseases of *Cannabis* are caused by organisms or abiotic sources. Organisms include fungi (first and foremost), nematodes, parasitic plants, bacteria, and viruses. Abiotic (non-living) causes include nutrient deficiencies, pollutants and genetic diseases. Different diseases prevail in different crops (*e.g.*, drug cultivars versus fiber cultivars). Disease prevalence is also modulated by geography and climate. The claim that *Cannabis* has no diseases is not correct, *Cannabis* suffers over 100 diseases, but less than a dozen are serious. Serious diseases include gray mold, hemp canker, damping off, assorted leaf spots, blights, stem cankers, root rots, nematode diseases, broomrape, macro- and micronutrient deficiencies, and genetic diseases. Environmentally stressed plants become predisposed to diseases. Stress incudes drought, insufficient light, untoward temperatures, or growing plants in monoculture.

Introduction

Despite the oft-repeated quote, "hemp has no enemies" (Dewey 1914), *Cannabis* suffers many diseases. Agrios (1988) estimates 11% of fiber crops are lost to diseases. This statistic does not include insect injury. Disease, by definition, is continued irritation damage by a causal factor (be it an organism or the environment). In contrast, injury is due to a transient causal factor. Insects are transient, they cause feeding injury, not disease. Insects will be the subject of our next review.

Organisms that cause continued irritation (disease) include viruses, bacteria, fungi, parasitic plants, and nematodes (Figure 1). Plant diseases are almost always caused by fungi and rarely caused by bacteria. In people this fungi-to-bacteria ratio is reversed. Few *Cannabis* diseases can be transmitted to humans, but there are exceptions (McPartland, 1994).

Some diseases prevail in *Cannabis* fiber and oil seed crops, other diseases predominate in drug crops. Disease prevalence varies geographically. For instance, many virus diseases are limited by the range of their insect vectors. Disease prevalence shifts between greenhouse crops and outdoor crops. Disease prevalence alters as plants grow from seedlings to flowering adults. (Table 1).

Three lists of *Cannabis* diseases have been collated recently. McPartland (1991) lists diseases by their common names (American Phytopathological Society URL address : http://www.scisoc.org/apspress/common @names/cannabis.html). This list is unweighted—severe and epidemic diseases are presented next to rare and benign diseases without differentiation. Termorshuizen (1991) lists diseases by their causal organisms, alphabetically. His discussion is weighted by disease severity and organized geographically. But he is not entirely critical of old taxonomy. Gutberlet & Karus (1995) list diseases by their causal organisms, taxonomically. Their list is not weighted by disease severity nor critical of taxonomy. The taxonomy of *Cannabis* pathogens has been ignored since the 1930s. Concerning fungi alone, the scientific literature cites 400+ taxa as *Cannabis* pathogens. Research reveals many of these species are misidentifications or taxonomic synonyms (McPartland 1995 a-e). After a name-by-name review, McPartland (1992) determined the 400+ taxa represent about 88 true species of *Cannabis* fungal pathogens.

This review is presented taxonomically, weighted by severity. Discussion is organized primarily for fiber crops and geographically centered in Europe. The review does not discuss control measures.

Fungi

As mentioned above, at least 88 species of fungi attack *Cannabis* and more are being discovered every year (McPartland & Hughes 1994, McPartland & Cubeta 1996). By far the most significant is gray mold, caused by *Botrytis cinerea* (teleomorph *Botryotinia fuckeliana*). B. cinerea thrives in temperate regions with high humidity and cool to moderate temperatures. Under these conditions gray mold can reach epidemic proportions and completely destroy a *Cannabis* crop within a week (Barloy & Pelhate 1962). *B. cinerea* attacks many crop plants and weed species worldwide.

Gray mold presents in three scenarios, depending on plant maturity and cultivar. Seedlings succumb to damping off, discussed below. In fiber cultivars gray mold presents as a stem disease. It arises as a gray-brown mat of mycelium which becomes covered by masses of conidia (fungal spores). Stems become chlorotic at margins of the mat. Enzymes released by *B. cinerea* reduce stems to soft shredded cankers. Stems often snap at canker sites. Gray mold may encircle and girdle stems, wilting everything above the canker. Fiber varieties become more susceptible after canopy closure, In field experiments in the Netherlands the disease was found from the beginning of July (Van der Werf and Van Geel, 1994). Van der Werf *et al*. (1995) note Hungarian Kompolti Hibrid TC is more susceptible to gray mold than other fiber varieties. Dempsey (1975) says the Russian cultivars JUS-1 and JUS-7 are resistant, but these may no longer be available (de Meijer 1995).

In drug cultivars, gray mold infests flowering tops.

Large moisture-retaining female buds are most susceptible. Fan leaflets first turn yellow and wilt, then pistils begin to brown. Whole inflorescences soon become enveloped in a fuzzy gray mycelium then degrade into a gray-brown slime. Drug varieties are most susceptible during flowering near harvest time. Dense tightly-packed buds of *Cannabis afghanica* Clarke tend to hold moisture and easily rot (Clarke 1987). Afghan cultivars evolved in very arid conditions and have no resistance to gray mold. This unfavorable trait is often expressed in hybrids that have only a small percentage of *C. afghanica* Clarke heritage.

For the second most important disease, Termorshuizen (1991) lists hemp canker. This diease is caused by *Sclerotinia sclerotiorum*. The fungus primarily attacks fiber cultivars in Europe, but it has caused up to 40% losses in North America (Hockey 1927) and damaged hemp in Australia (Synnott 1941) and Tasmania (Lisson & Mendham 1995). Hemp canker has also appeared on drug cultivars in India (Bilgrami *et al*. 1981). Symptoms begin as watersoaked lesions on stems and branches of plants nearing maturity. The lesions collapse into cankers and become darkly discolored. Affected areas take on a shredded appearance and the pith becomes filled with a white cottony mycelium. Plants remain in this condition or wilt and fall over. By September large black sclerotia develop on the stem surface or within pith of dead stalks.

Damping off fungi kill seeds in soil or seedlings shortly after they emerge from the soil. Fungi invade stems of seedlings at the soil line, causing a brown watery soft rot, then the plants topple over. Most damping off is caused by two Protoctistan *Pythium* species (technically they are oömycetes, not fungi), *P. aphanidermatum* and *P. ultimum*. Several fungi also cause damping off—*Rhizoctonia solani*, *Botrytis cinerea*, *Macrophomina phaseolina*, and several *Fusarium* species, *F. solani*, *F. oxysporum*, *F. sulphurem*, *F. avenaceum*, *F. graminearum*. Together they make damping off a ubiquitous problem, attacking all cultivars of *Cannabis* (Bush Doctor 1985).

The two most common leaf spot diseases are yellow leaf spot caused by two *Septoria* species (McPartland 1995d), and brown leaf spot caused by about eight *Phoma* and *Ascochyta* species (McPartland 1995c). These diseases rarely kill plants but sharply reduce crop yields. Two common diseases of fiber varieties are downy mildew, caused by two *Pseudoperonospora* species, and olive leaf spot caused by a *Pseudocercospora* species and a *Cercospora* species. Pink rot, caused by *Trichothecium roseum*, has recently killed greenhouse-grown drug cultivars and seems to be on the rise. Less frequently seen but equally virulent diseases include brown blight (caused by two *Alternaria* and two *Stemphylium* species), anthracnose (caused by two *Colletotrichum* species) and white leaf spot (caused by *Phomopsis ganjae*). Powdery mildews, black mildews, and rusts are caused by high-visibility fungi, but rarely cause serious problems (McPartland 1983).

Some leaf disease fungi also infest stems, especially *Trichothecium roseum*, *Phoma*, *Stemphylium*, *Colletotrichum*, and *Phomopsis* species. The most serious causes of stem cankers are *Fusarium* species—*F. graminearum* and *F. avenaceum* occur in cooler climates, *F. sulphureum* and *F. sambucinum* in warmer climates.

Some root rots cause serious losses. Barloy & Pelhate (1962) considered root rot caused by *Fusarium solani* the worst disease of hemp in France. Pandotra & Sastry (1967) report a virulent strain of *Rhizoctonia solani* destroying 80% of drug plants in northern India. Root rot by *Sclerotium rolfsii* predominates in southern temperate zones and the tropics, on both fiber and drug cultivars (Ferri 1961).

Above-ground symptoms of root rots are hard to distinguish from wilt diseases. Three wilt diseases are important—fusarium wilt caused by two forms of *Fusarium oxysporum*, verticillium wilt caused by two *Verticillium* species, and premature wilt (also called charcoal rot) caused by *Macrophomina phaseolina*. Fusarium wilt received attention as a potential biocontrol to eliminate illegal marijuana plantations (Hildebrand & McCain 1978, Noviello *et al*. 1990). Wilt diseases are more severe in *Cannabis* fields harboring root-wounding nematodes or broomrape.

Nematodes

Nematodes are tiny roundworms, also called eelworms. Nematodes are not closely related to earthworms. Built on a much smaller and simpler scale, they have no respiratory nor circulatory systems. Their nervous system is so simple it can be described at the level of individual cells. *Caenorhabditis elegans*, for instance, has exactly 302 neurons.

Crop damage by nematodes is underrated due to their small size and the unseen (mostly underground) nature of their pathology. Above-ground symptoms consist of stunting, reduced yield and insipient wilting (drooping of leaves during midday with recovery at night). Farmers may misinterpret symptoms as mineral deficiencies or drought, mysteriously arising despite adequate nutrients and moisture. These symptoms do not occur uniformly across a field, but in pockets of scattered infestation. Below-ground symptoms are more distinctive, including root knots or galls. Six nematodes are known to infest *Cannabis.* All species attack roots except one.

Root knot nematodes embed themselves in roots and induce plants to form giant cells or syncytia. Syncytia swell into root galls and stimulate formation of adventitious rootlets, creating a bushy root. Compound galls arise on larger roots forming “root knots”: hypertrophied roots with a rough surface. The southern root knot nematode, *Meloidogyne incognita*, has been reported on fiber cultivars in Europe, the former USSR, Brazil, and the southern US (Goody *et al*. 1965). *M. incognita* is the most widely distributed *Meloidogyne spp.* worldwide, and attacks hundreds of hosts. Two other species are rarely reported, the northern root knot nematode *Meliodogyne hapla* (Norton 1966; de Meijer 1995) and the Java root knot nematode *Meloidogyne javanica* (Decker 1972).

The stem nematode, *Ditylenchus dipsaci*, uniquely lives above the ground and does not infest roots. Initial symptoms arise in stems, branches and leaf petioles, which swell and become chlorotic. Stems subsequently become twisted and distorted with shortened internodes. Plants are stunted. *D. dipsaci* is found in North America, southern Africa, Australia, and temperate areas of Asia. But *Cannabis* disease has only been described from fiber varieties in Europe (Mezzetti 1951). Other nematodes are rarely reported: cyst nematodes (*Heterodera schachtii*, *H. humuli*), needle nematodes (*Paralongidorus maximus*), and root lesion nematodes (*Pratylenchus penetrans*).

Parasitic Plants

Plants from two genera are genuine *Cannabis* parasites. They sink specialized roots (haustoria) into the host's xylem and phloem to withdraw fluids and nutrients. Broomrapes seem to be the worst. Dewey (1914) calls branched broomrape (*Orobanche ramosa*) "the only really serious enemy to hemp." Barloy & Pelhate (1962) consider a combination of *O. ramosa* and *Fusarium solani* the greatest threat to *Cannabis* cultivation in southern France. Broomrapes do most of their damage underground, their haustoria provide portholes for root rot fungi. Only briefly do broomrapes send shoots above ground, which quickly flower and set seed. Rarely *Orobanche aegyptiaca* and *Orobanche cernua* have been cited on fiber and drug cultivars.

Dodder, in contrast to broomrape, sinks haustoria into above-ground parts. Five species have been reported, mostly *Cuscuta campestris* (on drug cultivars in the US and fiber varieties in Europe) and *Cuscuta europea* (on fiber cultivars in Europe). Dodder arises as conspicuous tangles of glabrous yellow filaments, bearing vernacular names such as "gold thread," "hair weed," "devil's ringlet," and "love vine." They twine themselves around stems and branches. Robust specimens girdle branches and pull down hosts. Dodder, like broomrape, can vector viruses.

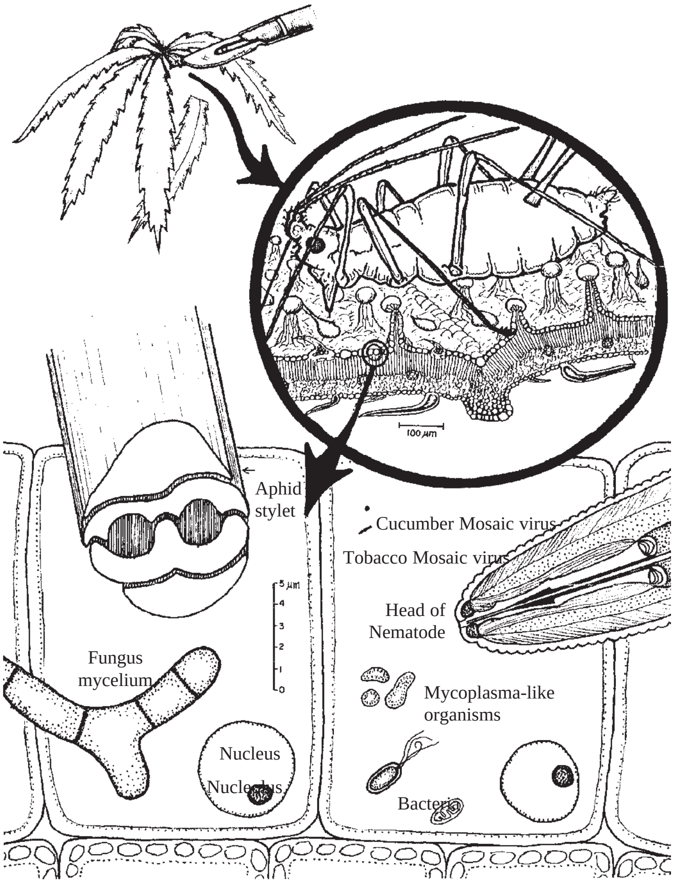

Figure 1. Shapes and sizes of some organisms associated with *Cannabis* (adapted from Agrios, 1988)

Viruses

Viruses rarely kill *Cannabis.* They only exist and replicate in living plants. Viruses can, however, seriously reduce yields. Once acquired, they are nearly impossible to eradicate. Viruses invade all parts of plants. Pollen and seed infections transmit viruses to subsequent generations.

Five viral syndromes are described in the literature. In addition to these naturally-occurring infections, Hartowicz *et al*. (1971) screened 22 common plant viruses for their ability to infect wild hemp. Over half the viruses could infect *Cannabis.*

The hemp streak virus (HSV) is frequently cited on fiber cultivars in Europe. Foliar symptoms begin as a pale green chlorosis. Chlorotic areas soon develop into a series of interveinal yellow streaks or chevron-stripes. Sometimes brown necrotic flecks appear, each fleck surrounded by a pale green halo. Flecks appear along the margins and tips of older leaves and often coalesce. Streak symptoms predominate in moist weather, flecks appear during dry weather. Leaf margins become wrinkled and leaf tips roll upward, leaflets curl into spirals. Whole plants assume a "wavy wilt" appearance.

The hemp mozaic virus has been described on fiber cultivars in Europe and drug cultivars in Pakistan. Symptoms were described as a gray leaf mosaics. Three other viruses have been cited on European hemp—the alfalfa mozaic virus (=lucerne mozaic virus), cucumber mozaic virus, and the arabis mozaic virus. Many insects transmit these viruses as they feed from plant to plant. According to Ceapoiu (1958), the worst vectors of *Cannabis* viruses are bhang aphids (*Phorodon cannabis*), greenhouse whiteflies (*Trialeudodes vaporariorum*), onion thrips (*Thrips tabaci*) and green peach aphids (*Myzus persicae*).

Bacteria and MLOs

The *Cannabis* literature concerning bacteria is confused. Dozens of bacteria have been cited, a morass of misidentifications and taxonomic synonyms. Species of hemp rettors and marijuana rotters have leaked into the literature, but they do not cause disease in live plants. Mutualistic species also appear. Kosslak & Bohlool (1983) isolated *Azospirillum brasilense* and *A. lipoferum* from the rhizosphere of marijuana plants growing in Hawaii. These diazotrophic bacteria live on the surface of plant roots where they fix nitrogen for their host. Diazotrophic bacteria have been sprayed on plants to serve as "biofertilizers" (Fokkema & Heuvel 1986).

Only four species of true pathogenic bacteria (with one species split into four pathovarieties) cause disease in living *Cannabis* plants. Bacterial blight by *Pseudomonas syringae* pv. *cannabina* seems to be the most common problem. Symptoms resemble those caused by brown leaf spot, a fungal disease. Bacterial blight has only been described on fiber cultivars in Europe. *Striatura ulcerosa* produces similar symptoms on stems and is caused by a similar species, *Pseudomonas syringae* pv. *mori*. It, too, is limited to fiber varieties in Europe. Uncommon diseases include crown gall by *Agrobacterium tumefaciens*, bacterial wilt by *Erwinia tracheiphila*, xanthomonas leaf spot by *Xanthomonas campestris* pv. *cannabis*, and a mycoplasma-like object described by Phatak *et al*. (1975).

Table 1. Common *Cannabis* diseases

Seedling diseases	Flower & leaf diseases, outdoors	Flower & leaf, diseases, indoors	Stem & branch diseases	Root diseases
Damping-off fungi Storage fungi Genetic sterility	Gray mold Yellow and Brown leaf spots Downy mildew Olive leaf spot Nutritional diseases Brown blight Bacterial leaf diseases	Nutritional diseases Pink rot Gray mold Powdery mildew Brown blight Virus diseases	Gray mold Hemp canker Fusarium canker Fusarium wilt Stem nema Charcoal rot Anthracnose Striatura ulcerosa Dodder	Fusarium root rot Root knot nema Broomrape Rhizoc root rot Sclerotium rot Cyst nema

Abiotic diseases

Diseases from abiotic (non-living) causes often arise suddenly. They usually resemble diseases caused by living organisms. Some abiotic diseases have unknown causes, such as "grandine" of hemp. Abiotic problems also predispose plants to other diseases. Drought-stressed plants, for instance, become much more susceptible to fungal cankers (McPartland & Schoeneweiss 1984).

The most common abiotic diseases are nutrient deficiencies (Frank 1988). Generally, deficiencies of mobile nutrients (N, P, K, Mg, B, Mb) begin in large leaves at the bottom of plants. Shortages of less mobile nutrients (Mn, Zn, Ca, S, Fe, Cu) usually begin in young leaves near the top.

Pollutants take their toll. Sulfur dioxide causes interveinal leaf chlorosis and hydrogen fluoride causes a complete chlorosis in *Cannabis* (Goidànich 1959). Sharma & Mann (1984) found *C. sativa* ssp. *indica* near a Himalayan highway suffering chlorosis and necrosis. Automobile-polluted plants produced fewer stomates but more trichomes per leaf area. Because of increased trichome density, Sharma & Mann thought auto pollution increased THC production.

Genetic diseases are common. Bócsa (1958) describes some consequences of inbred hemp *e.g.* short stature (only 68% the height of normal hemp), shortened lifespan (vegetative growth 9 weeks shorter than normal plants), production of sterile seeds, and increased susceptibility to fungal diseases. Crescini (1956) describes plant fasciation, ramification of stems, and strange pinnate phyllotaxy in mutagenic, inbred hemp. Borodina & Migal (1987) illustrate flower fasciation and other teratologies in monoecious plants. Lai (1985) describes the deleterious effects of inbreeding on yield of fiber and seed. Sitnik (1981) says "yellow stem" disease in the Ukraine is genetic, caused by a monogenic recessive mutation. The gene involved has a pleiotropic effect on plant yields, it decreases biomass, fiber and seed production.

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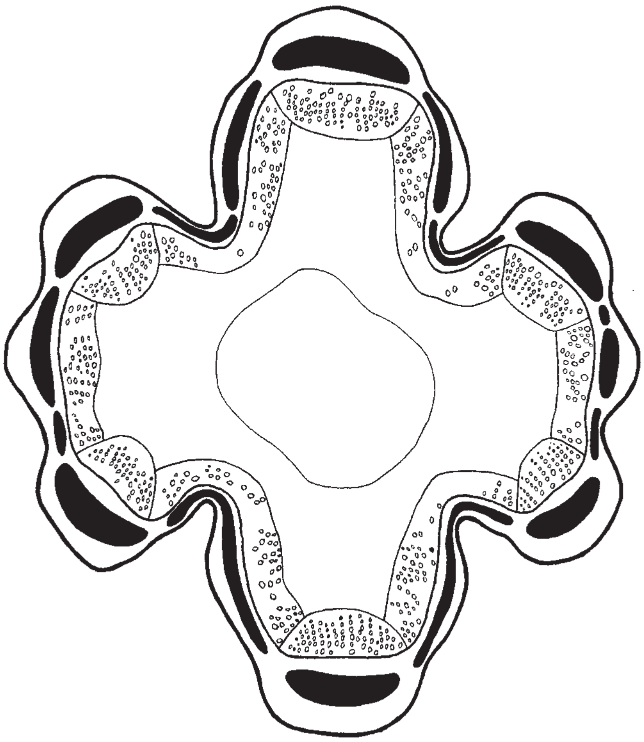

Cannabis stem cross section (courtesy of VIR)

Interview

Dr. Mahmoud A. ElSohly

In the United States, the University of Mississippi, and specifically its Research Institute of Pharmaceutical Sciences (RIPS), is famous for hosting the NIDA Marijuana Project, which grows the *Cannabis* it supplies to researchers. The head of this project is currently Mahmoud A. ElSohly, a Research Professor at the institute, as well as its former Assistant Director of Physical Sciences from 1976 to 1988. He is also the Director of his own private laboratory, where he continues to work with *Cannabis* and the cannabinoids. Our interview, conducted by Dave Pate on December 19, 1995, appears below.

JIHA: Dr. ElSohly, what is your academic background and how do you find yourself in this position?

MAE: I have a bachelor's and master's degree in Pharmacy and Pharmaceutical Sciences from the University of Cairo and I have a Ph.D. degree in Pharmacognosy, natural products chemistry, from the University of Pittsburgh. My major professor was Dr. Paul Schiff, who was a student of Professor Jack Beal at Ohio State. As soon as I had finished all my practical work for the Ph.D., we had twin daughters and my major professor said "Well, you better go and find yourself a job somewhere". He knew Carlton Turner at the University of Mississippi and said that he had a good graduating student and I was offered a post-doctoral position. I moved there in August of 1975, before I had actually defended my doctoral dissertation in November. Things worked out with Carlton and I started out on a poison ivy project and then a research associate position opened up with the marijuana project, which paid a little more money, in November, just a few months after I moved there.

JIHA: Sounds like you lucked into dropping through all the right slots.

MAE. Right, and then things just kept happening to me here and I began to move very quickly in the ranks, in 1978 coming into an assistant professor position, and by 1982 advancing to associate professor. When I first arrived at RIPS, all you could be was a "post-doc" or a research associate of some sort, but in the early '80s, one of the vice-chancellors, Peter Wagner, believed in rewarding those that have accomplishments, so in 1984, I applied for and received a full-professorship. To achieve that position in only 6 years is a record for the university. I guess I was in the right place at the right time, but I had also been turning in 7, 8, 10 publications every year, so I had a lot of good productivity at that time.

JIHA: When did you first become interested in *Cannabis*?

MAE: In 1976, when I was a "post-doc" working on *Cannabis*.

JIHA: You had no particular interest in the subject before then?

MAE: Not really. I knew about *Cannabis* from my undergraduate work in pharmacy and I knew hashish, but I didn't know what "marijuana" was, as a name, because in the middle-east where I come from, it's just not known as that.

JIHA: You were exposed culturally to hashish?

MAE: I don't believe that I ever saw it myself, but in the culture people always talked about hashish and smoking it. My father never did, but there were a lot of people in my town that smoked hashish all the time.

JIHA: Is that seen as clandestine or just an accepted tradition?

MAE: It's seen as clandestine, because, at least when I was growing up, it's distribution was a major crime. It was 25 years in prison if you were caught with hashish as a distributor, which didn't mean necessarily tons. Even just a few grams and if you are selling it, you were considered a distributor. It was a terrible punishment, so it certainly was clandestine, but the use was culturally allowed, a lot of people were using it. But in the culture, it was known who was using it. As a child, I knew who in my hometown were the people that used hashish and if you wanted hashish, where to go to get it. So it was a very well-known thing, but nevertheless it was not known to the authorities.

JIHA: It was not broadly practiced, but did occur sporadically.

MAE: That's right. So, when I came to Ole Miss, I didn't know about "marijuana", but I did know about hashish, the botany of the plant, etc., so when that position became available, I was ready. We isolated a lot of new cannabinoids and other phenols, alkaloids and other new compounds. That period, the late 70s and early 80's was the surge of new compounds found in *Cannabis*.

JIHA: Over 60 at last count.

MAE: Yes, and in 1980 we did our review article which showed 412 compounds belonging to 18 different classes.

JIHA: Has that vein of research been pretty-well exhausted?

MAE: Well, we have just finished

another review, submitted for publication, in which we have mentioned another few compounds which were not previously reported.

JIHA: These compounds are present in minuscule amounts aren't they?

MAE: That's true.

JIHA: What is the scope of your research activities?

MAE: We do potency monitoring of roughly 3-4 thousand seizures of marijuana every year, and we get samples of hash and hash oil.

We have done a lot of work, not part of the funded project, but on the side, looking at the biology of the plant material: some smoke studies with Dr. Sue Watson looking at the immune system, new formulations for THC, and so on. I would say our most significant contribution in the area of *Cannabis* research was the isolation and characterization of a good number of the new components that were discovered in the 80s. There really haven't been many compounds discovered after we stopped working.

We also have monitored the incidence and levels of paraquat, sprayed by the Mexican government, in confiscated marijuana, which would be a good representation of the marijuana on the streets, to see if it represented a terrible health hazard or not.

JIHA: What was your opinion on that?

MAE: Based on our results over the last few years, there is only about 5% of the material we examined that had any level of paraquat, but the levels aren't as high as people think it might be. Most sample have less than 100 parts per million, on the average 20-30 parts per million, which is not enough to cause any lung damage. In addition, this figure is based on material seized at the Mexican border and doesn't account for material coming into the country from other areas, which we don't monitor, so the percent of contaminated material is probably less.

JIHA: I found intriguing the RIPS discovery that there are varieties of *Cannabis* without any CBD whatsoever (some of the South African varieties) considering some of the proposed cannabinoid biogenetic theories.

MAE: Right, CBC and CBD weren't separable until relatively recently and their reliable separation was a critical discovery done by Carlton Turner, before I actually started working on the project. Plant material with CBC predominant is felt to be a drug type. Either CBD is not present or only in small amounts.

JIHA: So you would say that temperate fiber varieties would be characterized and identifiable by the predominance of CBD and a lack of, or small amount of, CBC. And the tropical drug varieties would have the reverse ratio.

MAE: That's correct.

JIHA: Have you examined any tropical varieties that were grown for hemp purposes?

MAE: No.

JIHA: What would you do if you were given a blank check and told to do something that you've always wanted to do, but had up to now, lacked a priority.

MAE: I've been fortunate enough to have really had the opportunity to do a lot of things, so there's not something out there in particular that I would say "if only". But the one thing that I started years ago, and for which the funding was discontinued, was the fingerprinting project. We did a good bit of work and actually brought it to a conclusion, but it was just a matter of taking it one step further to confirm the conclusions. I would also like to do breeding with analytical feedback. That was my next step, to take the chemical fingerprinting and kind-of marry that with the genetic fingerprinting and see if they agree.

JIHA: Are these results proprietary?

MAE: At this time they are proprietary, but I think I'm going to go ahead and publish, since these conclusions are three years old. Unfortunately, because of the funding cuts, it was never put to a comprehensive field test with blind samples. Even though our work was reasonably large in scope, it was not large enough to make it foolproof. But it was giving us at least 90% confidence. I could tell you where it was not from, and where it was very probably from, but some samples were so similar that it was hard to tell for absolutely sure, but at worst, you could narrow it down to between two countries.

JIHA: But if someone imported seeds from one geographic area and grew them in another, what would happen?

MAE: If you got Colombian seeds and grew them in the US, that material would be different than if it would have been grown in Colombia. There would be much similarity, obviously, but there would be enough difference between them to say they are also different.

JIHA: So, there are both environmental and hereditary inputs.

MAE: Yes.

JIHA: How many varieties of *Cannabis* do you have?

MAE: We have a number of the usual varieties, Colombian, Jamaican, Mexican, Thai. We used to have Turkish material, but haven't used it in recent years. But we can get just about any material that we want from a country through the DEA offices there. The bulk of our production material is Mexican.

JIHA: Do you have any interest in industrial hemp?

MAE: It's a new interest since I have received many, many phone calls from interested individuals, entrepreneurs, and state legislators from Kentucky and other states.

JIHA: What would you say is the potential for industrial hemp in the US?

MAE: There's a tremendous interest in the US for industrial hemp. Now obviously there is, from the law-enforcement standpoint, opposition, simply because it makes their life harder and they really don't know how to control it. People might want to grow other varieties of *Cannabis* and it is hard to tell which is which, just from looking at it, and it might be used as a cover up.

There's also the issue about what to do with the leaves. They're afraid people will try to make hashish or hash oil. Where all of this is going to end up is anybody's guess. But there is movement in other countries and we are having to import these fiber materials and yet have the capability to produce that here, so there is the question of "Why can't we also do that as well?". I think that Canada is currently doing stuff, so that's putting a lot of pressure on our government to move on this issue.

JIHA: What directions should the hemp movement take, as far as you're concerned?

MAE: Certainly one area that if it is resolved, would have a tremendous economic impact is if you can produce a *Cannabis* variety that does not have THC.

JIHA: Zero?

MAE: Zero THC or close to zero THC. Something not enough to make hashish or anything out of it.

JIHA: What would you say is that target level that would be universally acceptable?

MAE: Less than 0.1%

JIHA: You would think the DEA would have no problem with that?

MAE: I can't, obviously, speak for the DEA, but I would say that if you say the THC content is less than 0.0-something, they might be able to listen, but what they really want is zero, there's no THC in it, so that it becomes like the stalks, like the roots, like the seeds. Although seeds have a little THC.

JIHA: Adherent?

MAE: Well I don't know, adherent or otherwise. I haven't examined it closely enough to tell. *Cannabis* seed oil has THC and it's legal. They're not worried too much about it because the amount is just so small. And so that's the kind of level you would need to get in the leaves of a variety, and you guys ought to make this a priority item for you. That can be a tremendous plus.

JIHA: For the expansion of *Cannabis*?

MAE: Yes, as hemp! If you didn't have THC, you wouldn't have to worry about it!

JIHA: But what about the fact that technically CBD, CBC and all these other compounds are also forbidden substances in the US?

MAE: Yeah, but I think that right now, it's just because they are associated with THC. But I think that problem could be overcome. Right now, there is THC, so there's no reason to look beyond that. Now obviously CBD could serve as a starting material for manufacturing THC, and that's why CBD might also be a problem, but for now, probably more than 90% of the problem is with THC.

JIHA: What about the medical potential for *Cannabis*, either as whole drug or isolated products?

MAE: There is no question about the use of *Cannabis* for certain conditions. It does have a history. It does have the utility and so on. However, *Cannabis* as a smoked product, in my judgment, would not be a useful product simply because of the lack of standardization, the fact that's it's a smoked material: you can't determine the dose, people smoke in different ways, plus the interaction of the many different components and degradation products, and the tars associated with smoked materials. So smoking is not a good delivery system.

However, *Cannabis* as a plant that is rich in chemical components, would have potential for producing useful drugs, for example, THC. Now THC in the oral preparation, it doesn't seem to be doing the good job it should or was expected to. My personal view on the reason for this is the "first-pass effect". The material taken orally goes through the liver and is converted to the 11-hydroxy metabolite, which is 4-5 times more potent in terms of psychoactivity, before getting into the bloodstream, and the profile of these two drugs is quite different. Smoked material doesn't cause much of the 11-hydroxy metabolite to appear in the blood at all. You really only see THC and its inactive carboxy metabolite. Therefore, the pharmaco-logical profile of smoked material is the result of free THC in the blood.

Suppositories were tried with THC and it didn't get absorbed at all, zero. So I took THC and converted it to a pro-drug that would be bioavailable from a suppository. Then, once it hits the bloodstream, it gets immediately converted to THC, which then mimics the smoked material. This has a number of advantages: number one, it avoids the "first pass effect" through the liver; number two, it never gives such a high level of THC all of a sudden, which gives a "rush" high that is normally associated with "abuse" and also paranoia for those people who are not used to the effect of THC, the overwhelming effect. Our dosage form gives a very subtle effect. If anything it's a more calming and sedating effect that does not make the individual "lose touch with reality", and that blood level remains for quite a long time, it has a long plateau. Plus, it has a very quick onset of action, as compared to the oral. In 15 minutes, you see good measurable blood levels of THC, reaching a maximum at an hour, stays up there for 2, 3, 4 hours and then comes down again slowly. So it appears to me that what we ended up with is a preparation that you give as a suppository, but that doesn't have to be kept in the body for a long time, only 15-20 minutes. If you can retain it for 15-20 minutes, that's sufficient. The reason I say that, is that there was the concern about AIDS patients who might be suffering from diarrhea. There is diarrhea associated with that condition and if the person can keep the suppository in for 15 minutes, that's all you need to do. What happens is this drug almost gets sucked into the mucosa, maybe the fatty tissues of the intestine, and then it's a slow release into the bloodstream from that point on.

JIHA: Has any work been done on the anti-nausea, appetite stimulating properties or other potential medical uses of the 11-hydroxy compound?

MAE: No, not as much, no. The notion some people have that the action of smoked *Cannabis* is due to the 11-hydroxy metabolite, I honestly don't believe that, because in the blood stream you don't see much 11-hydroxy at all. When we developed our THC suppository, we did it with the idea of imitating smoking, without actually smoking. One option is to give it by injection. If you do, then you get the same profile as the smoked material, but people don't want to get a "shot". So the next choice is intradermal, a skin patch. But it doesn't work, THC just does not get absorbed through the skin.

JIHA: Have you ever considered anything like a bronchial inhaler?

MAE: Somebody made bronchial inhalers, but they couldn't get those particles to be small enough. There were some technical problems. Technical problems with the inhalers and technical problems with the skin patches, which leaves really two available ways: suppository or injectable. And certainly injectables would work and would work fine if someone would want a shot, every now and then. But especially in chronic use, the suppository would be the second, and better, alternative.

JIHA: THC is an accepted drug in the pharmacopoeia at this point. Can you tell us about some of the other ones, perhaps in the order of their likelihood to become commercial products?

MAE: I certainly think that CBD will be one of those. CBD is being looked at as an analgesic. I read in a newspaper article that Professor Evans and his group in England are looking at CBD as a possible component that is responsible for analgesic activity and so they were going to do trials with different types of *Cannabis* and with CBD itself.

JIHA: Have you heard of the anti-psychotic effect of CBD that the Brazilian groups of Zuardi and Guimarães are investigating?

MAE: No, the main activity that I know CBD is famous for is the anti-convulsant activity. Now the anti-convulsant activity of CBD would be worthwhile pursuing.

JIHA: So it may have some use in epilepsy?

MAE: Yes, in epilepsy. This use and this activity has been around for many, many years. And then CBC obviously has good anti inflammatory activity. Now whether this would be something that could be commercialized or not, there are so many non-steroidal anti-inflammatory agents, that CBC might take a "back seat" to those compounds. But certainly there is the folkloric use and every day you look at the cannabinoids and activities in the light of today's science and today's pharmacology and so on, and you can really go back and scientifically and legitimately explain the use of *Cannabis* over the years for so many things.

JIHA: *Cannabis* may contain particular useful compounds, but in an unpredictable fashion in the whole natural product. That's been probably the main drawback of *Cannabis* in history. Some people would find it would work and for others it didn't, probably because they would be using different strains of plant.

MAE: Different strains and even with the same strain collected at different times. You might have different chemical compositions and that's really one of the reasons why *Cannabis* as *Cannabis* would suffer from problems in terms of its use as a drug. Unless you can really specify every component in there, how can you say that the variety that you use today is going to have the same effect as the variety you use tomorrow? Unless you go with the kinds of material that HortaPharm is going with right now.

JIHA: So you would say that defining chemical profile, overcoming pyrolytic products in the lungs and perhaps microbiological contamination are probably the three major objections of the medical community for using crude *Cannabis* as a medicine?

MAE: That's true, yes.

JIHA: Do you think the lack of other cannabinoids on the market, besides THC, has more to do with pharmacological or commercial considerations?

MAE: Number one, the pharmacology of most cannabinoids is not overwhelming. They have some activity, but their activity is often not as high as some already existing products. Number two: the stigma of being associated with marijuana. Pharmaceutical companies just don't want to deal with that. Number three: the fact that they have already been known for so long and therefore there's no exclusivity, you can't patent it anymore and therefore pharmaceutical companies are not interested. It's already well known, so what are you going to do? The only reason we were able to do this suppository patent is because we have a new formulation, a new prodrug that you could prescribe for these indications, but you couldn't patent THC itself for these indications, since it's already known.

JIHA: What about anandamide? Do you have any interest in that?

MAE: No, I really haven't had much to do with this particular area. Obviously the discovery of this compound and the receptor have made people believe more in cannabinoids and the possibility of developing real drugs. That discovery in itself has "legitimized" cannabinoid research and made it on par with research on other potential pharmaceuticals.

JIHA: There are illegal, but unofficially tolerated, *Cannabis* "buyers' clubs" which have sprung up, some of which cater to thousands of patients. To implement the same thing on a more legitimate basis would require an expansion of the existing federal "compassionate-use" program, which is now down to, I believe, 8 patients. Do you think that is feasible, if politically mandated?

MAE: First, let me comment on that program, which provides 300 cigarettes per month to a patient. In my judgment, that's way too much material for an individual to use for whatever condition. It's too much THC. I don't know how this was picked as the dose. But coming back to your question, if there is the political will to make it happen, it just means that NIDA will provide material for these clinical trials, because these are nothing but clinical trials.

JIHA: Even the current "compassionate-use" program is considered a clinical trial?

MAE: Absolutely, under an IND (Investigational New Drug protocol). And that's the reason most of this has been stopped. You've started doing research to see if it will work, yet you're continuing to do it, so you're beyond the scope of a clinical trial. So you can do one of two things. Either you can continue to give it to them whether it works or not. Or you have decided that maybe the stuff works, so you continue to give it. Then you're talking about giving it to them as an approved drug for that indication.

JIHA: As an investigative drug or as a more accepted pharmaceutical? Can it stay in that limbo, practically speaking?

MAE: I guess its up to the FDA.

JIHA: The program would have to be expanded on a case by case basis with multiple clinical trials or could one huge clinical trial be opened up?

MAE: There's not just one clinical trial. Each of those patients is on a different clinical trial. You can have one IND that includes 15 or 20 or 100 patients, but you've got to have a physician monitoring all these patients.

JIHA: And the normal site protocol for monitoring these patients has to be followed?

MAE: Absolutely, yes.

JIHA: In San Francisco alone, there are several thousand patients and if you add to that, the demand across the country, that's a rather large load.

MAE: It would be, there is no question that it would be. Then our program here would have to expand tremendously to keep up with that. But those INDs don't get approved all at once, they take time. And all those thousands of patients are not going to be under one IND. They will not, because no one physician can monitor and deal with all those people. So this would be a slow process, but I would say that if the number of people is going to be in the hundreds, we could probably deal with it under existing circumstances. We could produce in excess of 5000 kilograms, so we could produce about 5 million cigarettes.

JIHA: Do you think that you could produce reliable material, consistent in quality, in those quantities? You certainly have the analytical capability, but do you think that, horticulturally speaking or otherwise, you would have significant practical problems with giving everybody the same thing?

MAE: Not really, no. We can do a lot. We've done an experiment this last season with cuttings and things like that. We have done one part of the garden, just all cuttings. And it works. We did cuttings of different plants and each group of cuttings came out exactly the same. I don't think it's unreasonable to do that. We would have to have a facility and a whole program to do it that way. But I don't think in an initial clinical trial, that everyone has to be given the exact same thing, so long as you blend things together to get the required THC level.

JIHA: Do you put any credence in the lore that certain types of *Cannabis* are good for one thing or not so good for another? Do you see that as just subjective impression or do you think that there is a chemical and pharmacological basis for variation of patient reaction?

MAE: Well, that depends on what you say it is good for or not good for. Now I don't want to understate the importance of the chemical profile of the plant material, because it's very important what you have in there. After all, when it gets smoked, you're getting the effect of everything that's going in. But for small differences between varieties and so on, I don't think they are going to have a really significant effect on the pharmacology simply because THC is by far of the highest concentration in whatever it is that's being consumed. The overwhelming effect is going to be that of THC in my judgment.

JIHA: Do you see subtle effects by CBD, CBC, CBG?

MAE: There are effects, but whether these will have a pharmacological impact or not, I'm not really sure. But in terms of approving that as a drug, in the final analysis, you would have to show what impact those changes are going to have on the final activity, or get a variety that's similar to whatever you did your clinical trials with.

JIHA: Any final comments on the future of *Cannabis* ?

MAE: In terms of the cannabinoids, I think that THC is going to have a much wider use in the pharmaceutical area, for other indications. We've already gotten a patent on the use of suppositories for the treatment of different conditions, glaucoma, nausea and vomiting, appetite stimulation, as an analgesic, as an anxiolytic, and also as an anti-spastic for MS, spinal injuries and so on. These are conditions that we have actually applied for in the patent and these are good legitimate areas where THC could be a very helpful drug. So I would say in the future we'll see much more acceptable use of THC as a drug.

JIHA: More broadly prescribed.

MAE: More broadly prescribed, yes.

JIHA: Thank you.

Cultivation of *Cannabis* fiber varieties in central Finland

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Introduction

The cultivation of *Cannabis* has a very long tradition in Finnish agriculture. The earliest evidence of *Cannabis* use and cultivation in Finland has been radiocarbon dated to 3,000 and 5,000 years ago, respectively, a time which corresponds with the Finnish Stone Age (Laitinen 1995, Vuorela 1995). These findings suggest that early-blooming varieties of *Cannabis* were once native to this region, and that this plant had agricultural value. Many Finns over 60 years of age remember the cultivation of this durable fiber plant, and especially its use in the fabrication of rope and sacks for agricultural products. However, *Cannabis* has not been extensively cultivated in Finland since the 1960s.

The typical Finnish farm is family owned, and often exists as a relatively small-scale operation. Increasing industrialization since the early 1940s, in combination with more recent European Union (EU) agricultural restrictions, has left the Finnish farmer in need of valuable cash crops to maintain what is left of the family farm. Until recently, forests were often sold to offset agricultural losses, however, this strategy is now being recognized as only a short-term solution to a much larger problem. Since the long Summer days of high-latitude regions promote rapid asexual growth in *Cannabis*, we saw the reintroduction of fiber hemp as a potentially significant contribution to the cultural and agricultural life of the Nordic countryside.

In collaboration with the Culture Secretary of Hankasalmi, Finland, we began the Hankasalmi Hemp Project in the Autumn of 1994, with the intention of demonstrating fiber hemp as a non-food agriculture product during the Summer of 1995. We planned to present a small scale model for the cultivation of hemp, so that almost any motivated individual could manufacture limited runs of specialty hemp paper, yarn and fabrics during the long winter months as potential sources of additional income and creative expression. Our primary goal is to return some amount of autonomy to our agricultural community in the coming years. The following is an account of our experience, which may be of use to others who plan to reintroduce *Cannabis* within their local cultural context.

Trial Preparations

The seed of two French varieties of fiber hemp (Futura-77 and Fedora-19) were delivered to the Hankasalmi Culture Secretary's office by surface post, eight weeks before planting. We encountered no problems with their importation. The local sheriff was informed of the planting six weeks after the seeds arrived. The two varieties were mixed and planted in several plots throughout central Finland during the first two weeks in June, at densities ranging from 50-100 seeds/m^2, and harvested between mid-August and early October (Table 1).

Local and regional reporters were invited to witness the planting of the educational plot in the middle of a small village of about 3,000 inhabitants, and informed of our purpose. We also carefully explained the differences between hemp and marijuana, in an attempt to circumvent potential misunderstandings of this controversial plant. Levels of THC were monitored throughout the summer (Table 2) by gas chromatography with mass spectrometric detection (GC-MS), using an undisclosed method, by the Central Crime Laboratory in Helsinki, Finland.

Observations

Weed suppression by *Cannabis* was effective against common weeds, since none of them grew faster than hemp. The maximum growth rate was recorded to be 3.8 cm/day during July 7-29, days 24-46 (Figure 1). Day lengths during this time of rapid growth ranged from 20-18 hours, respectively. By early August (day 54), tetrahydrocannabinol (THC) had increased to 0.08%, from the previous 0.04% level at day 21 (Table 2).

Soon after a dubious newspaper article was published on this last fact, we began to witness crop predation by local misinformed youth, which technically is a crime in Finland. As the situation continued to deteriorate, a decision was quickly made by Project members to have an 'early harvest' of the educational plot on August 16 (day 64), to preserve the high community spirit which had already formed around the Hankasalmi Hemp Project. Fortunately, several smaller plots of these and other varieties of *Cannabis* were grown simultaneously in more remote areas without informing the press, and local authorities allowed this to continue as long as it did not become a problem.

Surprisingly, the appearance of the remaining crops were not significantly affected by a series of night frosts between September 15-28 (days 94-96). The larger leaves typically regained their form after wilting, over the course of the following day, as temperatures increased above freezing. At no time were male or female inflorescences observed on any plants. Long photoperiod maintenance of this vegetative state probably contributed to the crop’s sustained growth until harvest (Figure 1). Less than 1% of the total plant population succumbed to mold. Some plants reached an overall height of 400 cm, and some had a base circumference of 5.5 cm by the October 14 harvest (day 123).

Table 1. Events, days and corresponding dates for the development of fiber hemp in Central Finland during 1995.

Event	Day	Date	Height (cm)
Local sheriff informed	-	April 24	-
Planting	0	June 13	0
Police collect samples	21	July 4	5
Police collect samples	54	August 6	140
Early harvest of 0.5 Ha plot	64	August 16	190
Frost -2 °C	94	September 15	280
Frost -6 °C	96	September 17	285
Police collect samples	107	September 28	330
Final harvest	123	October 14	375

Community Involvement

After the Hankasalmi educational field was harvested, about 300 kg of plant material was immediately taken to a local lake for retting. The remaining material was plowed into the field rather than burned. Fiber from the dried, retted stalks were hand-collected by a children's art class and used for the production of hand-made paper. Plants from other plots were cut in October and also retted in water. With the more mature plants, retting was accomplished in about 10 days, and the moist bast fibers were easily removed from the stalks by hand. Further soaking under a variety of conditions, or dried directly, resulted in several distinct collections of dry fiber and pulp masses.

Most local elected officials in Hankasalmi appreciated the positive benefits of free popular attention for the community. Over 30 articles have already been published in Finnish newspapers and agricultural magazines on various aspects of the Project. One member (AMH) even had a spot on the national news (August 16, the educational field being harvested just after it was used as a backdrop for the interview).

The Project officially concluded on September 9, 1995 with a day-long informational seminar, reviewing the events and presenting future possibilities (Kolehmainen *et al*. 1995). The seminar featured a diverse group of 10 speakers, including the local farmers, green activists, a historian, elected officials from the local government, researchers, paper artists and representatives from the International Hemp Association and the Finnish Forest and Agricultural Ministry. Over 50 invited participants attended the seminar, which was also covered by local, regional and national media. A wide variety of literature was on display, in addition to many hemp-related products. We borrowed items from a local farm that were last used for the production of hemp rope in 1964. In addition, a 50 year old hemp rug was lent by the regional museum of handycrafts. Such a hemp product is extremely rare in Finland, since fibers were aggressively recycled during shortages in the 1940s. The elderly woman who had made it was registered for the seminar, but unfortunately passed away only a month before she could attend.

Table 2. Results from forensic testing of Futura-77 and Fedora-19 (courtesy of the Central Crime Laboratory in Helsinki.)

Day	Date	%THC
0	June 13	-
21	July 4	0.04
54	August 6	0.08
97	September 28	0.16

Conclusions

Although the two French hemp varieties were mixed, no variation was readily apparent in any of the plots. Fortunately, for our purposes, these strains of *Cannabis* were routinely bred for THC levels below 0.3%. This was certainly a useful point in our discussions with officials. Previously in Finland, forensic test results were simply reported as 'positive' or 'negative' for THC in criminal cases involving *Cannabis*, no prior consideration having ever been made for actual amounts. It is interesting to note that levels of THC in our plants grown at a latitude of 62^{o} were approximately half the maximum level claimed for the same varieties grown in France.

Although we applied for the EU hemp subsidy for the 0.5 ha plot, the regional agricultural office in Jyväsklä announced that no subsidy would be granted. Initially this agency had informed us that only a portion of the subsidy would be allowed, due to the early harvest and consequent low yield. However, in December, Project members were informed, without explanation, that no subsidy would be allowed. Just recently we were informed by a local agricultural official thet the subsidy was refused by the EU because “the plants were cut before they made seeds”.

It has been decided that the 'non-drug' cultivation of hemp will be allowed to continue in Finland. Although the cultivation of *Cannabis* has never been prohibited in Finland, the law currently states that '*Cannabis* sativa' may not be cultivated for 'drug-purposes'. Therefore, it can be argued that someone who uses any variety of *Cannabis* for drug purposes would be technically in violation of the law, no matter how low the concentrations of THC may be. On the other hand, even high THC varieties can be grown, in theory, as long as the intent is not for 'drug-purposes'. The issue of medical marijuana has not yet been seriously considered in Finland.

Both law enforcement officials and members of the Hankasalmi Hemp Project underestimated the amount of positive public support and interest in the reintroduction of *Cannabis*. In our experience, we found it extremely useful to inform public officials and other individuals of our work, and to form cooperative alliances with a wide variety of individuals and agencies. In particular, similar startup projects should certainly have open dialogue with local elected officials, law enforcement agencies, farmers, ecological activists, people from the arts and crafts, teachers, health care professionals and members of the business community. Another important factor to consider is how the event will be covered by the news media, and a special effort must be made to provide reporters with accurate verbal and printed information. Finally, at least for the foreseeable future, one should expect a certain amount of political fall-out from the past 30 years of political propaganda directed against *Cannabis*.

On the bright side, our greater rewards were an overall positive national awareness of the plant in Finland and the continuing possibility of re-introducing *Cannabis* into modern Finnish culture.

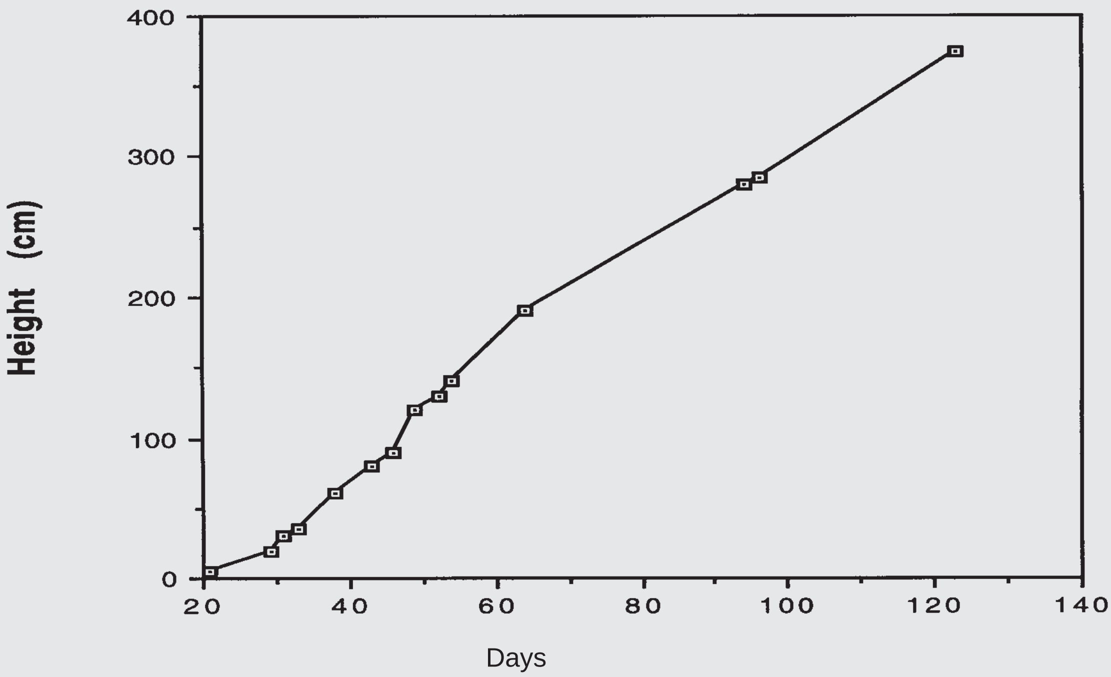

Figure 1. Fiber hemp growth rate (1995) in central Finland at 62.2° N. latitude.

Acknowledgments

We gratefully acknowledge the technical support of David Pate and thank the International Hemp Association for supplying our hemp seed. Special thanks are due to Ulla Kolehmainen, the third member of the Hankasalmi Hemp Project and Culture Secretary of Hankasalmi, who made the 0.5 hectare educational plot in Hankasalmi available for this project. We would also like to thank DC from the Ohio Hempery, Inc. and John Roulac from Hemptech.

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Cultivation of *Cannabis* oil seed varieties in Finland

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Introduction

From a nutritional perspective, *Cannabis* seed is quite extraordinary (Deferne and Pate 1996). But aside from this, the Finnish farmer is currently in desperate need of valuable cash crops to maintain what is left of the traditional family farm. Increasing industrialization since the 1940s, in combination with more recent European Union (EU) restrictions on agriculture, have all but eliminated this rural mode of existence. It was hoped that the introduction of an early-blooming and frost-tolerant variety of *Cannabis* might add a significant financial contribution to Nordic farm life. From the available information on the nutritional value of hemp seed, it should be only a matter of time before the potential of this resource is fully appreciated.

Trial Preparations

Two early-blooming varieties of *Cannabis* (VIR-313 and 315) were originally sourced from the Vavilov Research Institute (VIR) in St. Petersburg, Russia *via* the International Hemp Association. We received a mixture (800 grams) of both varieties in April of 1995. These were planted in several plots throughout central Finland in early June at a density of 20-30 seeds/m^2 and harvested between late September and early October (Table 1, typical data). The resulting hybrid is tentatively designated FIN-314.

Observations

Considerable competition with common weeds resulted from the sparse planting of seed. Males began to flower on July 7 (day 27), and females began on July 17 (day 37). Interestingly, both males and females continued to grow and develop after inflorescence (Figure 1 and Table 1). The typical maximum growth rate was recorded to be 4.2 cm/day during July 4-29 (days 24-49) from a smaller garden plot in central Finland, having good soil (Figure 1). Day lengths during this time of rapid growth averaged 19 hours. In the sunniest portions of the plots, some plants reached a height of 210 cm. Surprisingly, these varieties were not significantly effected by a series of night frosts between September 15-28 (days 97-110). The larger leaves typically regained their original unwilted form during the following day as temperatures increased. Another outstanding feature of these varieties was their reluctance to branch after flowering, even when allowed adequate space. Instead, they continued to grow in height. Only late in September did some of the plants begin to show significant branching.

The total yield from the largest plot (0.1 hectare) was 22 kg of seed (after mechanical threshing) from a very sparse planting of 500 grams of seed. Analysis of the seed (Table 2) resulted in data that indicated a clear superiority over most other varieties, in terms of both oil yield and fatty acid (particularly GLA) content.

Approximately 1-5% of the total plant population succumbed to mold *(Sclerotinia)* or black aphids. An additional 1% of the developing females began to develop mold on and around the bracts during maturation, and these individuals were culled from the plots by hand.

Although the cultivation of *Cannabis* in Finland for 'non-drug' purposes has never been prohibited in

Table 1. Events, days and corresponding dates for the development of VIR-313 and VIR-315 in central Finland during 1995.

Event	Day	Date	Height (cm)
Local sheriff informed	-	April 24	-
Planting	0	June 10	0
Police collect samples	24	July 4	30
Male flowering begins	27	July 7	35
Female flowering begins	37	July 17	70
First pollen appears	39	July 19	85
Police collect samples	57	August 6	135
Frost -2 °C	97	September 15	145
Frost -6 °C	99	September 17	145
Initial harvest	103	September 18	145
Police collect samples	114	September 28	150
Final harvest	118	October 9	155

Table 2. FIN-314 Seed Analysis Results (means of 2 analyses each of 2 random samples, standard deviation in brackets), chlorophyl in mg/kg, other parameters in %.

Parameter	Sample 1		Sample 2	
oil content	36.94	(0.226)	36.79	(0.431)
chlorophyll	181.50	(2.121)	197.00	(4.242)
Palmitic acid (C16:0)	5.65	(0.007)	5.76	(0.070)
Palmitoleic acid (C16:1)	0.12	(0)	0.15	(0.007)
Stearic acid (C18:0)	2.18	(0)	2.25	(0.021)
Oleic acid (C18:1)	8.76	(0.028)	8.87	(0.077)
Linoleic acid (C18:2)	56.53	(0.205)	56.13	(0.141)
GLA (C18:3)	3.96	(0.077)	4.07	(0.021)
Linolenic acid (C18:3)	21.03	(0.120)	20.89	(0.007)
Arachidic acid (C20:0)	0.79	(0.007)	0.81	(0.021)
Eicosenoic acid (C20:1)	0.39	(0)	0.41	(0.014)
Eicosadienoic acid (C20:2)	0.00	(0)	0.09	(0.007)
Behenic acid (C22:0)	0.29	(0.063)	0.29	(0.028)
Lignoceric acid (C24:0)	0.27	(0.014)	0.24	(0.014)

Finland, and despite favorable forensic laboratory analyses, a few officials attempted to enforce a non-extant 'zero-line' policy they claimed applicable to *Cannabis* containing any detectable amounts of THC. Fortunately, after much discussion and support from the agricultural community, our plots of these VIR varieties were allowed to mature and be harvested.

Conclusions

These two early-blooming strains are truly unique varieties of *Cannabis*. Considering their growth habit, it seems possible that these strains are descended from *Cannabis ruderalis*, which is thought native to the Altai region of Siberia. Although the seed was delivered as a mixture of the two varieties, it was possible after flowering to distinguish between them. For both male and female plants, one variety had flowers distinctly darker in color (light purple) while the other was lighter (light-yellow). No other differences were readily apparent.

The season was unusually warm and dry during 1995, which may have enhanced growth rates in this typically cool and wet environment. However, many plots were not in areas of maximum solar exposure. Also, the soil was somewhat depleted in the 0.1 hectare plot after growing barley the previous year and rape seed the year before that, with no additional fertilization prior to the cultivation of hemp. In addition, planting depth in this plot was uneven

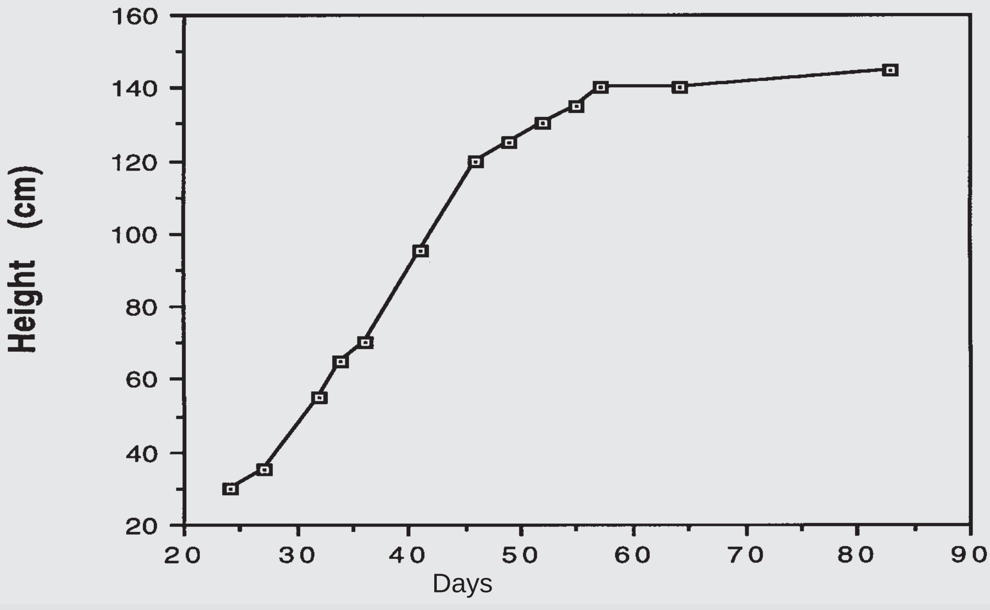

Figure 1. Oil seed hemp growth rate (1995) in central Finland at 62.2° N. latitude.

and mild compaction of the soil surface may have hindered germination. With this in mind, and considering the results from smaller plots on better soil, it seems likely that yield can be increased under optimal conditions.

Recent reports (Theimer and Mölleken 1995, Deferne and Pate 1996) suggest that degree of molecular unsaturation in hemp seed oil may be higher in temperate *vs*. tropical varieties of *Cannabis.* It is not clear, however, whether this effect would be due to genetic or environmental influences. Should an actual correlation exist between latitude and polyunsaturation (and our preliminary results support this), Nordic hemp farmers may realize a distinct advantage over *Cannabis* grown further south for the production of food oil.

We received a considerable amount of attention from the media and law enforcement agencies throughout the course of this project. Through frank and open dialog, we were able to continue this experiment to fruition. Fortunately, these Russian varieties possessed THC levels well below the EU-mandated 0.3% level, which was verified by laboratory tests (0.08% maximum). This was certainly of great advantage during our interactions with the Finnish authorities. It seems that the 'non-drug' cultivation of *Cannabis* will be allowed to continue in Finland.

Acknowledgments

We gratefully acknowledge David Watson and the International Hemp Association for providing the seeds for this adventure in botany and politics, and we especially thank David Pate for his technical support. Additional thanks are due to Hannele Sankari and Leila Salo for the seed oil analyses.

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History of hemp in Finland

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Arrival in Finland

Hemp, a crop plant found all over the world, has been cultivated for at least 3,000 years. It was grown in India during the years 800-900 B.C, and was the first fiber plant to be used in China. In Europe, hemp became known a little later than in Asia. Its use is mentioned at the end of the 'golden' period of Greece and during Roman times, approximately 2,000 years ago. At that time, hemp was already being cultivated throughout the Mediterranean region, according to historic documents.

Recent scientific investigations have, however, changed established opinions on the age of hemp cultivation in Europe. Evidence of hemp cultivation in the area of modern Switzerland, Austria and Germany during the period of 800-400 BC, has been suggested from the analysis of soil samples from these regions. It may be assumed that with continuing paleoecological (*i.e.*, research on pollen from lake sediments) and macro-fossil (*i.e.*, research on plant deposits from the ground) studies, the established dates and accepted geographic distributions for the cultivation of hemp will begin to be altered.

These new research methods are changing opinions on the history of hemp cultivation in Finland. According to current opinion, hemp cultivation reached Finland from Russia (through Karelia, an area bordering modern Finland and Russia) approximately in the 14th century. There is, however, very little recorded information concerning hemp in Finland, even from the 16th century. However, the lack of written source material does not mean that hemp would not have been cultivated in Finland before this time. Paleoecological and macro-fossil research, which have become more common during the last few years, have begun to establish earlier cultivation dates and broader geographic distributions of hemp cultivation in Finland.

The oldest site of hemp cultivation in Finland is on Ahvenanmaa (a large island between Finland and Sweden). In macro-fossil studies, hemp seeds were found in a habitation and burial complex near the present castle of Kastelholma. They were dated from the Viking age (800-1050 AD). Hemp seeds have been found in several southwestern excavations in Finland, dating from a long continuous period from 1100-1500 AD. Hemp was a commercial commodity during that time. Usually it was traded as fiber and not as seed. Thus, the seed discoveries indicate that in this area, hemp was cultivated and not imported.

An interesting discovery was made in Suojoki (county of Keuruu in Central Finland). In the beginning of 1990, excavations were made in a boggy meadow bordering a lake where a large quantity of boat parts were found (*e.g.*, main boat parts, planks, oars, etc.). The cracks between the planks had been caulked with tarred hemp. Hemp serves this purpose well, since it does not rot as quickly as flax. The discoveries in Keuruu have been dated to be from the 13th century. They are thought to be from early inhabitants of the 'Inner-Finland' wilderness of that time. This population has been called the 'fishers and hunters' of the inland since they lived mostly by these means. The latest paleoecological research shows that side by side with hunting and fishing, this population also practiced agriculture. Previously, it was thought that land was cultivated only in Southern Finland during this time.

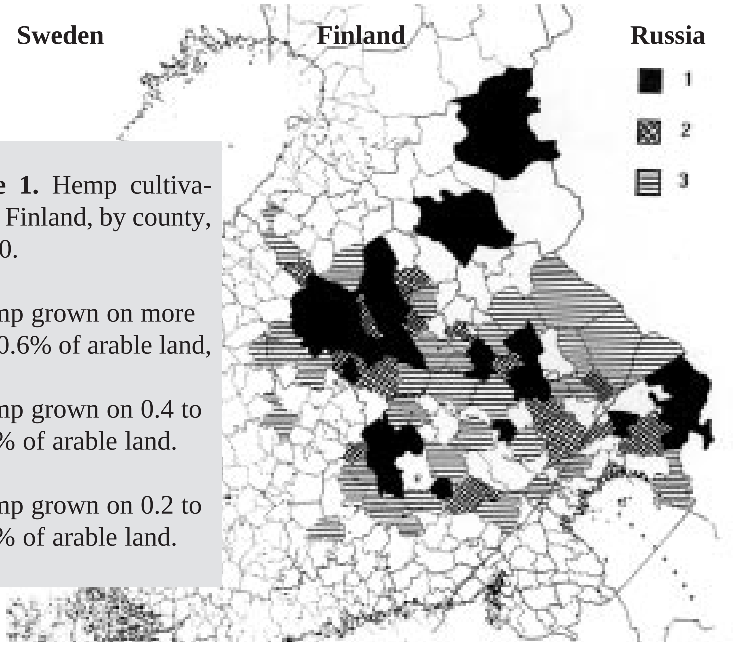

Figure 1. Hemp cultivation in Finland, by county, in 1910.

1: Hemp grown on more than 0.6% of arable land,

2: Hemp grown on 0.4 to 0.6% of arable land.

3: Hemp grown on 0.2 to 0.4% of arable land.

Pollen analysis

Hemp pollen is both easy and difficult to study. It is carried by wind and found in the bottom of lakes and ponds located near cultivation. Problems arise when trying to establish the difference between the pollen of hemp and that of hops, its botanical relative. In most studies, hemp and hops are not separated from each other. Instead, they have been reported as hops/hemp or Cannabaceae. Hemp pollen is always a sign of its cultivation, since hemp has never grown wild in Finland. Pollen from hops, however, is always from a wild plant, for only the female plants were cultivated and not the pollinating males. Wild hops can also be a proof of human influence on nature, for the plant spread with people. However, one cannot build a comprehensive picture of hemp's early history in Finland solely on the grounds of pollen analysis.

Pollen from Cannabaceae, dating as far back as the year 4000 BC and from several periods before and after the year 2000 BC, was found in samples from Säkinlampi (a pond in the county of Hankasalmi in Central Finland) during 1994. However, according to Dr. Virma Vuorela, these pollen samples were from wild hops. The next time period showing pollen from Cannabaceae was from 500-600 AD. This is also the time when pollen from cereal plants increased signifi-cantly. This time period can be regarded as the beginning of stable agriculture in Hankasalmi and Central Finland. It is possible that hemp was then cultivated in the area, although it is more likely that the plant in question was actually wild hops.

Pollen found in the bottom sediments of Armijärvi of Hattula in the region of Häme (in the Finnish southwest) was dated in a pollen analysis to be from the year 570 AD. The study, however, was unable to specify whether or not the plant in question was hemp or hops. Again, this dates back to a time of major increase in pollen from cereal crops. If the plant in question is hemp, its cultivation started with the beginning of established agricultural settlesments.

According to pollen studies, hemp became common in the region of Southern Savo (west of Southern Karelia) during the 15th and 16th centuries, and its cultivation was most widespread during the 18th century and into the beginning of the 19th century. When estimating the culture of cultivation and the long history of hemp, the latter observation is especially remarkable. It tells when hemp became "the plant of the whole population" and when its economical importance was at its greatest.

Current thought

The main objective of pollen and macro-fossil studies is not to know the exact date of the earliest observations on cultivation but the main lines of development. So far, the results can be summarized as follows. Cultivating hemp in Finland is older than what has been formerly believed. It is younger than the cultivation of cereals but, at least in Finland, its breakthrough and popularity began at about the same time as a period known as "the second expansion" of pioneer settlements during the 15th and 16th centuries. This is when stable agricultural settlements became significantly more established. In Central Finland, the beginning of agriculture, a period known as the "first expansion" roughly dates back to the years 500-700 AD. It is possible that the "base population" practicing inland agriculture was already cultivating hemp but, at least so far, this has not been convincingly demonstrated. In the old southwestern agricultural regions of Finland, hemp has been cultivated for at least 1,000 years, and maybe even over 1,500 years.

Based on macro-fossil studies one might estimate that hemp cultivation may have spread into southwestern Finland through Central Europe, the Baltic or Scandinavian regions and not necessarily from Russia. Hemp most certainly spread into Eastern Finland from Russia, as has been assumed to this day. According to many researchers, the cultivation of hemp in Finland is older than that of flax.

Paleoecological research is reshaping the entire history of settlements and agriculture in Finland. A new assessment considering the whole country in this matter has yet to be done, even though a lot of local pilot studies have already begun. When representative sites of the total area are eventually surveyed, the picture of early hemp history in Finland may also become clearer.

Regional expansion

According to pollen studies and written sources the cultivation of hemp increased noticeably during the 18th century. Its greatest expansion in Finland takes place in the 18th century and beginning of the 19th century. By this time, hemp was already cultivated throughout most of the country. It cultivation was more common than flax. Hemp was cultivated to a particularly large extent in Eastern Finland, where flax was almost unknown. Hemp from Eastern Finland was taken, for example, to Pohjanmaa (a region located in the northwestern part of Finland). In the region of Häme (central and southwestern Finland), hemp cultivation flourished in the same locations as flax cultivation. In other words, hemp and flax were not excluding each other as alternatives. In the region of Häme, one could even talk about particular fiber plant areas. People from Häme sold flax and hemp into Southwestern and Western Finland.

The most prominent core area for hemp cultivation was in Eastern Finland, in the Karelia and Savo regions. The skill for its cultivation was also more highly developed there, when compared to Southern or Western Finland. People from Eastern Finland knew to treat the male and female plants differently for optimal fiber production. This knowledge was unknown to Western Finns. Male hemp plants are shorter and mature earlier than female plants. When the male plants were pulled out of the ground, two weeks before the females and treated separately, a finer fiber was obtained from the males. In this way, Eastern Finns substituted the need for thinner fibers and finer fabrics from hemp instead of using flax. In Western Finland all hemp plants were pulled up at the same time, discarding the dry and hardened males.

Exact statistics on the regional cultivation of hemp , by county, only exists from the first Finnish agricultural census in 1910 (Figure 1). . Only those counties having at least five hectares of hemp cultivated per 1,000 Ha of arable land are included. It is clear that in the beginning of the 20th century hemp was mostly cultivated in Eastern and Central Finland. However, this was a period when hemp cultivation was already in a steep general decline. In the long history of hemp cultivation, Southern and Western Finland were once planted much more densely.

Finnish use

Hemp was a versatile plant in Finland. Coarse yarn was spun from it after the fibers had been separated from the stalks. Durable fabrics were woven from this yarn. Eastern Finns, especially, wore primarily hemp clothes well into the 19th century. Hemp was separated into different categories, according to fineness, and was made into linen, towels and table cloths, work cloths, etc. Hemp twine was knit into fishing nets and sacks, and it was also good material for making sails.

Until the post-Second World War era, hemp was the most abundant raw material in the world to make rope. Being a plant with long and strong fibers, it was ideal for this purpose. Water resistant hemp rope - especially if it was tarred- was well suited for damp and wet conditions. Particularly large amounts of rope were needed during the period of sailing ships. Until the late 19th century, ropes were made by hand. Although the Englishman, Huddert, had already patented a rope twining machine in 1793, it was not used industrially in Europe until 1862. Little by little, mechanical twining replaced twining by hand. The latter method remained as a means of providing rope for the Finnish home needs or for small scale local sales well into the 20th century. In some areas Finnish rope was still made by hand after the Second World War.

Rag paper is an old Chinese invention. In Finland its production was started in the middle of the 17th century from rags that were gathered from hemp and flax clothing. Torn rags were beaten in water into a mass, out of which thin sheets of fiber were rolled out. These were dried and pressed into paper. Paper making, which had started as handwork, slowly developed into an industry.

The first paper factory in Finland was established in Tervakoski in 1818. It concentrated on making rag paper even after the use of wood as raw material became common in other Finnish paper factories during the 1860's. Even during the period between the two World Wars, only rag paper was made in Tervakoski and the addition of wood fibers to rags was implemented only after the Second World War.

Better, thinner and stronger paper is obtained from rags than from wood. Until the time just after the Second World War, and to some extent until today, rag paper has been used for the production of the most demanding paper qualities required for fine printing (*e.g.*, currency, bibles, stamp, and bonds), as well as exceptionally thin cigarette paper. Most Finnish currency was printed on rag paper starting from the latter part of the 19th century. The paper of modern money is still made of hemp and flax fibers.

Since hemp and flax fibers were so well suited for paper making, why were they not made directly into paper, but only after they had been used as fabric? Probably because it would have become too expensive, since processing hemp and flax into fiber was so labor intensive. Rags and discarded clothes were cheaper fiber sources and more easily processed into paper mass than fibers taken directly from plants. Flax fibers were not bought directly from farmers by Tervakoski factories before or during the Second World War and sources do not reveal to what extent rags were used or what part of those rags were hemp or flax. Probably during the 19th century, and in the beginning of the 20th century, hemp was more widely used. Most of the hemp rags were brought into Finland from Russia, which at that time was the largest producer of hemp in the world. As the 20th century progressed, flax became increasingly more common.

The oil pressed out of hemp seeds had been used in Finland, for example, as a lamp oil, a raw material for soap and in the production of varnish.

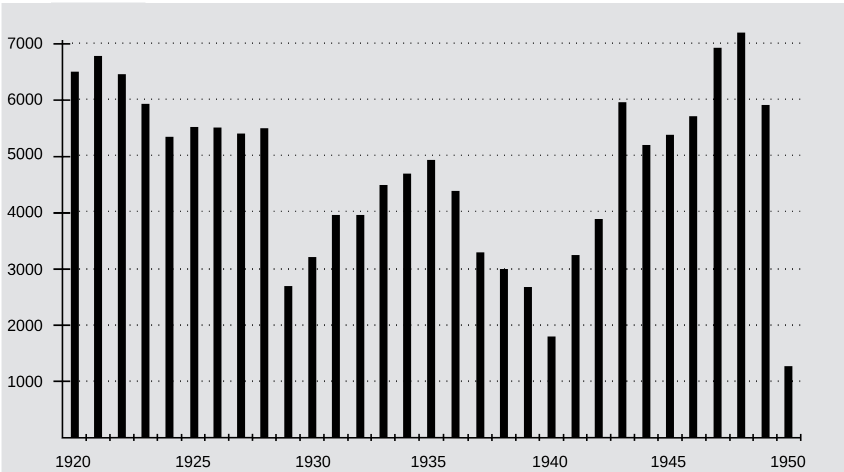

Figure 2. Area of hemp and flax grown from 1920-1950 in hectares.

Decline of cultivation

Practically speaking, hemp cultivation ended in Finland during the 1950's. By the beginning of 1960's hemp was not grown any more, aside from some private farms for domestic needs. However, the decline of hemp had started a lot earlier: in Southern Finland at the beginning of the 19th century, and on a national scale during the latter part of the 19th century. First flax passed hemp as the most important fiber plant for home use, and then for the textile industry. The use of flax was eventually replaced by cheaper cotton imports. Also the commercialization of agriculture added to the decline of hemp cultivation. When more wood began to be sold to bring in money, the labor intensive and time consuming chores associated with the cultivation of hemp and flax lost their appeal. Modern fabrics and clothes could be more easily bought rather than made.

Exact yearly records for the cultivation of fiber plants can not be obtained before the year 1920. The development of the total area of cultivated fiber plants (hemp and flax) since the year 1920 is illustrated in the Figure 2.

During the 1920's fiber plant cultivation experienced a slight decline, which became steeper towards the end of the decade. During the years of shortage in the beginning of the 1930's the cultivation of flax and hemp increased, but during the years of a strong economy at the end of the decade, cultivation turned towards a steep decline again. During the shortage and regulations of the World War II years, people in Finland had to turn back to the cultivation of fiber plants. But as soon as the restrictions were abolished, importation resumed and with more available money, production of hemp again declined sharply. Figure 3 shows the ratio between the cultivation of hemp and flax, and illustrates how hemp cultivation clearly declined before the cultivation of flax.

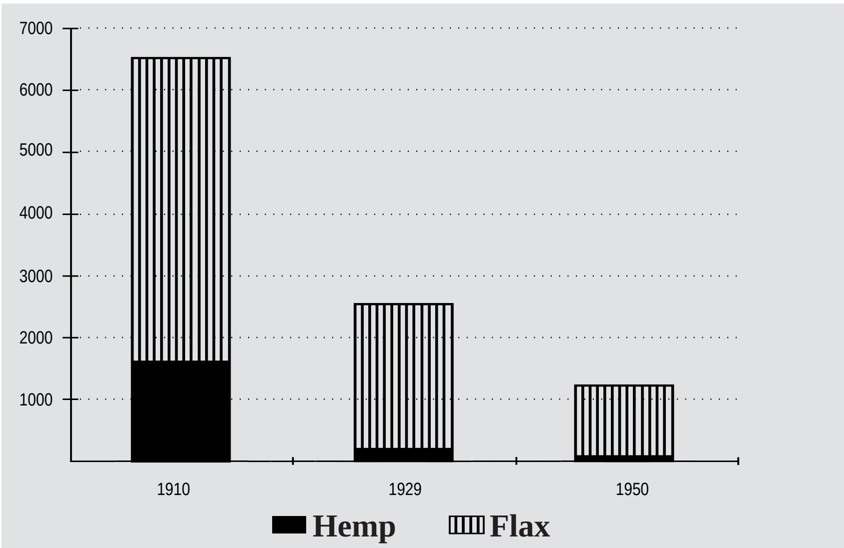

Figure 3. Area of fibre plants in hectares.

New era?

To be realistic, one must recognize that a large scale reintroduction of fiber plant cultivation - especially hemp - in Finland would not be an easy task. The history of Finnish agriculture offers plenty of examples where areas of production have dwindled and lost their importance against cheaper imports. Besides flax and hemp, other examples include the raising of goats (very common at one time), the raising of sheep (almost disappeared), the growing of buck wheat and the use of different kinds of roots in feeding cattle.

It is difficult to rekindle the fire under a production area that has already declined, and which is also labor intensive. Examples of this also exist in industry and in the crafts. Now, even the cultivation of rye, which should be a sacred matter for Finnish culture, seems threatened in the new EU-Finland. Even without obstacles (e.g., legal regulations), the hindsight of history implies that the task of reviving hemp cultivation will require new economic and ecologic ideals, which must then break through into Finnish agri-culture and industry. However, an interest towards blowing new life into hemp cultivation has already awakened in Finland.

Acknowledgements

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Update: Industrial hemp in Germany

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On March 1, 1996 the German Bundesrat (representing the states) followed the Bundestag (federal parliament) and passed a law re-legalizing the cultivation of industrial hemp by a large majority. This step concludes two years of heated public debate of the economic merits of industrial hemp vs. the potential for drug abuse. The law follows applicable EU regulations, which limit hemp farming to full-time farmers, require the use of EU-certified varieties with less than 0.3% THC, and provide for verification by German authorities. Eligible farmers will receive a EU subsidy of 1,500 DM/ha (US $400/acre).

Based on sales figures for hemp seeds and industry interviews, nova Institute estimates that, in 1996, hemp will be grown in Germany on 1,400 ha. The area is limited primarily by tight supplies of French certified seeds, which has driven costs in the German market up from 5 DM/kg to more than 10 DM/kg. The registration of Hungarian and German varieties, expected for 1997, will likely remove this obstacle.

Farmers have contracted with recently emerging hemp entrepreneurs and processors for much of this area. For example, 300 ha in Northern Germany have been contracted by the Dutch group Hempflax, and the Badische Faseraufbereitung (BaFa) near Karlsruhe has contracted 112 ha with 40 local farmers in plots of typically 1-3 ha. In addition to the subsidy, farmers will typically receive 80 DM per delivered ton of straw (next year it will be about 120-140 DM/ton).

Several recently established options will be in place by harvest time for processing of the field retted stalks . All involve decortication and, subsequently, various degrees of mechanical refining of the bast fiber. BaFa plans to install a processing line manufactured in Belgium by Charle, an experienced supplier to the flax industry. It has a maximum annual processing capacity of 10,000 tons of straw, corresponding to 1,000-1,500 ha. In 1996/97 it will process 4,000-5,000 tons of straw primarily into fiber for pulping and automotive applications and hurds for animal bedding (see below). Hempflax is also close to completing a line which combines in-house R&D and equipment purchased outside. The German manufacturer Bahmer is installing three of their newly developed FLAKSY lines in the former East Germany, each with an hourly straw processing capacity of 2 metric tons. Two of the lines are intended to process flax into a fine short fiber for the textile industry, but will likely also process hemp. One of the units is combined with a detergent processing step which produces a very fine, cotton like flax fiber (FLASIN). Another unit may be combined with fine separation equipment offered by TEMAFA. Total capital cost for these lines, all of which have yet to demonstrate their capability to process hemp on the full-scale, vary between DM 1-4 million depending on the quality of the breaker/decorticator unit, the number of separation steps and the sophistication of the dust collection system.

There are several potential markets for the estimated 2,000-3,000 tons of bast fibers and 4,000-6,000 tons of hurds produced in 1996. Karl-Heinz Hofmann at CHEMISCHE BLEICHEREI EUGEN JETTER near Dresden has secured the financing to start-up his production of unbleached long-fiber hemp pulp for specialty papers, such as filter and cigarette papers, in October. The plant will have a maximum output of 7,500 tons of pulp per year. Hofmann expects to pay 700-800 DM/ton for clean, decorticated fiber with a hurds content of less than 5%. Suppliers to the automotive industry show interest in a more processed short fiber for use in compression molded dash boards, door covers, etc., for which they will pay 800-1,000 DM/ton. Whether the dew-retted, highly refined short fiber, which will likely be available at prices between 2-4 DM/kg, can be rotor-spun for use in textiles remains questionable. Additional chemical processing, e.g. by steam explosion, may be required. As in the UK, the Netherlands and France, the hurds will be used for animal bedding and in construction, and will fetch 200-300 DM/ton for the processor, compared to flax shives which fetch only 50 DM/ton.

Small quantities of hemp for seed will be grown in Southern Germany. A growing market for hemp oil in the food and cosmetics sectors now pays 2-4 DM/kg to the producers of organically grown seeds.

For Germany, 1996 represents a challenging "field test" of various aspects of hemp farming, processing and marketing. It is unlikely that hemp cultivation in Germany will expand beyond several thousand hectares without development of new products and markets. To support these market development efforts and to help focus limited resources, nova Institute and two research partners are currently conducting a major study for the DEUTSCHE BUNDES-STIFTUNG UMWELT (German Environmental Foundation). It will evaluate major potential markets for hemp products under economic, technical and environmental criteria and identify the product lines which can be implemented in the short-term.

Conference report - Industrial hemp: Economic opportunities for Canada

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The conference "Industrial Hemp: Economic Opportunities for Canada", held on March 25 at the Design Center in Toronto, fueled the hope that Canada will continue on its route to gradually reestablishing hemp as an industrial crop. Craig Crawford of the Ontario Realty Corporation, a branch of the Ontario provincial government, initiated the event in order to improve the dialogue between the groups involved in reviving the hemp industry and to identify needs for regulatory reform and technology research and development.

The event was sponsored by Agriculture Canada, Environment Canada, and the Bank of Montreal. Of the more than 250 attendees, approximately half were members of the young, growing North American hemp industry. The balance were farmers, designers, manufacturers, distributors, researchers and representatives of industry, banks, governmental agencies, and unions. The presence of significant numbers of Americans and Europeans underlined the international nature of the industry.

Presentations were aimed at giving the audience an overview of various aspects of industrial hemp potentially relevant to the situation in Canada. Gero Leson, nova Institute, presented estimates on global hemp cultivation and markets with a focus on recent developments in Europe. He highlighted the need for implementing processing strategies other than the classical long fiber route for textiles if hemp is to be used more widely for industrial purposes. Sue Riddlestone, Bioregional Development Group, presented her experience with the recent establishment of a lab-scale long fiber line in the UK. Dennis Crone of Mackie International, the world's largest manufacturer of long fiber spinning equipment, introduced his company's equipment and capabilities.

Three presentations covered developments in the US. Andy Graves, president of the Kentucky Hemp Growers Cooperative, summarized the status of legal initiatives in several states and the interest of US farmers in an alternative crop. The recent recommendation by the American Farm Bureau, representing US farmers, that hemp's viability as a crop should be investigated further is largely due to his group's extensive educational and lobbying efforts. Don Wirtshafter, Ohio Hempery, and Eric Steenstra, Ecolution, discussed the experiences of young US firms involved in the manufacturing and trading of hemp oil and textiles which have to rely entirely on imported goods, with limited means of controlling raw material quality in the countries of origin.

The situation in Canada was discussed by the last two speakers. Gordon Reichert, Agriculture and Agri-Food Canada, summarized the results of the 1995 growing trials. Late issuance of growing permits and correspondingly late sowing contributed in some cases to unfavorable growing conditions, such as competition from weeds. Although such conditions will not be representative of large-scale farming, they demonstrated that pests and weeds can cause losses under unfavorable conditions and suggested careful planning for the crop. His main point, however, was that the current legal situation in Canada, which does not permit farmers or processors to sell hemp based materials for profit, is the primary obstacle to further cultivation. To attract farmers and investors alike, changes to the law are of the highest priority.

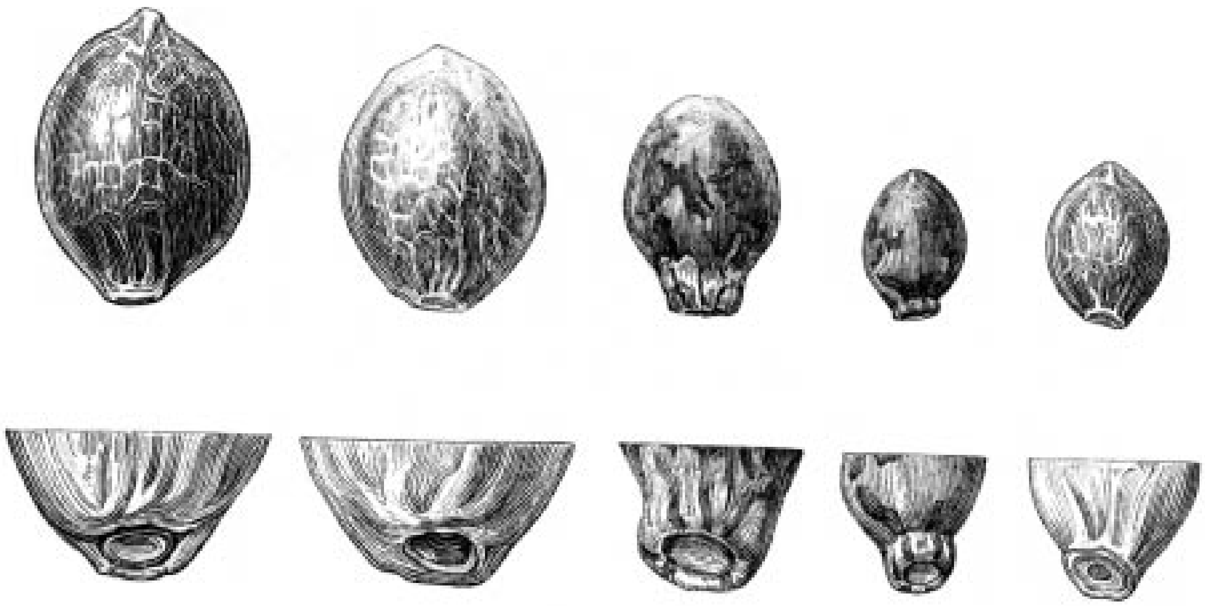
Finally, John Convey of ORTECH, a large national research institution with experience in the textile sector, suggested that simply importing hemp processing technology may not be wise. Instead he proposed the evaluation of various potential processing strategies in light of product specifications by domestic end users. Such an evaluation, initially on the pilot scale, would also have to include economic and environmental features of each technology.

The formal presentations were followed by a lively panel discussion and informal discussions. They demonstrated the wide range of backgrounds of the participants and also their need for information on specific aspects of the industry.

The following day, 40 of the participants, including several representatives from major banks, industrial firms, government agencies, and unions, followed up with a visit to ORTECH's facilities and one day of in-depth discussions of the need for action if hemp is to be revitalized in Canada. The need to overcome the current legal restrictions on commercial farming, processing, and trading was confirmed as the primary action item. Improved communication and coordination between the ministries of agriculture and health, which currently administer hemp cultivation, were emphasized as one potential means of accelerating the political process. The establishment of workable THC standards and cost effective enforcement mechanisms was identified as yet another priority. A working group was subsequently formed to evaluate various regulatory approaches. The long-fiber spinning line offered by Mackie as one of the processing options for the textile industry was discussed in more detail. At a capital cost of $15-20 million, the line produces 80 kg/hr of long fiber yarn and 150 kg/hr of short fiber products. A second working group was formed to compare this and other available processing strategies which may provide flexibility with respect to the use of the produced fiber and lend themselves to pilot testing.

In summary, the event was a success in several respects. Particularly, it demonstrated that there is a strong consensus among major interest groups in Canada to evaluate hemp's technical and economic viability and, in case of favorable results, reestablish it as an industrial crop. The current legal obstacles are seen as surmountable if coordination between the ministries of health and agriculture and the development of a workable regulatory framework for the farming of low THC hemp can be accomplished.

A second conference on hemp will, according to Craig Crawford, likely be held in Toronto in the summer of 1997, as part of the "Human Village", a world conference for designers. It may also be coupled with a trade show for hemp products.



Cannabis seed types, greatly magnified (courtesy of VIR)

Highlights from the Kentucky Hemp Conference

Craig Crawford, EcoDesign Group

The re-introduction of a fibre hemp industry in North America took another step closer to reality, judging from the very successful hemp conference held in Lexington Kentucky May 31, 1996. The key theme running throughout the conference — at least from a Canadian perspective — was the emergence of new technologies that promise to reduce the cost of cultivating and manufacturing fibre hemp.

For about 50 years, hemp technologies were frozen in time as one country after another placed legal restrictions on its commercial cultivation. Much of the farm equipment and manufacturing capacity dates back to the 1940s and 50s and is extremely inefficient compared to today's modern technologies. Market prices for fibre hemp, as a result, are high and therefore restrict market penetration to niche areas. Over the long run, a domestic hemp industry is not sustainable in North America without the introduction of new and more efficient equipment.

The Kentucky conference gave a tantalizing peak at the first wave of new technology about to hit the international market.

Sergei Vorontsov, from the Ukraine, treated the audience to a video that described a new Russian prototype for seed harvesting. The machine combines into one operation both seed collection and the cutting and bundling of the fiber stalk. The result is a dramatic reduction in the need for manual labour in the field. Sergei is looking for Western partners to help finance commercial production of the machine.

Flores de Vries, from Hempflax in the Netherlands, announced the formation of a new company called Hempflax Akkerbouw vof (HFA). After reviewing more than fifty conventional agricultural machines, as well as modern hemp equipment from France, the company concluded that new technologies and methods of cultivation are necessary for large scale cultivation. HFA has now developed a sowing machine that can seed 30 acres per hour. A prototype cutting and mowing machine was also developed that cuts 3-4 metre long stems into pieces 60 centimetres long at a capacity of 7.5 acres per hour. The mower avoids problems associated with long fibres from the hemp plant wrapping around moving parts. Three turning machines were built that do not damage the fibre and leave most of the woody core in the crop. Square bale presses manufactured by Deutz-Fahr were also improved and can bale up to 20 tons per hour in 300 kg. bales. These advances in technology allow 150 acres of hemp to be baled and transported each day. Hempflax B.V. is growing 1,000 ha. of hemp in the Netherlands and 500 ha. in Germany in 1996.

Adrian Clarke, from the Australian Hemp Company, announced his firm has patented a new machine that allows the farmer to harvest and decorticate hemp in the field. The prototype decorticator is expected to cost about $60-70k (US) when it hits commercial production. An enzyme solution is then used to reduce the retting time of the green decorticated fibre from 2-3 weeks, which is normally required with field retting, to a mere 2-3 days. This is expected to lower the costs and risks of retting and reduce the variability of fibre quality. More details about the new equipment and retting processes will be released soon.

New technologies and improvements are also happening in the secondary processing areas of pulp and paper and textile manufacturing.

Med Byrd, Director of Applied Research at North Carolina's Department of Wood and Paper Science, announced "the days of the behemoth 1,000 ton/day, $1Billion pulp and paper mills are over". The trend now is to look for options that include 100-300 ton/day 'mini-mills' that use agricultural fibres and cost $100-150M. Like the Australian decorticator mentioned above, these mills can be located close to the source of raw material supply and contribute to rural economic development.

One of the keys to reducing the size of pulp and paper mills is to eliminate the $300-400M furnaces that are used to power the big mills and control effluent discharges associated with the production of 'black liquor'. The lower lignin component in fibre hemp reduces this waste stream and opens up possibilities for new forms of smaller and lower cost power generation and waste treatment systems like thermal depolymerization (TDP). Paul Baskis, from International Technologies, Inc. of Chicago, Illinois, ran a video describing a continuous flow pilot plant that was constructed in 1993.

The TDP technology is a chemical reforming and separating process that uses heat and pressure in a water environment to convert organic wastes into water, gas, oil, and solid carbon. The oil and gas may be used, among other things, to power the TDP process and the hemp processing facility. The carbon may have industrial value in electronics manufacturing, plastic extrusion, activated charcoal, steel manufacturing, and power generation. When biomass or organic compounds are processed, the mineral ash produced may find use in the fertilizer industry, which uses similar compounds.

John Roulac of Hemptech, a publishing and consulting firm based in Ojai, California, provided information on the composite board, hemp seed and seed oil markets. He emphasized that the capital, technology and infrastructure required for entering the seed and oil markets are significantly lower than with paper or textile production.

Geof Kime, Director of Operations for Hempline Inc. in Ontario announced that the Canadian government is close to passage of a bill allowing the Minister of Health to issue commercial hemp farming licenses.

Finally, Dennis Crone from Mackie International Inc., updated the conference on new technological advancements that will speed up the processing and fibre quality of hemp textiles. Mackie has a long and well established tradition in the manufacture of hemp processing machinery. And in response to the resurgence of interest in hemp, their company is now bringing onto the market new innovations in hemp textile equipment. For example, high technology features have been incorporated into the hackling process to improve sliver regularity, increase throughput speeds and reduce labour. The latest Mackie hemp hackling machine has a capacity of 110 kg/hr of line fibre. The Hempmack series of Wet Ring Spinning Frames are suitable for spinning fine counts of hemp yarn. The recent introduction of the more flexible and versatile Hempmach Mark V further increases spinning speeds and improves yarn quality. Another innovation is the new Demimack Spinning Frame that allows for the dry spinning of both line and tow from sliver for the yarn range Nm 7.2 to Nm 15.

Perhaps one of the most exiting highlights of the day was an unscheduled presentation by Hugh McKee, President of Flaxcraft. Mr. KcKee pointed out that major changes are taking place in the linen industry. Linen producers are upgrading their equipment, and shifting production to America where the mills can avoid paying import duties, reduce transportation costs by being closer to the huge American market, and take advantage of US wage rates that are up to 50% lower than Europe. Flax is now being grown in Vermont, Maine, Oregon and North Carolina. Because hemp and flax can be spun on the same machinery, the costs of implementing a new hemp textile infrastructure in North America can be shared between hemp and flax producers with each fibre targeting different segments of the market. Although hemp fibres are coarser than linen, hemp has the advantage of producing about 60% more bast fibre per acre than flax, and it is more environmentally-friendly because it uses little or no pesticides and herbicides and returns nutrients to the soil as its leaves shed. Under full production, many experts predict that hemp prices will fall somewhere between those of cotton (at the low end) and linen (at the high end).

In summary, the conference was decidedly upbeat, with highly technical discussions often punctuated by foot-stomping applause - something more reflective of religious revivals or political conventions than technical conferences. Although a North American hemp industry has a long way to go, one is left with the feeling that something major is about to happen.

The Kentucky Fiber Hemp Conference was organized by Joe Hickey, Executive Director, Kentucky Hemp Growers Cooperative Association.

Financial assistance was provided by Woody Harrelson, Mackie International (Ireland), Fayette County Farm Bureau, Hemptech, Community Farm Alliance and the North American Industrial Hemp Council (NAIHC).

Craig Crawford is an environmental consultant with the EcoDesign Group, 16 Glenmount Park Rd., Toronto M4E 2M9, Ontario, Canada. He was an organizer of the recent Toronto hemp conference called Industrial Hemp: Economic Opportunities for Canada. He is a member of the board of directors of the North American Industrial Hemp Council (NAIHC) and the newly formed Canadian Agricultural New Uses Council (CANUC). Craig can be reached at tel. +1 (416) 691-1737 fax. 691-0427 or ihn@interlog.com.

BOOK REVIEWS

Analysis of the Profitability of Hemp Cultivation for Paper

Fertig, M. 1995. Wirtschaftlichkeitsanalyse des Anbaus von Hanf (*Cannabis sativa*) für die Papierproduktion. MSc-thesis, Humboldt Universität, Berlin, Germany. 80 pages + appendix.

The study "Wirtschaftlichkeitsanalyse des Anbaus von Hanf (*Cannabis sativa*) für die Papier-produktion" analyses the feasibility of growing hemp for the pulp and paper industry in Germany. The study shows that the option of pulping the whole hemp-stalk for the bulk market -substituting wood- does seem to be less attractive and may not be feasible economically. Given the present market conditions, hemp has its best position in the specialty market. This conclusion is very much in line with the study done in the Netherlands. For example, Van Onna and Van den Ent (1994) also did a feasibility study on hemp cultivation for pulp and paper and came to the same conclusion.

Fertig's results not only agree with other recent studies; they are also being confirmed in practice. None of the pulp and paper industry based on wood has seriously considered the use of hemp, while paper manufactures using non-wood fibres such as flax, cotton linter and abaca have shown real interest.

Furthermore, Fertig is realistic in positioning hemp against wood, concerning the environmental aspect. He is right in saying that additional research on that item has to be done, before one can say hemp is more environmentally friendly as a substitute "wood". The recommendation to choose a method in which the whole life cycle is analysed is very much in line with my opinion. Life Cycle Assessment (LCA) methodology can be recommended in that regard.

Finally, Fertig emphasizes the necessity of considering not only the fibre of hemp, but also the exploitation of the other components. Van Onna and Sengers (1994) have shown the huge market potential of these plant components.

So, Fertig's publication contributes to a realistic positioning of hemp in the market and is worth mentioning.

Before commenting further on the study, it is important to emphasize its focus, otherwise one might expect another approach to be followed and therefore different results of the study. The reason to do the feasibility study is the increasing use of wood and the linked increase of environmental effects. The feasibility study is therefore focused on the substitution of wood by hemp and this validates the approach Fertig has chosen. If the feasibility study had wanted to assess the introduction of hemp as a new crop for farmers an additional option should have been taken into consideration, namely the market of specialty paper, pulps and (non-wood) fibres. A few comments on the scientific approach of the study will be made.

[1] Fertig proposes an integrated-chain approach, in which the market - the pulp and paper industry - dictates the possibilities for hemp. Indeed, one can find costs and other items to consider each of the processes in the production chain - hemp cultivation, storage, transport, pulp production and paper production. However, the integration of all these components into one overall picture is missing. For example: pulp prices have been inventoried, but have not been used in the following calculations. Point 3 illustrates this lack of integration.

[2] Fertig also proposes a market driven approach. In line with that announcement, he should take the market price as a starting point. However, one can see that in the economic analysis Fertig uses 180 DM per ton hemp as a reference. He bases that reference price on the market price of wood (120 DM per ton) and technical arguments. I believe that, for a market driven approach one must consider some additional market aspects also. The first to mention is that one must have in mind that using the whole stalk of hemp means that the (very) short core fibres are still present and that these fibres might need separate processing, causing higher costs in the processing step. A second consideration has to do with the need of a guaranteed supply of fibrous raw material. Regarding

this item, the use (and world-wide availability) of wood can be considered as less risky than the use of hemp. These two market considerations (and I'm sure there are more) make it doubtful whether 180 DM per ton hemp is a realistic reference. Fertig didn't follow the market driven approach, by taking only the technical issues into consideration!

Another (minor) point to think about is the justification of the integration of subsidies on hemp cultivation in a market-driven feasibility study, where the market (pulp and paper industry) is very reluctant to use agro-based fibres, due to the subsidy image of the agro sector.

[3] One of the items that shows that integration of all components in the production chain has failed, is the item "scale of production". Fertig shows a cost profile of CTMP pulp (for a 73,000 ton plant) and suggests that the production of hemp pulp is cheaper than the production of pulp based on wood.

Furthermore, Fertig suggests that paper production based on hemp is not cheaper than wood-based paper production. This conclusion is based on an approach that considers the costs of transport, of processing and paper making separately. However, when one considers the items "production", "transport", "storage" and "processing" in relation to each other, one can conclude that the costs of producing hemp-based CTMP are higher than the costs of CTMP from wood! Two of the determining factors will be discussed.

[a] First is the factor "transport". The area needed to supply a 73,000 ton plant is in the case of hemp much larger than in the case of a wood-based pulp plant. One has to have in mind that hemp is to be grown as (only) one of the crops in a crop rotation, while wood is grown on large-scale plantations, sometimes just "in the back yard" of the pulp unit. This results in higher transport distances for hemp than for wood, assuming a similar capacity of processing. Therefore I seriously doubt whether a transport distance of only 50 km is realistic in the case of hemp and whether transport cost for hemp will decrease to the level of transport cost for wood.

[b] Second is the cost of production of the fibrous raw material. The production of hemp only is viable when the margin of hemp exceeds the margin of other arable crops. Otherwise, the farmer will choose to grow the other arable crops. When a large amount of hemp is needed not only the crops with the lowest margin have to be substituted, other crops with higher margins have to be substituted also. Consequently, the larger the scale of processing, the higher the amount of hemp needed and the higher the costs of raw material will be. Besides this, one has to consider that the substitution of only the least profitable crop is not realistic. Often grain is the crop with the lowest margin, but the farmer must grow this crop due to crop rotation demands.

Marieke J.G. Meeusen-van Onna

References.

Van Onna, M.J.G. and E.J. Van den Ent, 1994. Afzetperspectieven voor Nederlandse hennep en henneppulp in de Papiersector. Den Haag, LEI-DLO, verslag 118

Van Onna, M.J.G. and H.H.W.J.M. Sengers, 1994. Perspectieven voor de laagmoleculaire verbindingen in hennep een eerste inventarisatie. Den Haag, LEI-DLO, mededeling 501 118.

Nutritional and Medicinal Guide to Hemp Seed

Kenneth Jones, 1995. Rainforest Botanical Laboratory, Box 1793, Gibsons, British Columbia, Canada V0N 1V0. US$7.95, 60 p.

From hemp's wide range of possible products, only a few require little or no infrastructural support. Basic products such as animal bedding or building materials are successful examples. *Cannabis* biomass for energy production, especially as a scavenging operation in an integrated manufacturing utilization scheme, is another such use of considerable, but under-realized, "low-tech" potential. However, when all is said and done, it is utilization of the diminutive *Cannabis* seed as a food that poses the single most significant chance for direct economic return and social benefit.

Nearly everyone in the hemp movement vaguely realizes that hemp seed is a source of good nutrition, but where can one seek the actual facts and figures? Until publication of the "Nutritional and Medicinal Guide to Hemp Seed", this data was scattered throughout many different sorts and eras of literature. Author Kenneth Jones has done an admirable job of compiling and interpreting this diverse data and integrating his efforts into one slim, well-referenced and nicely illustrated volume. In this 60-page indexed paperback, some of the seeds' more arcane uses in Chinese folk medicine are first reviewed, with the translation help of Norman Goundry, but it is the last two thirds of the book that provides its core value. This section is divided into four chapters on protein nutrition for humans and other animals, as well as on the seed oil and its health implications.

Mr. Jones is a talented general science writer and has competently handled an interesting topic, but he may not have a great depth of experience specific to hemp. If this is the case, he is to be all the more congratulated, because it won't be evident to most people. However, there are some discrepancies apparent upon close inspection that, if corrected, would make for a better book.

To start off, contrary to claim (p. 7), *Cannabis* is not a member of the Mulberry family (Moraceae) and has not been thought so, for quite some time. It's now classified into its own family (Cannabaceae), along with the genus Humulus ("hops"). It might also be mentioned, in the context of the same paragraph, that seed diameter, as well as length varies quite a bit, even more so than indicated in the text solely for the latter dimension.

A few errors lead one to suspect

that the author did not actually read some of the references cited. In the first case, it was not a German researcher, as stated twice (p. 11 & p. 47), but an Austrian, Peter Rausch, who published observations concerning the superior skin-care (not skin-penetrating) properties of unsaturated fatty acid triglycerides in hemp seed oil. His affiliation and location were appropriately displayed (albeit in German) in the original document. (Jones also uses the terms “cosmetics” erroneously in the second instance and “bodycare products” correctly in the first.) Rausch’s comparison of hemp seed oil was made to a limited suite of somewhat more saturated plant oils also possibly employable as alternative skin emollients, not all other possible plant oils. Flax seed oil, being as highly polyunsaturated as hemp oil, would probably work as well upon topical application, although it is possibly unsuitable due to its taste and smell.

In the second instance of citation error, and more pointedly, the paper of Matsunaga *et al.*, concerning cannabinoid levels in commercially available seed, is not published in Japanese as indicated (p. 53), but English, although the title of the journal is certainly anglicized Japanese. This mistake will unnecessarily dissuade many from acquiring this important reference.

Milder criticism can be made of the author’s throwaway speculation (p. 8) concerning the anaphrodisia of being “stoned”. It is trivial and specious and should be eliminated. Of a slightly more serious nature is the rather generous reported (p. 27) hemp seed yields (1.2-1.5 tons/hectare), certainly not typical of normal harvests (0.5 to 1.0 ton/hectare).

The 2:1 ratio quoted (p. 36) as optimal for fatty acid balance may or may not be true, but in any case, its awkward juxtaposition with the more often quoted 3:1 ratio, renders that sentence confusing. The reported quantities of vitamins in hempseed (p. 22) is exaggerated by three orders of magnitude. The reference cited is inadequate and probably a corrupted version of the original definitive article authored by Don Wirtshafter for the Bioresource Hemp symposium held in Frankfurt last year. The claimed protein content of hemp seed (p. 48) is also inflated at 30%, 20-25% being more the case (p. 22). The author apparently meant to say “crushed hemp seed cake”, for which the former figure is correct (p. 29). However, the idea that the “starving peoples” of the world will be fed (p. 47) with animal products derived from hemp feed, rather than this rich food directly, is nutritional nonsense, rather reminiscent of Marie Antoinette’s famous quote.

Lastly, as miscellaneous nit-picks, seed may contain “0.3% or less” THC (p. 12), but percentages are, of course, autonomous values and not subject to the absolute amounts measured: “(per 100 grams of seed)” is redundant. In that same sentence (as well as pages 5 & 11), the word “narcotic” needs to be replaced with “psychoactive” or even “psychedelic”. Please folks, *Cannabis* is not and has never been a “narcotic”. The characterization of gout simply as “hereditary arthritis” (p. 7) is perhaps misleading. The reference “18” citation (p. 17) is misapplied, referring to another subject entirely. “*Gamma*” is misspelled twice as “gama” (p. 35).

This “laundry list” of greater or lesser errors is correctable in the next edition, since a book of such value is sure to provoke a demand for many more printings. Hopefully, the author will perfect and expand its solid foundation of information, done in comprehensive scope and admirable style. Kudos are also deserved by photographer Geof Kime and by Rich Rawlings who designed the handsome format for a book (printed on 70% hemp paper) that Jeff Chilton of the Rainforest Botanical Laboratory should be proud to distribute (US distributor: Homestead Book Co. Seattle, WA 206-782-4532) at a decent CA$10.95 (US$7.95), postpaid (US$5.57 each for 2-10 copies). Hemp shops, schools and activists will want to inquire about the attractive further discounts available for larger bulk purchases.

D. W. Pate

Hemp & Co

F. Waskow: Hanf & Co. Die renaissance der heimischen Faserpflanzen, published by Die Werkstatt-AOL, Göttingen, Lichtenau, 1995

A new volume has been added to the German literature on hemp. Only 40% of the book actually deals with hemp, the remainder being taken up by fibre flax, stinging nettles and kenaf. The production of the two latter species is a complete novelty in Europe. This reviewer is not competent to give an opinion on the whole book, so this review will concentrate on hemp, which also fits the profile of this journal.

It is very difficult to form a positive picture of the book, since it is extremely similar in form to the Herer-Bröckers-Katalyse book entitled “Hemp”, published in a new edition two years ago. This in itself would not be a problem if it contained a lot of new information, but unfortunately, this is not the case. To be fair, the much smaller size of the book (hemp is treated on a total of 80 pages) does not allow such a wealth of detail as was provided on 400 pages in the book's "big brother". Nevertheless, the book does contain a certain amount of new information, in both the historical section (chiefly as regards Germany) and in the chapters on processing and technology, since literature and results from 1995 are also cited. No book on hemp is free of a discussion of the plant as a source of drugs, though cultivated hemp has very little to do with this. However, this is the first occasion when an author has made a distinction between stimulants and other drugs, [mistakenly] including drug *Cannabis* in the former category.

As is frequently the case when popular books on hemp are written in non-hemp-growing countries, there are a number of objective errors and glaring deficiencies. As regards taxonomy, for instance, hemp is classified in the Cannabaceae family on p.12 and in the Moraceae family on p. 56, while in fact, according to the latest classification it belongs to neither, but to the Cannabinaceae family. The statement (p.20) that hemp was the most frequently cultivated crop in the first thousand years A.D. cannot possibly be true, since wheat, barley, rice and maize certainly took precedence. This is one of the greatest errors in the book, though in other respects it is moderate and endeavours to free itself from the initial hemp euphoria and be realistic.

However, the author falters when it comes to production statistics. To start with, he makes no mention of Hungary, despite the fact that in 1988 the sowing area was still as high as 6000 hectares, with the highest yield average in Europe (9 t/ha). Nor is it true that France has only grown hemp on a relatively large area for the last 8 years. On the contrary, France is the only Western European country where hemp has been grown since the sixties on 4000-5000 hectares. When discussing European production, the author seems to have something against Hungary, because it is the only Eastern European country he does not mention, although it has a 70-year tradition of breeding and the Hungarian varieties are some of the best in Europe. (In another context he does mention one Hungarian variety on p. 73). In connection with the hemp gene bank in St. Petersburg he mentions 72 German varieties (!), although Germany has only ever had 4 or 5 varieties throughout its history. Mistakes of this magnitude are inexcusable even in a popular work.

Another objective error is that hemp seeds retain their germination ability for 5 years, whereas in fact they are unsuitable for sowing even in the third year. He writes of Australia, or rather of Tasmania, as if hemp was cultivated there on large areas; the fact is that cultivation is banned and at most small-plot experiments are carried out, with special authorisation. It is hardly worth wasting words and space on discussing US "production", when this has been banned partially for 60 years and completely for 25 years. It is verging on the ridiculous to mention that experimental production was carried out in 1994 on 0.125 hectares (!). It is an exaggeration to say that modern hemp varieties average 30 % fibre content; this is at most true of the best varieties. Data indicating a fibre yield of 3.3 t/ha probably originate from a small-plot experiment, since this would be equivalent to a stem yield of 12 t/ha, which is the upper limit of the potential yield of southern hemp varieties in Germany. The suggestion that when grown for seed a yield of 2 t seed/ha can be achieved is nothing but an illusion.

The author is also mistaken in his estimation of the nutritional requirements of hemp, and contradicts himself in places. On p. 58 it is stated that hemp requires 60-100 kg less fertiliser then other crops; while hemp is known to have a high nitrogen requirement. At the same time the table on p. 62 indicates that under German conditions a total of 300-520 kg/ha of fertilizer is required, which is no less, or even more than that provided for other crops. So which statement is true? Is the reader to decide for himself? I am not sufficiently familiar with soil conditions in Germany, but it seems unlikely that the best hemp soils are the podzol soils of Mecklenburg-Vorpommern and the pre-Alpine regions of Southern Bavaria. The two regions are approx. 600 km apart in a N-S direction, as the crow flies, and it is highly improbable that the hemp soils follow the administrative boundaries. (see map on p. 60).

In the Appendix (which is quite unnecessary, as it could have been included in the body of the book) discusses varieties ("Die Hanfsorten"). This designation appears to indicate cultivars, *i.e.*, improved varieties. But it seems that the author is either unfamilar with the meaning of the term variety, or has become muddled, as he refers to fibre hemp, seed hemp and marihuana as "varieties".

Finally, it is conspicuous and quite superfluous to include three tables, basically informing readers unfamiliar with the subject of the use of hemp, all containing much the same data on pages 59, 65 and 206 (Appendix).

The general conclusion to be drawn from the chapter on hemp is that everyone would do better to stick to his own field and that, if he must write about biology and agriculture, he should have his manuscript reviewed by a professional. Unfortunately, this step was omitted, so that even the slight virtue of the hemp chapter is dulled by the objective errors. Such errors are probably not to be found in the discussion on paper manufacturing and other technologies. I can only hope that the information on flax and the other fibre crops is more accurate.

I. Bócsa

Upcoming Conferences

A seminar entitled **Renaissance of Hemp** is planned to be held on September 18, during the International Autumn Fair in Novi Sad (100 km east of Belgrade, Yugoslavia). For details contact Dr. Janos Berenji (tel: 381-21-780-365, fax: 381-21-780-198).

The **Fourth European Regional Workshop on Flax and Hemp** will convene in Rouen, Normandy, France on September 25-28 and will include contributions about hemp agronomy and processing. Contact Dr. Ryszard Kozlowski at tel: +48 61 480-061 fax: +48 61 417-830 or by e-mail at SLAWA@ruby.poz-.edu.pl.

At the same time the **Ernte '96** (Harvest '96) hemp conference and expo will be held in Berlin from September 27-29 and promises to showcase innovative pioneers in hemp product research. For further information contact Mathias Brokers of HanfHaus in Berlin at tel: +44 (0)30 614-9884 or fax: -2911.

The **Hemp Industries Association** will hold their annual meeting September 27-29 in Albuquerque, New Mexico. For more information contact Christie Bohling at tel: +1 (602) 988-9355 fax: 988-9438 or hia@aol.com.

The **North American Industrial Hemp Council (NAIHC)** will hold their annual meeting will be held in Fresno, California on October 7-8. For further information visit their web sites @ naihc.org and/or http://www.interlog.com/~ihn/naihc.hton or write to NAIHC, P.O. Box 259329, Madison, WI, 53725-9329.

High Times magazine has promised a **Hemp Expo** on November 23-25, to occur simultaneously with their other well known *Cannabis* event in Amsterdam. Details can be obtained from their magazine or by calling their European coordinator Annie Riecken at tel/fax: +31-20-673-5910.

The Canadian Industrial Hemp Council (CIHC) has announced sponsorship of a **Commercial and Industrial Hemp Symposium** to be held on February 17-20, 1997 at the Vancouver Trade & Convention Center. For more information contact Sotos Petrides or Matthew Kynaston (tel: 604-258-7171, fax: 604-258-7144, e-mail: events@dowco.com or events@wisenoble.com).

Finally, the **Second Bioresource Hemp Symposium** will be held at the Exhibition Center in Frankfurt, Germany from February 27 through March 2, 1997. It will be primarily a scientific symposium, with a minimum of product exhibits. They expect approximately 500 participants from over 20 countries, and if anything like the first conference held in Frankfurt (March '95), it will be the one hemp event of next year that you cannot afford to miss! For further details, Michael Karus can be reached at tel: 49-2233-97-83-70 or fax: 49-2233-97-8369.

EDITORIAL

Comments on a strange decision in Brussels

The flax and hemp committee of the European Union has passed a resolution, published in the "Merkblatt" (official publication) of the Bundesanstalt für Landwirtschaft und Ernährung (Referat 321), which is completely erroneous from a scientific point of view and which will lead to a reduction in income for the producers. This resolution decrees that EU subsidies will only be paid to hemp growers who do not harvest their hemp until the seeds have ripened. If the stand is harvested earlier, they will not only be refused a subsidy, but will also be liable to a fine of 50.000 DM.

This resolution is unprecedented in the history of hemp production for its dilettantism and clumsy interference with the production process, which cannot be justified from any point of view, be it scientific, legal, economic, or any other. This intervention in the production process is reminiscent of the centralised planning directives of the communist era, though even during that period such enormous anomalies did not occur. I have the following comments to make on this resolution :

1) No hemp farmer should be forced to produce seed when the aim is not seed production, but the production of raw material for the textile or cellulose industries, in which case the seed is lost.

2) It is a well-known fact that, especially in the case of the textile industry, the fibre quality of densely sown fibre hemp is at its best at the beginning of female flowering, well before the beginning of seed setting. By the end of seed ripening the quality is substantially worse, due to the lignification of the fibres and the accumulation of large quantities of secondary fibres. This is particularly true for dioecious varieties.

3) It is also common knowledge that even in varieties with a THC content of below 0.3 %, the THC content rises considerably at seed ripening, while it is lowest in the middle or at the end of flowering. Dioecious varieties contain even less THC during this period, since male hemp does not form resin, so it has a negligible THC content.

4) The resolution will promote abuses by making it easier to use stands of low THC hemp to hide plants with high THC contents, which must be grown to seed maturity for the production of marihuana or hashish.

5) The resolution penalises farmers, as it deliberately reduces the yield, particularly in countries such as Germany, the Benelux countries and England, where the weather in late September and early October is often foggy or wet, making it impossible to harvest the crop at the correct time, to dry it and thus to transport it to the processors. This is valid for both monoecious and dioecious varieties. Naturally, the situation is different in France, where hemp is grown at a latitude of 46-48°N, under less critical weather conditions.

6) The resolution is especially damaging to the dioecious Italian varieties Carmagnola, Cs and Fibranova, which are to be found on the EU list, but which could only be grown at great loss in northern countries with a maritime climate, since their seeds would not even mature, making it impossible to fulfil the harvesting conditions laid down in the resolution.

In the light of the above it can only be concluded that some lobby is responsible for the passing of this resolution, since interference of this nature in purely professional questions of production cannot be justified by any rational scientific, legal or economic arguments. It would appear that circles interested in the suppression of late-maturing and dioecious varieties in northern countries must be behind this decision. It is sad to think that such a prestigious international organisation as the EU allows itself to be influenced by narrow-minded lobbyists.

Prof. I. Bócsa, Kompolt, Hungary

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-List of explanatory captions for the transparencies
-Industrial Hemp by John Roulac (donated by Hemptech)
-Nutritional and Medicinal Guide to Hemp Seed (donated by Rainforest Botanical Laboratory)
-Audio tape of Hemp- Raw material of the future by Helen Barrington (with permission of Radio Nederlands Wereldomroep)
-Medical Marijuana excerpts from the Journal of the International Hemp Association
-Voucher for sterilized (North America only!) hemp seed (donated by Ohio Hempery) or a small package of viable (Europe only!) hemp seed donated by the IHA
-'Hempy' hemp seed candy bar (Europe only!- contains live hemp seed) donated by Green Machine Ltd. <u>or</u>
-Roasted hemp seed snack (North America only!-contains sterile hemp seed) donated by Mary Jane's Hemp Seed Snacks
-Small bottle of hemp seed oil (donated by Green Machine)
-Lip balm and body care samples (donated by Alma Rosa N.V.)
-Hemp seed oil spot remover, laundry detergent and crayons (donated by Hanf Haus Gmbh, Berlin)
-Short section of hemp stalk (donated by HempFlax B.V.)
-Small hank of Chinese hemp bast ribbon (donated by Taishan Trading NV)
-Small hank of Chinese degummed hemp sliver (donated by Naturetex International B.V.)
-Short piece of hemp rope made in Holland (donated by the IHA)
-Pure hemp and hemp blend textile samples (donated by Naturetex International B.V.)
-Small package of hemp hurds (donated by HempFlax B.V.)
-Small square of hemp hurd and fiber composite board (donated by HempFlax B.V.)
-Samples of 'Hempstone', a plastic-like composite formed from 100% hemp pulp (donated by Zell Form Gmbh)
-*Cannabis* homeopathic medicine bottle (donated by VSM
-Hemp World's *Hemp Pages* industry source book

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Send this form to: International Hemp Association, Postbus 75007, 1070 AA Amsterdam, the Netherlands. Please enclose the annual fee, preferably as an International Postal Money Order or an American Express or Thomas Cook Money Order. US$ personal checks accepted. 1996 membership fees, Student: US $25 (Dfl.40) Individual: US $50 (Dfl.80) Substaining/Business: US $100 (Dfl.160) or more! (PLEASE PRINT)

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