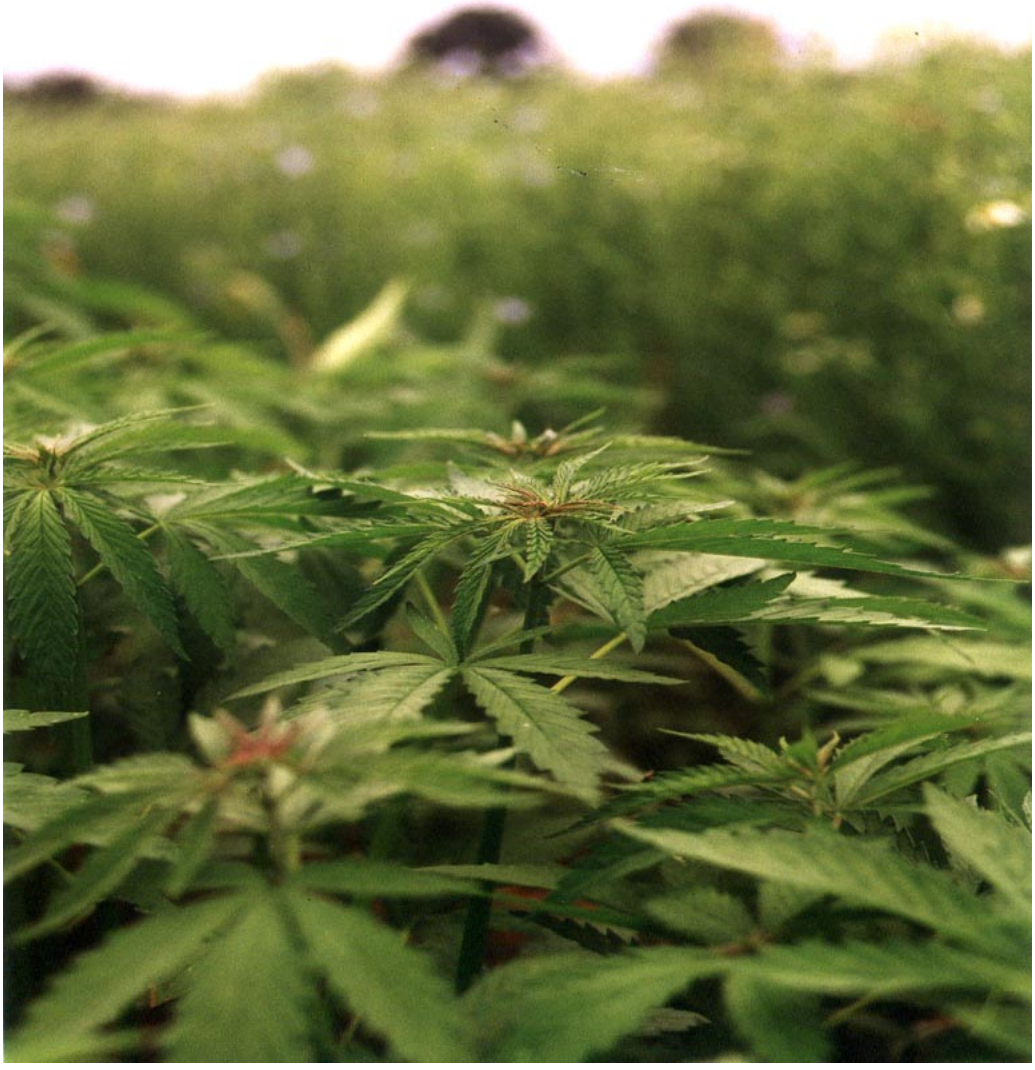
- Ecological Agriculture I -

INTEGRATING HEMP IN ORGANIC FARMING SYSTEMS:

A Focus on the United Kingdom, France and Denmark



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Abstract

The cultivation of hemp declined in the 19th century but it remains one of the oldest and most prominent non-food crops in history. The hypothesis formulated was that hemp's high versatility makes it a prime candidate for integration in organic farming systems. It was also hypothesized that its entrance into mainstream markets is not challenged by its agronomic characteristics but rather by a variety of social, economic and political forces.

The objective of this project was to ascertain the characteristics of hemp, *Cannabis Sativa,* in order to assess their agronomic benefits. Secondly, we assessed the suitability of its incorporation on the farm as a whole-system. Thirdly, we investigated the implications allowing for or disallowing for hemp to become a viable alternative in modern day organic agriculture.

Our project was motivated by the current need for diversification in agricultural systems and the industry's search for alternative cropping solutions. There is also a for-seeable change to non-food varieties due to current overproduction of food crops. Additionally, an increased demand for sustainable fibre production is emerging as we correct our reliance on the use of non-renewable resources.

The project was sectioned into three main parts: an agronomical review of the crop compiled on a literature basis, an active research section based on the analysis of interviews with farmers, advisors and researchers and the final section combining the knowledge gained and opinions formed from the prior two components to analyse the place of hemp in organic systems.

To strengthen their validity, interviews were conducted in person; lessened emphasis was given to literature aspects as information was found to be limited, and in some cases its accuracy (and therefore reliability) often hard to assess. Systemic methods of analysis were employed to extract information from the interviews and gain a whole system picture regarding the incorporation of hemp in organic agriculture.

The main conclusion from our research is that hemp is a viable cropping option for organic farming systems. It relies on minimal inputs in comparison to conventional crops especially once crop establishment has occurred. Its weed break potential and tolerance of pests and diseases were among the main contributions to organic systems. Additional benefits included soil conditioning abilities, contributions to local economies and increased diversity within food and fibre industries. Though the current market situation is impeded by legislation, the potential for expanding the hemp market appears to be promising.

Preface and Acknowledgements

In the context of the course Ecological Agriculture we have come together to produce a final project that would reflect the new knowledge and insight gained of crop production within organic farming systems. We have chosen to explore the potential and suitability of hemp for integration in such systems, a theme that intrigued all of us due to the amount and conflicting nature of information on it that we had come across in the past. In times of change for global agriculture, it is of significant value to explore alternatives to the relatively reduced amount of crop species we rely upon.
To produce this work has certainly been the most enriching experiences we have had as individuals in the context of this course. Denmark follows an education principle of group work, which none of us had extensive experience with before coming here, and certainly not in a language that was not native to 3 of our 5 group members. The path was certainly not always even, but the rewards proved bigger than the obstacles. We devised systems of work division that enabled everyone's input into all parts of this report and produced most of it in a series of tea-drinking/laptop-writing/poster-drawing/food-making/laughter-inducing discussion sessions that ranged from early morning starts to early morning endings. We have truly discovered the dimensions of teamwork, people management and problem solving. We have found that not only do more people produce more work, but one which is of better quality and larger scope: the result of "emergent properties" than none of us as individuals could have offered – a systems thinking concept now intrinsically understood by a truly organic group!

We could not have done this report without the help and support of many individuals, to whom we owe grateful acknowledgements:
To all the farmers we interviewed, without whose experience and insight we could never have reached the level of understanding of the real issues surrounding the growing of hemp. For their time, commitment and patience to receive and help us obtrusive students at one of the busiest times of the year. Your farms were the most beautiful classrooms we have been in.
To the researchers and advisors who helped us in our enquiries, both over long phone conversations and interviews in person, whose knowledge and resources have given us strong lines from which to draw our investigation. Of these, we would like to give a special thank you to Malcolm Leitch, Letitia Brunnevalle, Geraint Hughes and Jim Dimmock for providing us with cornerstones.
A big THANK YOU to our supervisor Henrik, whose guidance and fresh approach has greatly inspired us: your encouragement and confidence in us were priceless.
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Last but certainly not least, to Lee, for his patience during the gestation of this project and continuous support in the most varied range of needs, from tea making to typing and text revising. You never tired and have our heartfelt gratitude: we owe you one!
To all the above, in appreciation for your help, we hope we measured up to it!

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Introduction

Industrial hemp (*Cannabis sativa* L) is grown for a variety of end products from the seed, fibre and wooden core. These include numerous paper products, insulation material, textiles, replacement for glass fibres, building material and seed for human consumption. It is one of the oldest non-food crops world-wide. In Europe, flax and hemp were the most important fibre crops from the 16th to the 18th century. Although the cultivation of hemp declined during the 19th century, interest in the crop has recently been renewed within various European countries, and around the world (Struik et al., 2000).

Such interest has been triggered by a number of factors. The general overproduction of many agricultural commodities within the EU has stimulated the search into novel uses of land, as a way to both ensure increased economic viability for farmers in the face of the falling price of many cereals, but also to overcome the increased susceptibility of common crops to pest and disease outbreaks. Of additional concern, are the environmental problems resulting from the high inputs of chemical fertilizers and pesticides within modern agricultural practices (Meijer et al., 1995). Furthermore, hemp's role within the pulp and paper industry has provided a potential solution to widespread concern over current deforestation practices. It is in this context that hemp has been re-discovered as a "new" crop, with a large plasticity, and which can be grown under a variety of agro-ecological conditions (Struik et al., 2000).

From a commercial point of view, both the crops productivity, as well as the variety of raw materials it produces, put it ahead of many other non-food crop (Struik et al., 2000). Hemp has not only proven to be very high yielding compared with other crops (Van der Werf et al., 1996), but has also developed a reputation as being a relatively easy crop to grow. It requires little or no biocides, suppresses weeds effectively and has limited demands with respect to fertiliser usage or rotation requirements (Van der Werf, 1994). Potential improvements to soil structure and nutrient status (DEFRA, 2002), as well as to the surrounding biodiversity (Montford and Small, 1999) are a few of the potential added benefits that have been put forth concerning the crop. Such attributes place hemp as a prime candidate within organic farming systems (Hemcore Growers Guide, 2003).

In spite of such benefits however, hemp remains a marginal crop within European agriculture in general, with an especially limited role in the organic community. Although a substantial body of research has examined the effect of various management strategies; such as planting density, harvesting time and choice of cultivar; on the yields and quality of hemp fibre, no research has studied the crops potential within organic agriculture.
Our research seeks to fill such a gap, and answer the questions:

Why integrate hemp into organic farming systems? And what are the challenges faced in doing so?

Our hypothesis is that hemp's high versatility makes it a prime candidate in organic farming systems. Its entrance into mainstream markets is currently challenged not by its agronomic characteristics but rather by a variety of political, social and economic forces.

Our objectives are to establish:
1)…the different agronomic characteristics and assess the benefits of hemp as a crop.
2) …the suitability of hemp for use within organic farming systems, with a focus on the UK, France and Denmark. .
3)…the limiting factors influencing hemp's entrance into mainstream markets.

As important as the content of our research is the employed methodology, which reflects a systems based approach. Systems theory holds that the behaviour of higher systems cannot be completely understood simply from the study of its different components, but must both acknowledge the interactions that exist within the system, as well as the particular properties that emerge from the system as a whole (Checkland, 1981). Such a way of viewing the world, we feel, remains central to the principles of organic farming, where a holistic and integrated approach to managing natural systems is pivotal. We believe that extending these principles, which we recognize as inherent to organic farming systems, and incorporating them into our research methodology, is the most appropriate way of responding to the particular needs of organic farming.

Our intent in following a systems approach has been present in both the sources of our research, as well as in our method of analysis. While the first part of our research will involve a review of the literature, in order to both better understand hemp's agronomic potential as a crop in organic agriculture, and to establish the scope and nature of the relevant literature, the bulk of our research will be interview based. From these interviews we hope to obtain the perception of researchers, advisors, and especially farmers, regarding hemp's potential within organic farming systems. The choice to interview farmers emanates from a) the existing literature's limitations on the topic b) recognizing the central role of farmers as stewards of such knowledge and attempting to involve them in the research process and c) our desire to take into account the larger socio-economic and political reality. Given the latter's potential scope, our focus will remain on the agronomic and ecological contexts, while the social, economic and political influences will be touched upon to the extent to which they affect farmers' decisions.

Our analysis included a systematic review of the interviews and representation through the visual technique of "mind mapping" (*vide infra* figures 21 and 22). Finally, in order to bring together our findings from the literature with those from our interviews, we have produced both a SWOT analysis; which assesses the strengths, weaknesses, opportunities and threats of hemp's integration within organic farming systems, as well as a short practical guide entitled "10 Steps to Becoming a Successful Organic Hemp Grower."

Organic Farming in Context

Before beginning our analysis, we thought it was important to provide a background about organic agriculture, which is central to this endeavour.

Organic farming is establishing an important role in the world as an alternative to conventional agriculture, and is based on a value system that recognizes the inherent worth of people, animals and the wider environment (with special emphasis on the soil). It derives its sustainability through working in closed cycles, relying on biodiversity, renewable and local resources and by combining ecological considerations with socio-economic ones (DARCOF, 2000).
One of the differences between conventional and organic farming lies in the latter's search for optimisation, not maximisation, of the agricultural interaction.
While conventional agriculture tends to concentrate on the input-output relation in terms of resource sufficiency and economic stability, organic agriculture shifts the focus to the values and relations existing on the farm and beyond, making the individual a part of their surrounding environment, which has been referred to as the system's functional integrity (Thompson, 1997).

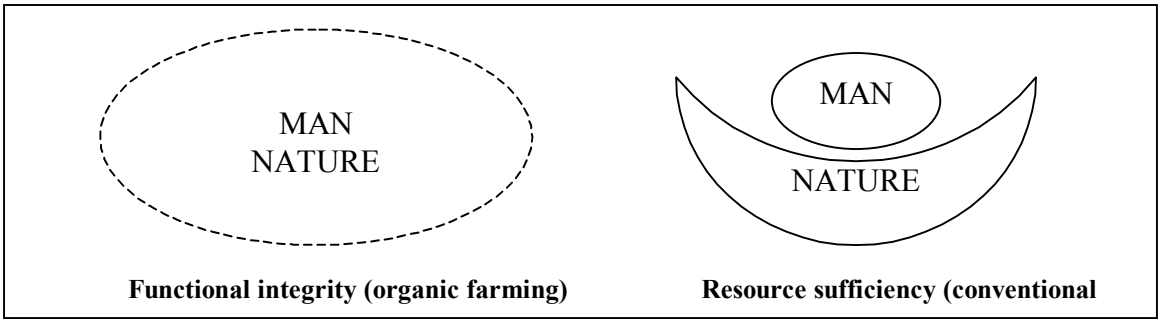


Fig 1: Two views of the relationship between man and nature (Thompson, 1997)

Therefore, organic farms recognize themselves as being an integral part of a complex agroecosystem, and maintain strong connections between farming practices and the socio-economic reality upon which they depend.
We would like to add that organic farming is a real and realistic player in today's agricultural market, going from strength to strength within the agri-business industry. We see it as a modern and innovative way of achieving equitable methods of production and trade and thoroughly expect to contribute to it becoming a mainstream option for consumers throughout the world.

PART I: The Cultivation of Hemp

1. A Bit of Hemp History

Hemp has been an agricultural crop for thousands of years. Originating in Eurasia it was probably native to India, southern Siberia, southern Russia and China. Hemp is the first plant known to be domestically cultivated. Throughout most of its history it has been heavily relied upon to support the growth and expansion of the human population across the globe in a large and diverse range of uses.

More than 10,000 years ago the Chinese were processing hemp fibre for use in ropes. The earliest hemp fabric found dates back to around 8000 BC from ancient Mesopotamia. This makes the textile fibre of hemp as old as pottery and older than records of metal work (Ryan, 1994). The first pulp paper made in China in 105 AD was made of hemp and bark (hempmuseum.org). The oldest printed-paper in existence is made of 100% hemp. Archaeological sites of Ancient Egypt have uncovered concrete made from a hemp base.

It was being cultivated in the Middle East at least since 450BC for fibre, oil and as medicine. Its medicinal and mood-altering properties have been known and used since ancient times. The Chinese, Indians and Ancient Greeks treated a range of physical and psychological illnesses with Cannabis. To gain the effects the leaves were smoked or infused in tea while the nectar from flowers was baked into cakes. It became the most common additive in patent medicines, after alcohol and opium, in Western Europe during the nineteenth century (Ryan, 1994).

It made its way to the rest of Europe and Africa via trade routes becoming known as a very useful and easy to grow plant. Its introduction into Europe occurred about 1000AD. Italy became a major exported of hemp fibre that was used for clothing, tents, sails, linen, drapes, quilts, sheets and towels.

By the sixteenth century it had become the most widely cultivated crop in the world (www.viperrecords.com). As the longest and strongest plant fibre known, it demonstrated excellent qualities such as abrasion and rot resistance. The word canvas is a derivative of the Latin word *Cannabis.* This product supported the fishing industry in the Netherlands throughout the seventeenth century contributing to the manufacture of nets, rigging and cordage, and sails. Hemp continually increased its number of applications producing rope, cloth, fuel, paper, paint, food and medicine. Hemp seed oil was the most common lighting oil before 1800. It was also used for in cooking and later, for engine lubrication (Ryan, 1994). In 1619 farmers in America were ordered to trial hemp cultivation. Spanish Royalty imposed mandatory quotas throughout Spain also about the same time (Mignoni, 1999). England ventured along the same path and fines were often given to those who refused to grow it (Herer, 1998).

Other fibrous products came into the market after the seventeenth century. Cotton, flax, jute and even silk all were in competition with hemp. The steamship era of the late nineteenth century yet again diminished the demand for hemp (Mignoni, 1999).

This was particularly evident in Europe and America. In the 1820's the invention of the cotton engine allowed cotton to become as economically viable (if not more so) as hemp for textile fibre (Ehrensing, 1998). With the discovery of paper production from trees hemp was left unable to compete in this industry too. Chemical production made paper production from wood pulp much cheaper than paper made from hemp. Paper production from recycled hemp fibre continued in Europe until 1883. Competition against hemp continued to grow at the turn of the twentieth century as the use of petrochemical substitutes increased.

With increasing difficulty for farmers to produce at a profit, a declining trend in hemp cultivation began. In response to this growing pressure, the hemp industry developed the technology to mass process hemp both efficiently and economically. With updated machinery it was predicted that resurgence in hemp popularity would revive the industry. But advancements in technology were occurring in other industries too. New and improved materials were entering the market. 1937 introduced a new competitor, nylon. The production of this new product, advertised as synthetic hemp, was pressuring hemp again (Roussel, 1999). Having been used for thousands of years to treat conditions of epileptic fits to arthritis, hemp extracts became replaced by synthetic drugs. Its use for fuel also lost relevance as fossil and chemical fuels became more easily synthesised. The reliance on the plant was diminishing.

Narcotic laws being passed at the time hugely affected the decline in production. Industrial hemp was tied to marijuana and therefore was prohibited around the globe. Many European, all American as well as ex-European colonial countries banned the cultivation of all hemp for the most part of the century. America was the instigator of this change:

America and Hemp Controversy

Hemp's versatility led to its prominence in American culture in the Colonial era. Advocated by both George Washington and Thomas Jefferson and even grown by them for its fibre content, the crop's future looked promising. Jefferson invented the hemp break designed to separate the hemp core and fibre with greater speed then past retting processes. Benjamin Franklin opened one of the first hemp paper mills. This enabled America to end their reliance on England for paper and books (Herer, 1998).

Being heavily relied upon for such a large variety of products hemp cultivation was made compulsory in many young communities (www.hempcar.org). The sails and ropes of colonial ships, maps and bibles were made from hemp fibres. At the same time oil from hemp seeds was used as lamp oil. The growth and development of these communities was reliant on the multifunctionality of this single crop. Hemp fibres were even used as money and as a currency for paying taxes from 1631 and continued for over 200 years (Herer, 1998, Roussel, 1999). Up until 1937 hemp continued to be cultivated as a highly respected and dependable resource. At this point the American Government outlawed the narcotic marijuana. Three men who played very active roles in the prohibition process were Henry Anslinger, Lammont DuPont and William Randolph Hearst. Anslinger was the deputy commissioner of the federal government's alcohol prohibition campaign and then later was appointed the head the Federal Bureau of Narcotics. DuPont owned the leading chemical company and Hearst ran the largest chain of newspapers. There are thoughts of conspiracy

surrounding their actions but much bias clouds fact and so inhibits conclusions being drawn. What is known is that they worked hard to achieve hemp prohibition and were not supportive of its return to the market. The Marijuana Tax Act was economically beneficial to them all. Though this legislation did not specifically target industrial hemp it failed to make clear the distinction between the cannabis varieties. The bill charged a hundred dollar tax on each ounce of hemp sold and rendered the crop uncompetitive (www.viperrecords.com). The hemp industry quickly took a down turn as the new legislation meant all hemp used was imported.

Surprisingly, hemp cultivation resurged due to the federal government's war effort took precedence in 1942. Hundreds of farmers were encouraged to produce hemp for wartime needs. It was required for uniforms, ship's rigging, shoes, parachute webbing and baggage. Three thousand acres of hemp were planted and seventy-one processing plants were built to keep up with the demand for war products (www.viperrecords.com). Then when World War II was over so was the allowance for cannabis cultivation.

2. Hemp Today

It remains quite difficult to obtain figures concerning the numbers of hemp growers, as in certain countries the questions of legality or public perception will impede the availability of such information, nevertheless, we know that at least 26 countries allow for the commercial cultivation of hemp.
Present day overproduction of foodstuffs has resulted in the agricultural sector looking for cropping alternatives (Conrad, 1994). This has renewed interest in the once "worshipped" crop. Research into new applications for hemp fibre has begun worldwide. This has brought about the need for government policies and legislation. Clear distinctions are required as to know what is now legal and what is still under prohibition. Basically the confusion around hemp cultivation needs to be eliminated so not to hinder its return to the market.

2.1. Politics and Legislation

A new surge of interest is being voiced as to the present day potential of industrial hemp as we search for more sustainable methods of agriculture and resource management. This sudden upward trend in industrialization is most active in Europe. Policy makers and legislators have understood this, and an easing of restrictions is already noticeable in many countries.

Licensing

Grown as a fibre crop, prices and trade agreements for hemp are often the same as regulation for flax. The obvious difference arises from authorities controlling the spread of the narcotic use of the species. Therefore licensing and allowed varieties are more strictly regulated. Legislation in the EU set the THC limit of cultivated hemp to a level of 0.3% (Wynn, 1998). This was further lowered to a level of 0.2% for the years 2001/02. THC is the psychoactive drug in Cannabis. In the marijuana variety the THC level is nearer the range of ten to fifteen per cent (Hemcore, 2003). A formal application must be drawn and sent to the EU before permission to cultivate hemp is

granted. The application must report the size of the area designated to hemp and where it is situated. The grower must also declare the end use of the crop prior to licensing. The license needs to be renewed annually.

Only certified hemp varieties can be purchased and must be done so through a licensed seed seller. EU approved varieties, as of November 1997 were:

- Carmagnola
- CS
- Delta-Llosa
- Delta-405
- Epsilon-68
- Fedora-19
- Fedrina-74
- Felina-34
- Ferimon
- Fibranova
- Fibrimon-24
- Fibrimon-56
- Futura-77
- Santhica-23

(Hennink, 1997)

Subsidies

The entire field nominated in the application must be sown and harvested (Hennink, 1997). The time of harvest for fibre production is also regulated to prevent the crop being used for illegal purposes. The crop must contain more mature seeds than immature seeds to insure that the pollen is not able to be collected at harvest. Unfortunately this regulation is at odds with the plants biological cycle (Mignoni, 1999). Ideally the crop should be harvested earlier as stem growth is completed at the time of seed production. Further conditions of the harvest procedure include mowing the crop at the maximum height of 20cm or pulling the crop up by the roots to end the growth period.

Just as for flax cultivation, subsidies can be obtained for hemp production within the EU. The subsidy was established in the early 1970's to help farmers establish economic competency on the world market (Hennink, 1997). Hemp subsidies are granted based on farmers' compliance to report the area and location of the field and to use only the certified seed varieties (McDougal, 2000). The grower is required to send with their application the labels of the seed to prove that at least 25 kg/ha of that variety have been sown (Hennink, 1997). There is also a set date by which the appropriate forms need to be completed.

Further steps are required by the grower after harvest to ensure the subsidies are paid. The grower must confirm the area harvested. It is also needed that they can provide information as to the storing of the crop and whom it was sold to. The appropriate authorities have the position to be able to take samples of each crop and test for THC levels (Hennink, 1997). These regulations are seen as necessary measures to prevent production of Cannabis for illicit use.

Aid for processing the fibre is available and is also coupled with that of flax. Authorised primary processors are granted aid according to the quantity of fibre contracted with the farmer for processing. It is possible for the farmer to also be the primary processor. In such cases, the processing is received in addition to the area subsidy (<europa.eu.int>). Aid amounts vary depending on the quality and the period in which the processing takes place. Hemp fibre containing a maximum of 7.5%

impurities received aid of 90 EUR for the period of 2001/02 to 2005/06 (<europa.eu.int>). Leniency of authorities in the period 2001/02 to 2003/04 permitted higher percentages of impurities than those originally outlined.

The UK

In the UK hemp production is monitored by the organisation Hemcore. No applications to cultivate hemp are permitted without prior approval by this organisation. This is due to the need to follow the end use of the fibres and to comply with UK environmental regulations. Previously each applicant farm would be inspected for site suitability but more recently there has been a change to a system of self-determination between Hemcore and the grower. The suitability of a field is determined by access by public roads and proximity to housing, school and recreational areas. This is due to incidents of crop theft (Hemcore, 2003). Licensing requires the grower to describe the selected field with the inclusion map showing its location and sign a growing contract.

As industrial hemp is a recognised crop within the Arable Area Payments Scheme (AAPS) it is subject to receiving aid subsidies just as in other EU membership countries. The scheme offers payments to farmers on the basis of the area of eligible land cultivated with hemp for fibre. Hemp cultivation for other purposes, such as seed production is not granted aid under this scheme. As well as area aid, a processing aid of 90 EUR per tonne is paid to the grower through the increased price paid for the straw (Hemcore, 2003).

France

France has established itself as a leader in industrial hemp production. From 1982 until 1985 it remained the only Western European country to continue industrial hemp cultivation (Mignoni, 1999). In 1968, regulations were decided by the union to protect textile raw material production (Mignoni, 1999).

Denmark

Currently the situation of industrial hemp cultivation in Denmark lies with only one grower. The grower is also processing part of his yield and so receiving both the subsidy for cultivated land area and the processing aid. The EU has developed production quotas for exportable hemp fibre for each of its member countries in an effort to regulate the market and control prices. With little hemp production, Denmark is contributing no amount of hemp fibre towards its quota let alone just no managing to fulfil it.

North America

Only a few years ago there was no such thing as a hemp industry in the United States. Government policies on the prohibition of hemp are slowly changing. In 1996, politicians in 4 American states introduced legislation allowing for domestic hemp cultivation (www.hempcar.org). Just one year before the same change was presented and dismissed. Now measures are being taken to increase hemp research while hemp importers, retailers, manufacturers and products are on the increase.

The Drug Enforcement Agency, DEA, is currently still strongly opposing the changes in legislation that allow hemp cultivation. The DEA is in charge of providing the licenses required for farmers to grow industrial hemp and has so far denied all large-scale applications for the past forty years. They continue to defend their position to the ever-increasing voice of hemp activists. The DEA classifies all *Cannabis sativa* varieties as Marijuana. In other countries hemp legalization issues go through agricultural and/or health (food) agencies (Morris, 2002). The DEA remains the single authority for hemp production in America and therefore the process for increasing industrial hemp production is as yet retarded.

So without the US to provide a comparison of legislation in a non-EU country, the example chosen is Canada. The governmental health authority Health Canada issues regulations. Hemp varieties are certified to have THC levels below 0.3%. Imported and exported hemp is in the form of seed or viable grain and only occurs with listed countries. Trade is made possible only under license and a permit needs to be issued for each shipment. To obtain the license, applicants first require a police security check (West, 1998). It is the importers responsibility to also ensure that foreign certification of the seed accompanies the product. No permission is given for the transportation of whole plants.

Seed growers are restricted to minimum plot size of 0.4 hectares. Licensing of seed growers requires demonstration of current membership in the Canadian Seed Growers Association (West, 1998). Plant breeders also need to show membership to gain their license. They are not subject to regulations of minimum plot sizes. Fibre producers require a license before they can purchase certified seed varieties. Growers are required to include records of the hectares grown in their last two years of cultivation as part of their license application.

Our perception

Industrial hemp cultivation requires much monitoring by authority organisations to ensure regulations are adhered to. If the market can support hemp as an economically viable crop then licensing requirements should not prevent it from being an additional crop option. The variety restrictions and then also having to maintain the crop until half the seeds are full seems to be unnecessary precautionary regulations. Add then also the need to reapply for the license each year and having random spot tests of the crop carried out by the authorities may be too imposing on some growers. Too many regulations and overlapping of legislation can have effect of deterring framers to chose hemp as an alternative crop in their system. This then hinders the growth of the hemp industry. Authorities have the responsibility to ensure that policies in hemp cultivation are reasonable, practicable and achievable and so sustain production for this crop.

2.2. The Marketplace

With 15.000 ha in Europe in 2002, hemp is consolidating its niche and it is reasonably assumed that the production can increase up to 30.000 ha at medium term. In the world, the global production is estimated to 200.000 ha (www.globalhemp.com).

Hemp has multiple end uses this is the main characteristic of its high versatility. Its properties make it able to cope with many different requirements for industrial use. Figure 2 depicts the breadth of the end uses.

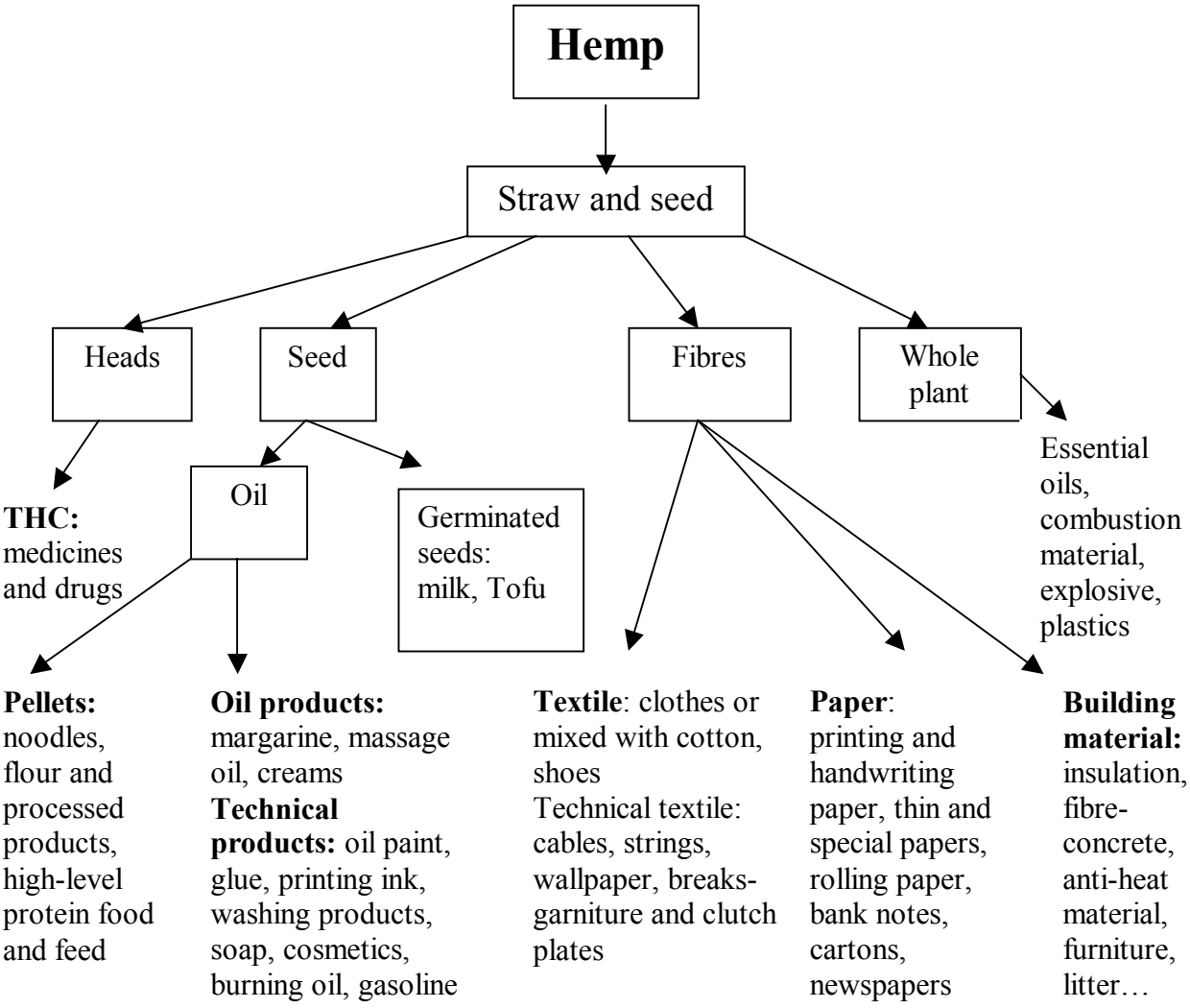


Fig 2: End uses of hemp (adapted from www.chanvre-info.com)

The growth potential of the market is considerable as is the number of companies selling hemp products. According to Hemptech (a California firm), in 1995 the wholesale of hemp processed products totalled 75 millions € and reached 1.5 billion € in 2001. The Wall Street Journal in 1997 reported that the demand for hemp products worldwide had increased from $75 million in 1997 up to $250 million in 1999, more than tripling the demand.

Some of the main outlets are:

Top-of-the-range paper: this market represents today more than 50 % of the European hemp fibres, processed into extra thin paper, technical paper, medical paper, rolling paper. It is a stable market but the development is still slow, as hemp remains uncompetitive.

Insulation by fibre wool and other parts of the fibre represents an important market for hemp, substituting products greedy in fossil fuel consumption (glass wool, polystyrene). This market is today handicapped by the excessive price in comparison with traditional products but its attractions in term of recycling capacity, sustainable development in agriculture and energy savings are the main assets. These advantages will have to mitigate a part of the price surplus for the consumer. Marketing and publicity need to be effective on these points.

Plastics: the replacement of the glass fibre, in the car production sector particularly, by natural fibres for plastic pieces like bumpers follow the same path as the insulation products. Furthermore, the products from hemp are lighter than the traditional ones for the same resistance capacity. This is the main strength for the development of this sector. The main problem for this outlet is the regularity of the demand compared to the seasonality of the production, in quantity and in quality.

Seeds: for traditional or new uses such as cosmetics and food products this market is an important source of benefits and could support the development of the other sectors of hemp research. The innovation of the hemp oil combined with its qualities (rich in radicals' omega 3 and omega 6) makes it a promising product for the future.

Textile: in disuse since the forties, hemp textile knows today a renewal thanks to the strong implication of Italian spinning mills like Armani, taking hemp to catwalks across the globe. This could be an opportunity for the opening of the market.

Silage: The main advantage of hemp is its high protein contents, which have to be added in the case of the oat/barley silage. Unfortunately, the high price of the hempseed does not make it competitive but with the increasing production, economies of scale can be achieved, prices decreased and hemp could become a source of forage for cattle producers.
Research led in Alberta, Canada shows heifers easily accepted hemp (Hanks, 2000).

Medical applications: the potential market for low-THC hemp cultivars is linked to the high-CBD content. CBD is a component of hemp, high in the industrial varieties, but low in marijuana. CBD can help in the treatment of epilepsy, dystonic movement disorders, inflammatory disorders, pain, chronic insomnia, chorea and cerebral palsy (Wynn, 1998). CBD can also prevent brain cell death (National Institute of Health, USA, 1998). But the main strength for the medical use of hemp seems to be the relief of secondary effects of chemotherapy (De Petrocellis et al, 2000).

2.3. Research and Development

Given the widespread restrictions regarding the growing of hemp that have existed during the past few decades, especially in the developed world, it is not surprising to find a rather underdeveloped level of research and development (r&d) when comparing that of hemp to other crops. Figure 3 depicts the evolution in number of worldwide scientific journals pertaining to hemp, over the past 40 years. The graph reveals an increasing trend in hemp research which reflects the recent surge in interest for the crop.

Discussing the state of R & D regarding hemp is a very complex issue, as its focus and scope varies widely between countries. Research initiatives will have a tendency to follow a country's legislative history, with a large portion of hemp R&D being limited to rather obscure initiatives which likely go unfinished and unpublished.

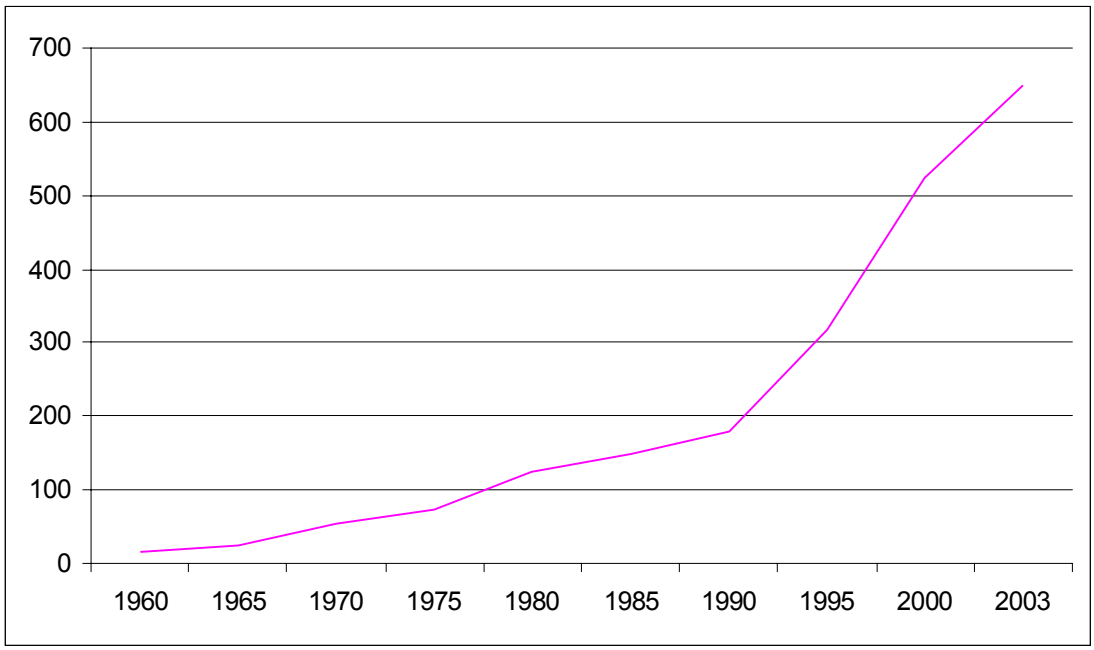


Fig 3: Number of articles related to hemp found in the KVL worldwide database

The tight controls that have prohibited the growing of hemp have also greatly influenced hemp R&D, which has, until very recently, focused largely on the development of low THC varieties. The situation has changed over the last decade, as numerous countries have regained interest on growing hemp, for a variety of reasons mentioned earlier in the text. Europe in particular, has been the centre of much Research and Development; not only at the country level, but also through a number of coordinated efforts.

Within the context of hemp R&D, we have chosen to focus on the countries where we have conducted our interviews (France, Denmark and the UK), with a slightly greater emphasis on the R&D which reflects our projects' interest into the agronomic aspects of hemp.

Hemp for Europe

In February 1996 the European Community (EC) approved a three year Research, Technological Development and Demonstration proposal (The Hemp for Europe-Manufacturing and Production Systems Project; MAFF, 1999). The project was submitted by ten partners in five European countries' (Italy, France, the UK, the Netherlands, Germany) centres in plant breeding, agronomy , crop processing, and product development, and included a number of commercial companies. The purpose of the project was to stimulate the expansion of the hemp crop in the EU. Limitations were identified at each phase of the production chain and were addressed experimentally. Although a number of varieties had been grown across Europe, it was felt that the interactions between husbandry, resource capture, yield and fibre quality were poorly understood. Some of the specific objectives in overcoming some of the limitations to the development of the hemp crop in the EU were to:

- Produce cultivars with improved fibre yield and quality, low THC content and pest and disease resistance.
- Develop from crop physiology models and crop modelling, cost effective crop management systems for the main climates of Europe, and carry out field evaluations.
- Improve current harvesting systems and develop novel technology for improved extraction of bast fibres. .
- Characterize, in relation to end-product use, the effect of production, harvest and extraction techniques on fibre quality
- Develop new materials and products and initiate commercial production

A substantial amount of work concentrated on the processing and product development of hemp. Work was also done to improve the drying of hemp, through a process of stripping the crop of leaves prior to drying. A breeding program was carried out in order to combine root knot nematode resistance with good fibre production characteristics and low THC contents into one hemp variety. Also, two kinds of treatments were tested (explosion and ultrasonic) as alternatives to conventional retting and decortication techniques, in order to improve the quality of the fibre to make it better suited for added value uses. In terms of product development, research investigated the potential for using hemp as a raw material for chipboard or medium density fibreboard (MDF). Work was also carried out in strengthening conventional thermoplastics through the addition of hemp fibres; and in creating alternative new biodegradable thermoplastics with fibres.

In addition to the work done regarding the industrial processes involved in hemp production, a great deal of research concentrated on the more agronomic side of hemp development. Given the nature of this paper, more attention will be given to this aspect of the research.

Agronomic R&D

Prior to the Hemp for Europe project, a substantial amount of research carried out in the Netherlands at Wageninen University, concerning the agronomic characteristics of hemp. Although the Netherlands is not one of our chosen countries, the scope and nature of the research calls for a brief discussion on what was carried out. Research was especially focused on particular physiological features of hemp requiring special

attention in breeding and crop management, due to their considerable influence on crop yields and quality. A first area of work thus revolved around hemp's behaviour as a short day plant. For, once the plant starts flowering, the efficiency with which intercepted radiation is converted to dry matter drops rapidly, thus affecting crop productivity. Selecting for later cultivars was therefore seen as one way of prolonging the growing season (Van der Werf, 1994). The second main area of research concerned hemp's large degree of heterogeneity: large differences in growth rates between male and female plants and significant variation in size among plants were found to depress yields, reduce the efficiency of resource use, and potentially result in variable quality (Van der Werf et al., 1995). Thirdly, research focused on increasing plant densities in order to increase the bark:core ratio. This was achieved primarily by increasing plant densities (Van der Werf et al., 1995). Finally, timing of the harvest in relation to environmental conditions was examined, in order to harvest when cellulose yield is maximal, and before the formation of lignin begins to dominate (Struik et al., 2000).

In the context of the hemp for Europe project, a coordinated initiative among three of the Hemp for Europe partners (Netherlands, UK and Italy) sought to evaluate the effects of cultivar and crop management (nitrogen, plant density and harvest date) on the yield and quality of hemp (Struick et al, 2000). The most significant factor influencing fibre quality was the location where the crop was being grown, with the highest yields being obtained in Italy where later cultivars were used. In terms of fertilization, a relatively important amount of N was found to be adequate to cover the crops needs but an important part of the nutrients return to the field. Another finding was that lower plant densities were found to not affect too much yields but the quality of the fibre.

France, Denmark and the UK

The UK

Much of the research in the UK arose in the context of the Hemp for Europe project, and research today remains a continuation of some of that work. Research in the UK was partly based in North-West Wales, where the University of Wales in Bangor (UWB) brought together farmers, researchers, advisors and processors. The consortium came to an end in 1999, but some of those involved felt it was a purposeful research to continue. So, partly as their brainchild, the project "Participatory Research and Development of Best Practice Agronomy for Hemp and Flax in North-West Wales" arose (University of Wales, 2002). The project received its funding from the EU objective 1 program, the Welsh Development Agency and the National Assembly of Wales in 2000 and has been up and running since.

In conjuction with the Henfaes Research Centre near Bangor, local farmers began growing hemp destined to be processed by a local plant (BioFibres). They all worked in coordination with the UWB's Biocomposites Centre. The project's aim was to link the agricultural reality of growing both hemp and flax, to the technical demands of the industry. It combines research trials at the Henfaes Research Centre with a series of participatory (on-farm) trials. The project's focus is on the dissemination, gathering and generating of information on growing techniques for ensuring adequate and reliable crop yields and quality. The project is currently working with 9 hemp growers

and 20 flax growers. The Biocomposites Centre works on assessing fibres structural properties and in the development of product prototypes. In terms of product development, the centre focuses primarily on the utilization of hemp for insulation and composite materials destined for the automobile industry. They hope to begin looking more into hemp's potential in the areas of horticultural geo-textile materials.

France

La Chanvrière de l'Aube (LCDA), established in the vineyard region of Champagne in Eastern France, is the European industrial hemp agri-business leader, manufacturing its own line of products. LCDA affirms that they have "one foot in the soil, one foot in the industry", meaning that, since 1973, they have a clear industrial orientation. For this purpose, they have invested in R&D to adapt their fibres for industrial processing.

France is also the major seed producer in Europe due to its favourable climate; research is led by the National Federation of Hemp Growers (FNPC). Table 1 depicts the surface of hemp grown in different countries within Europe and shows the relative weight of the French hemp production.

Table 1: Current production in Europe (FAOSTAT, statistical database results 2000)

Country	Area harvested ('000 ha)
Bulgaria	0,008
France	8,2
Germany	3,0
Hungary	2,0
Poland	0,1
Romania	1,3
Spain	1,5
UK	2,0

LCDA has no direct link with FNPC; they are two separate entities, with separate attitudes and activities. The Federation is the main body for advisory in hemp.
FNPC is more farmer-oriented, using participatory research in everyday work, analysing harvest results from many farms. FNPC has stopped R&D in machinery a few years ago but is still improving the varieties through selection. In 2004, a body involving processors and producers will be created in order to find at the same time industrial and agricultural improvements for hemp.

Denmark

Limited research is being undertaken at the moment, as there is no industry pressure due to a barely existing industry. Research is currently being done at two known institutes. The Royal Agricultural and Veterinary University, Taastrup is carrying out research into determining the fibre strength if alternative treatments are applied during and after the retting process (the experiment makes a comparison between normal decomposing of hemp straw and enzymatic decomposing and afterwards submitting the fibre to different treatments with hot or mild steam to test in which case the fibre is more resistant). Also the Danish Advisory Centre, Department of plant Production

is developing non-traditional materials and components for building technology, including hemp in their research for insulation materials.

The research in Denmark is just in initial stages and it relies on hemp's use in alternative materials for a more friendly environment. Experiments in more agronomic purposes for hemp were carried out at Bioscope, in Jutland. Experiments focus on harvesting machinery, including hemp in the soil as a green manure and hemp oilseeds for medical purposes. The potential for hemp to be incorporated into Danish farming systems relies largely on the demand for the end use products for hemp. Advertising the benefits of these products in comparison to current products will determine the extent to which hemp products are incorporated into use.

Areas identified for further research

From the literature it became evident that research areas recommended often reflected the individual researchers' field of study, instead perhaps of the immediate needs of farmers. Visiting with researchers and advisors involved in the University of Wales Bangor (UWB) Flax and Hemp Participatory Research Project; and with farmers in France and Denmark; enabled us to look into what they thought should be R&D priorities. Our findings are more useful after having read more about the interviews we conducted. Page 70 deals explicitly with the farmers' views on R&D, as well as our own perception on the matter.

3. Hemp the Plant

In this section we approach the physiology of the hemp plant and the factors affecting its growth and development. We have felt that this was an essential area to cover in order to understand its biology and agronomy.

3.1. Plant physiology

Hemp is an annual plant, it rises in spring and dies naturally at the first frost. Its adaptability geared by its photoperiodic reaction enables it to grow all around the world. Hemp is a short day plant (Wareing and Philips, 1978) and the flowering initiation takes place at a precise moment related to day length. The crop has a constant rate of growth, producing a leaf every 79 to 85 °C of accumulated temperature (Van der Werf, 1995). This relationship between temperature and leaf node production is very important and can lead to predictions of the quality of fibre produced.

From a genetic point of view, the main problem with hemp is the variability within the field. Consequently, selection cannot be made on a lineage as with maize for example, which means that most of the seed obtained has a sufficient quality for each generation. The best individuals are reproduced to minimise genetic heterogeneity of the population. This characteristic leads to work in separating good seeds from bad seeds, which is an expensive process.

Hemp is originally a dioecious plant, which means that the male and female flowers are not held by the same plant (www.chanvre-info.com). The differentiation between them cannot be made during the growth stage; plants acquire their individual

characteristics when the maturation period comes and then the dimorphism becomes visible. The female plant is generally leafier than the male and moreover the male looses its few leaves after inflorescence and grows in small grapes (Fig 4) and contains about five stamens enclosing abundant yellow pollen. The male plant is very productive in stalks and grows quicker than the female.

The female inflorescence (Fig 5) is composed of almost sessile ears located at the axils of the leaves. The ovary is almost totally covered and only two stigmas, made to receive the pollen, are emerging. The ovary contains only one seed, grey or brown, very small, about half a centimetre long.

Fig 4: Male plant

Fig 5: Female plant (www.chanvre-info.com)

Hoffman and Von Sengbusch isolated plants (1 on 10 000) which naturally hold both inflorescences. Research has focused on reproducing these monoecious varieties. They display many advantages over dieocious varieties thus being the reason why monoecious varieties are the only plants grown today for industrial purposes (Mathieu, 1995).

The fibre yield of the monoecious varieties is much higher due to the high potential of all the stalks. All the monoecious plants can produce seeds and the yields for grain are consequently much higher. The flowering period is homogenous and therefore easier to harvest. The dry matter is homogenous, as is the quality of the fibres and the size of the plants.

3.2. Crop Requirements

Soil

Industrial hemp can be grown on a wide variety of soil types, but it does best on loose, well-drained loam soils with high fertility and abundant organic matter (Dempsey, 1975; Van der Werf, 1991; Girouard et al., 1998). It prefers a sufficiently

deep, well-aerated soil with a pH of 6.0-7.5 (table 3). Hemp is extremely sensitive to flooding and compaction as well as heavy soils (Girouard et al., 1998). Good soil drainage is therefore important to maximize hemp production. Repeated attempts to cultivate hemp on heavy, low-lying soils have demonstrated that while these soils may produce some large hemp plants it is practically impossible to raise a good, even stand of hemp stalks that produce high quality fibre.

Climate

Temperature

Hemp is well adapted to temperate zones and it will grow under a wide range of environmental conditions. Hemp grows best when mean daily temperatures range from 14 to 27^{0}C (Table 3) but can stand colder or warmer conditions (Wynn, 1998). Because of its relative tolerance to frost, hemp can be sown earlier than corn and will develop a closed canopy early in the season allowing increased light interception and rapid growth (Van der Werf et al., 1995). When mature, hemp can endure temperatures down to -6^{0}C, but younger plants are too sensitive for these conditions.

Except in rare varieties, hemp is a plant adapted for short days and the differences between varieties grown are mainly due to the photoperiod. In France, for instance, types grown have a vegetative period of 100 to 120 days and thermal additive requirements from 1750 to 2000 °C. Consequently, as long as the chosen variety is well adapted, this crop can be grown in most countries with the same conditions. Different types and varieties of hemp have individual requirements in terms of light and temperature (Table 2).

Table 2: requirements of hemp (www.chanvre-info.com)

Type of hemp	Vegetative period in days	Thermal requirements
Nordic	60 to 80	800-900 °C
French	100 to 120	1750-2000 °C
Subtropical	140 to 160	3500-4000 °C

Water

Hemp requires abundant moisture during the first 6 weeks of growth, while young plants are becoming established (Dewey, 1913). Once the plants rooted well, they can endure drier conditions; however, severe drought hastens maturity and produces dwarfed plants. Studies in Europe indicate that hemp requires 500-700 mm (Table 3) of available moisture for optimum yield and that 250-300 mm of moisture should be available during the vegetative growth stage. These amounts include both precipitation and available soil moisture. In Europe hemp yield is strongly dependent on rainfall during the months of June and July (Bocsa & Karus, 1998). The general conditions required for hemp crop are summarized in table 3.

Table 3: Climatic requirements of hemp (Traum B, 2001)

Optimal temperature		Precipitations	Soil	
Germination	*Growing season*		*pH*	*Type*
> 10°C	14-27°C	> 500 mm	> 6	Loam

Hemp is one of the most tolerant crops to dry conditions but it is also a crop that has a good response to irrigation, particularly important when producing grain. 30 to 80 mm of efficient water supply suffices in most cases to ensure a good yield in grain (Bocsa & Karus, 1998). Hemp resists well to drought because its root system can draw water from very deep with the soil profile. Hemp crops intended for straw production are not irrigated as the soil covers water requirements.

Nutrient requirements

Due to a very rapid growth rate, nutrients need to be well supplied and freely available. Hemp's need for nitrogen is high, especially during the vegetative growth period, and it should be available in the soil in sufficient quantity for a good yield.
Hemp's growth pattern can be divided in 6 stages depicted on the figure 6.

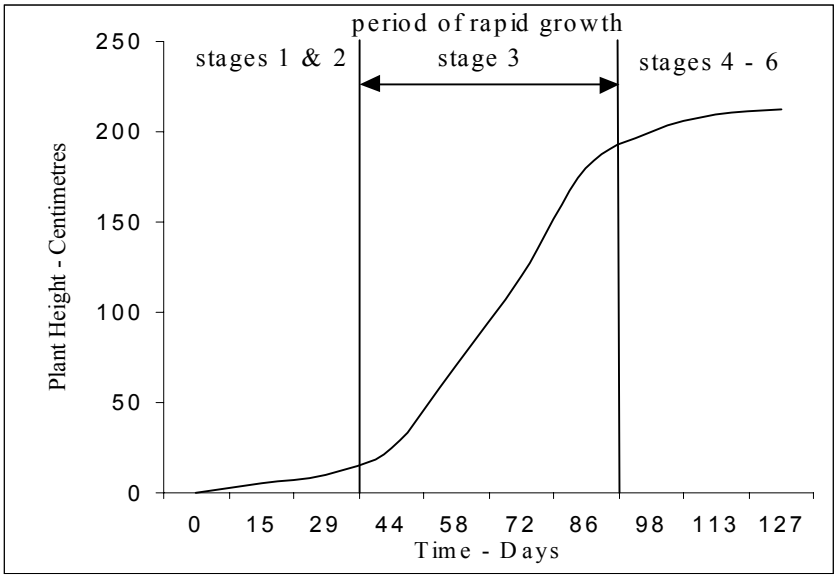


Figure 6: Growth cycle of hemp (Bócsa & Karus 1998)

The different stages presented are:

1. Germination
2. Slow growth, which lasts from the appearance of the first pair of true leaves to the fifth set of leaves
3. Rapid growth, which lasts till the formation of flower buds
4. From buds formation to first flower opening
5. Flowering
6. Seed production

Nitrogen

Nitrogen fertilization has to be adapted to the type of soil but is more or less the same as for maize (Girouard et al., 1998). The nitrogen requirements of the crop are estimated at 13 to 15 kg/t/DM (FNPC, 2002).
Inputs of manure have to be considered in relation to the soil potential and the season, varying in relation to the temperature and therefore the mineralization (MAFF, 1999).

A lack of nitrogen will result in a lower yield because steps of growth (internode's length, canopy area) will be missed and therefore reduce the efficiency of radiation use (MAFF, 1999).
Nitrogen fertilization tends to supplement the N supply from the soil depending on its potential and that of the crop (Starcevic, 1979). Knowing the current content of nitrogen in the soil is advisable to avoid excess application and consequent leaching.
In excess, N supports early lodging and keeps the straws green for longer. This is detrimental to the quality of the fibres. On top of this, the excess nitrogen leads to more difficult processing. In grain production, excess of nitrogen maintains excessive moisture in grains and leaves and therefore harvest is delayed. It can be then more difficult to harvest in the best conditions.

Manure and a good soil management can replace mineral fertilizers in organic farming systems, resulting in a healthy and more diverse agro ecosystem. The quantities of manure required have to be calculated in relation to the content of this manure in nutrients. Therefore, tables or analysis can be used to evaluate this amount. An application of 30 to 50 tons of organic matter can cope with the high requirements for nutrients of hemp (FNPC, 2002)..

Potash and phosphorus

Phosphorus and potassium are required later in the cycle, during the flowering and seed formation period (FNPC, 2002). Hemp has a strong ability to remove potash from deep soil but its requirements are very high (Girouard et al., 1998). Requirements generally range from 75 up to 100 kg/ha but can even be as high as 300 kg/ha (*vide infra* table 6 pp 23). The requirements in phosphorus are less, around 50 to 70 kilograms per hectare but it has an important role in the elasticity and strength of the fibre so availability in the soil is important.
Table 4 sums up the application of nitrogen, phosphorus and potassium for both seed and fibre production.

Table 4: Nutrients requirements of hemp (www.chanvre-info.com)

	N (Kg/ha)	Phosphorus (Kg/ha)	Potash (Kg/ha)
Hemp for fibres	80	60	150
Hemp for seeds	40	60	150

As for nitrogen, potassium and phosphorus applications need to be calculated in relation to levels present in the soil. Therefore it is necessary for the organic farmer to know the quantities of each in the manure to ensure optimal applications. The timing of application will also affect the quantity required. For example higher applications are required in autumn than in the spring (table 5)

Table 5: Timing of application (source: Starcevic Lj, 1979)

	Autumn - kg/ha			Spring - kg/ha		
Level of nutrients of the soil	N	P2O5	K2O	N	P2O5	K2O
High	-	45-60	45-60	45-60	-	-
Medium	40-60	60-90	60-90	40-60	-	-
Low	50-60	60-90	60-90	70-90	20-30	20-30

Other mineral requirements

Calcium is an important requirement to the same extent as potash. The quantities of which are largely available in normal soils. In instances where soils are acidic it is advised that lime be applied. The quantities advised by FNPC are about 1 to 1,5 t/ha. The requirements for magnesium are about the same as phosphorus; it is consequently useful to know the amount in the soil to prevent possible deficiencies. No deficiencies in trace elements have been revealed in hemp, application of such elements is therefore useless.

For the following crop

Although hemp requires high quantities of nutrients for good yield, it also returns to the soil a high quantity from the leaves which are left on the ground after harvesting and from the stem, after field retting (Table 6). The plant's leaves, roots and heads contents of nutrients is higher than 50% and approximately 42% of the total biomass is left on the ground after harvesting and retting, enriching the soil for the next crop once integrated (Baxter & Scheifele, 2000). Therefore, this OM will have to enter into the calculation of the amount of manure applied for the next crop. This characteristic is responsible for the reputation improving the fertility of the soils.

Table 6: Hemp plant nutrient uptake and return (Baxter & Scheifele, 2000)

Nutrient	% Removed by stems	% Returned to soil
Nitrogen	31.0	69.0
Phosphorus	67.0	33.0
Potassium	47.0	53.0
Magnesium	28.0	72.0
Calcium	28.0	72.0

The exportations of nutrients will have to be compensated by application of manure or fertilizers for the following crop at an adequate period above all if it requires high quantities in early spring.

Effect on weed populations

This species' fast vertical growth, the impenetrable leaf canopy and the water competition make it ideal as a weed control crop. There are few weeds that can persist in the dense shade of a good hemp crop (Hanks, 2000). When its requirements are met and it has a good establishment, hemp grows rapidly. The emergence is generally observed within three days and after three weeks the crop reaches 50 cm if the conditions are optimal so a dense canopy forms quickly and prevents growth of weeds by blocking the sunlight.

When the crop does not get a good start for one reason or another, competition from common weeds like thistles, quackgrass, wild oats, mustard and lamb's quarters can become a real issue. Poor drainage and lack of nutrients can slow the crop's growth and make it more vulnerable to invading weeds. To take advantage of hemp competitiveness, care must be taken to sow at a high enough density in fertile and

well drained soil to achieve quick ground coverage. In the case where the sowing is too sparse, an additional sowing should be considered. The production of hemp for grain is more sensitive to weeds because the sowing density is lower but so far, no herbicide has been developed (Girouard et al., 1998). Mechanical weed control can be efficient to eradicate early emerging weeds, especially in organic production such as false seed bedding or harrowing.

Pests and diseases

Hemp has over 300 identified pests and about 100 diseases (McPartland, 1996). Despite this, most pests and diseases don't cause any economic damage to the crop. There are a few hemp specific insect pests that can cause crop loss, for example the hemp flea (*Psilliodes Attenuata* Koch) and European corn borer (*Ostinia Nubilalis*).
This tolerance to pests and diseases gives hemp good reason to be used in both organic and conventional systems. Fibre hemp has higher sowing density to compete with weeds (Bocsa & Karus, 1998).
.
Hemp is not pest and disease free as some authors would claim (Herer, 1985; McPartland, 2000), but characteristics of pest tolerance and disease resistance lead to very few problems damaging the crop. Except hemp broomrape (*Orobanchae Ramosa)* that can parasitize hemp roots, this crop does not know other important diseases able to cause damages and losses of yield in Europe (FNPC, 2002).
In truth, hemp also suffers from hemp canker (*Sclerotinia sclerotans*), for which wheat is a vector. For this reason, hemp crops should not follow winter wheat (the reverse, however is not harmful).

There are other hemp specific diseases, such as hemp rust (*Melamspora cannabina*) but they are rarely found in European conditions.
Hemp broomrape (Fig 7) is a non-chlorophyll plant, which parasitizes the roots of hemp and canola. This parasite needs hemp or rapeseed to germinate and develop. Resulting from the parasite, an orange tuber is formed (Fig 8) and soon a branchy stem with flowers (Przytyk S, 1995).

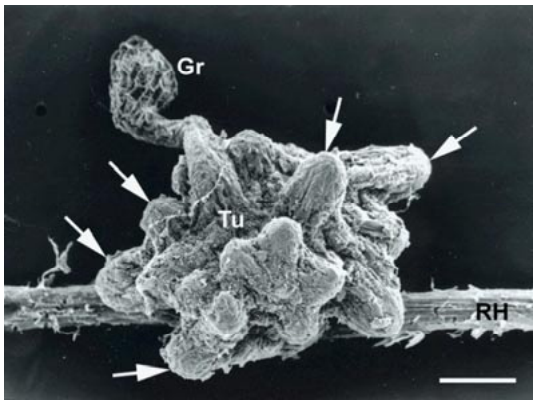


Fig 7: Tuber of hemp broomrape (www.snv.jussieu.fr)

Fig 8: Adult hemp broomrape (www.hemphasis.com)

The symptoms are loss of vigour that can lead to the death of the crop and a loss of density inducing infestation by weeds. The attack can be so severe as to kill off the entire crop. So far, no treatment has been found against this parasite but research is led in many countries. The only prevention is to ban hemp and oilseed rape from the rotation for at least 5 years and avoid crucifers, which are host plants for broomrape.

Nematodes (mainly the species *Meloidogyne spp*) have been revealed as a problem for growing hemp under precise climatic conditions (MAFF, 1999). Under other conditions, it was shown to suppress this type of nematode, even at very high inoculate levels (Kok et al, 1994; McPartland & Glass, 2001). This is an important result because of the wide host range, and the high damage potential of this nematode. Trials are presently led to use hemp as a break crop for a wide range of nematodes.

In certain circumstances, snails can destroy a part of the crop when it is rising from the soil in the first weeks (www.chanvre-info.com). It can be useful to apply anti-snail products (organic or conventional in relation to the system) if the field usually presents such a problem because the damages due to the snails can be significant. In seed production the birds are the main pest of the crop due to the high nutritive content of the grains. Birds can be kept away by noise or visual systems. Birds prefer hemp seeds and too many of them cause yield losses (McPartland, 1996).Vertebrates such as rabbits also feed on the crop.

A further problem that can occur is the development of fungal diseases like grey mould (*Botrytis cinerea*) or hemp rust (*Melanospora cannabis)*. For flower growth (essential oil production), it can be a problem if the weather is wet. The sensitivity to grey mould would be directly related to the level of calcium in the plant (McPartland et al, 2000). A higher amount of Ca would decrease the incidence of this fungus. In the early stage of infection, Bordeaux mixture is efficient if the local certification bodies allow its use for organic production.

4. Hemp on the Farm

4.1. Soil preparation

One of the most important things in every crop is the soil to seed contact. Hemp needs a well made seedbed for an easier germination and emergence. Also, smaller particles of soil retain water better - hemp needs a moist soil for good germination (Baxter & Scheifele, 2000).

For organic farming "no-till methods" are applicable, but in this case plants can germinate and emerge irregularly on the field. The emergence of weeds can be controlled by different methods suitable for organic farming, like the use of false seedbed because it stimulates the early germination of weeds, as shown in fig 9 (Melander, 2002).

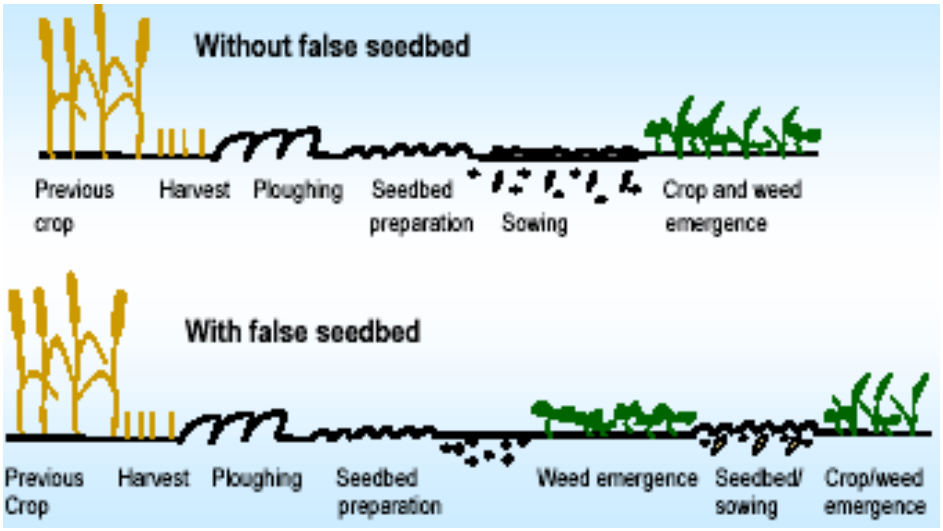


Fig 9: the mechanism of false seedbed (Melander, 2002)

On the other hand, conventional soil and seedbed preparation (ploughing, fertilizing and irrigating) leave very good conditions for the development of the plant (fine soil, good aeration, moisture, enough nutrients).
Requirements in compost are high and a proper rotation with legume crops essential to maintain yields.

4.2. Sowing

The seeds are quality certified with high standards for purity and germination.
Depth is an important factor to be considered, germination will be better if the seeds are well and evenly buried in the ground (Lovrin Agricultural Research Centre, Romania). Seed depth should be 3-5 cm.

The seeding date depends on the climatic conditions, but should be in late spring, after the hard frosts have gone, usually after the date for spring wheat, but before corn (Robinson, 1935; Dempsey, 1975). The optimum soil temperature is 10^0 C for early growth, but hemp can be seeded at a minimum of 6^0C. Seeds will germinate in 24-48

hours and emerge in 5-7 days (Fig 10). If sown earlier, hemp will grow slower and the yields won't be as high (Messenger & Low, 1996).

Fig 10: Hemp plant 2 weeks after germination

Seeding densities depend on the final purpose of the crop. When hemp is sown for fibre use, the density is high and this will lead to strong and tall plants, which will shade the ground almost completely, suppressing the weeds. The density is lower when planted for seeds. The development of the plant is therefore different: it will develop more branches and therefore the seed yield will be higher than the fibre one.

Machinery

Mechanical seeding is done using cereal sowing machines (Fig 11) or modified alfalfa ones (Nelson, 2000). After seeding, the use of a roller enhances the contact between the seeds and the soil (Messenger & Low, 1996).

Fig 11: Sowing hemp in action , Wales, spring 2003

4.3. Establishment and Maintenance

In order to have a good and low maintenance crop, along with a proper rotation, careful preparation for germination and emergence of hemp is required. Figure 12 shows the influence of main agricultural factors on germination and emergence.

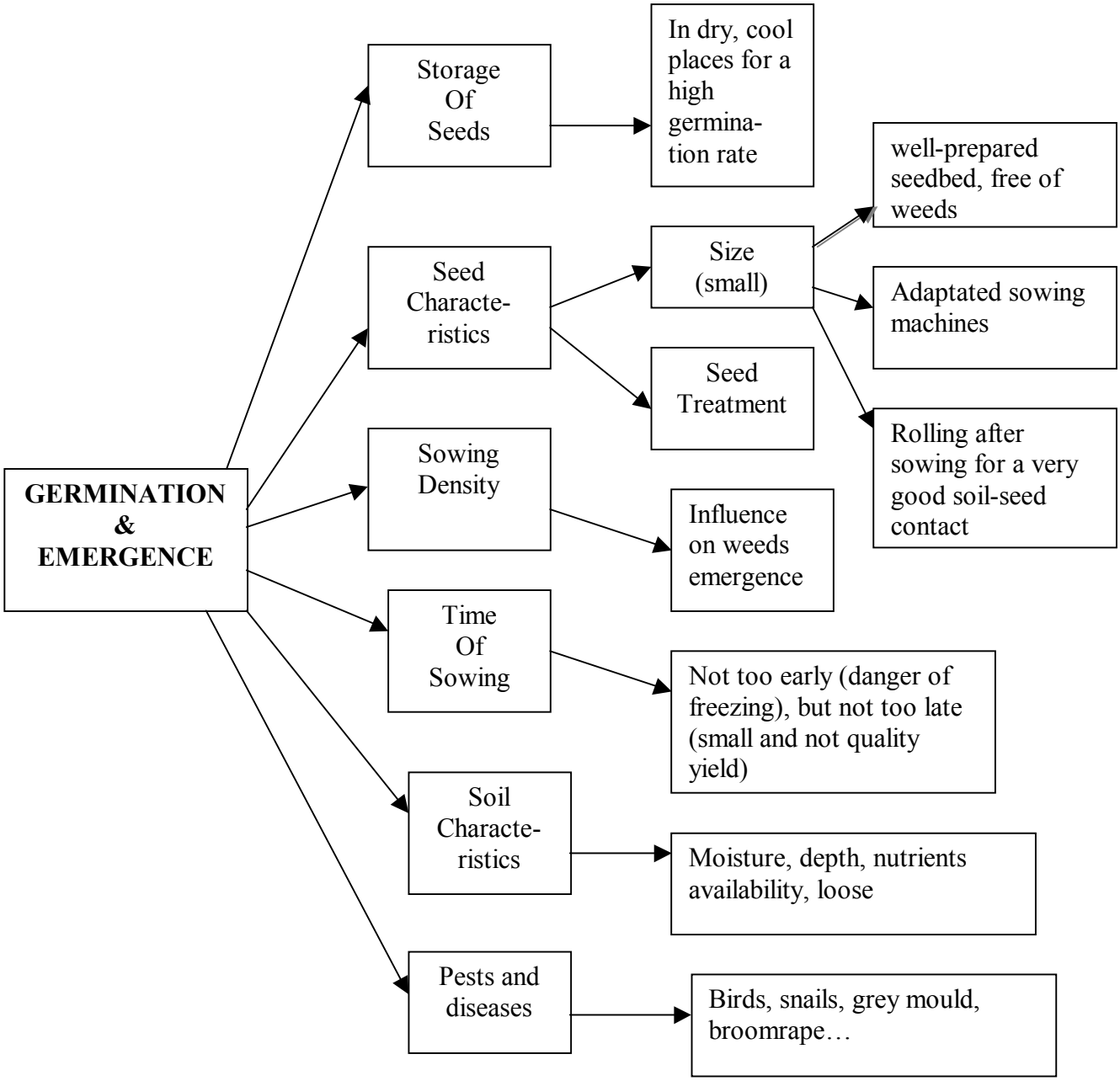


Fig 12: Factors influencing germination and emergence of hemp

4.4. Harvest and Post-Harvest Management

When grown for highest quality, fibre hemp is harvested when the plants have finished flowering, but before the seeds reach maturity. This is sometimes referred to as "technical maturity" (Van der Werf, 1991).
Hemp continues to grow after seed maturity (Van der Werf, 1991) but the fibre is changing its chemical composition, becoming weaker as the stalk lignifies. The crop is then only suitable for some products like paper or particleboard, as these don't require high quality fibre. The time of harvest is not the only concern: other factors should be considered along with the relationships between them (Fig.13).

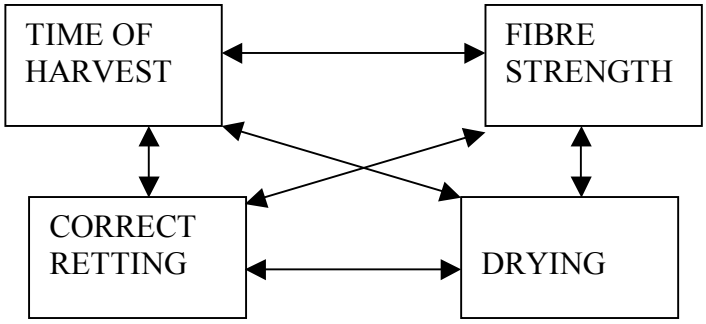


Fig 13: The interacting factors of post-harvest management

Time of harvest is an important factor. An earlier harvest would lead to less fibre loss or new techniques could be developed to allow a quicker dry process. Fibre harvest takes place in southern Europe in late July and early August. This varies with the north of France and the Netherlands where it occurs in late August or early September (Van der Werf, 1991).

Retting is a necessary process to allow the fibre to be separated from the woody core of the crop. It can last from 1-2 weeks in warm and humid conditions and up to 4-6 weeks in cooler, drier conditions. During this process microbes decompose the wooden core, facilitating the separation of long fibres from the short ones. If they are not retted completely, the stems are difficult to process and result in lower quality fibre.

Retting can be achieved by the three following methods:

- *Water retting* in which the stalks are kept in water. The result is a very good quality fibre that incurs high economic and environmental costs as a large volume of quality water, labour and capital are required.
- *Field or dew retting* in which the crop is spread on the field (Fig 14). The rain and dew provide the necessary moisture. It is widely used because it is cheap, has been mechanized over the years and it doesn't affect the water supply. In this case, after cutting, the stalks are left exposed in thin piles. Necessary for even retting is the turning of piles. After the field retting process, hemp stalks need to be dried before storing.

Fig 14: Field retting in Wales, autumn 2002

- *Stand retting* is the process by which the crop is sprayed with an adequate herbicide and left to dry standing. This is a reliable way to do it, minimising the risks of climatic variation. It takes longer than field retting, as the material does not benefit from the moisture of the soil to accelerate the process.

Over retting (due to excessive moisture) or under retting (not enough humidity) can lead to the loss of fibre quality and in the case of over retting the whole crop can degrade if there are no conditions for artificial drying.

A new retting method is in research: *enzymatic retting*, already in use in some research centres. Enzyme based products are used, consisting mostly in *pectinolytic* enzymes. This method is environmentally friendly and results in very good quality fibre - fine and strong (Dreyer & Mussig, 2000).

Fibre separation is another step in the processing of hemp and it consists of separating the fibre from the dried stalks. The stalks are passed through fluted rollers to break the wooden core in small pieces (hurds) which are separated partially from the long fibre. The remaining hurds and fibre are separated in another process called scotching. In the modern process, fibre bundles are gripped between rubber belts or chains and carried past revolving drums with projecting bars that beat the fibre bundles, separating the woody core and broken or short fibres (tow) from the remaining long fibre. The long fibre comes from the machine clean and ready for combing. Figure 15 explains the breakdown of the hemp plant from the green plant into water, dry green matter and dry fibre and tow.

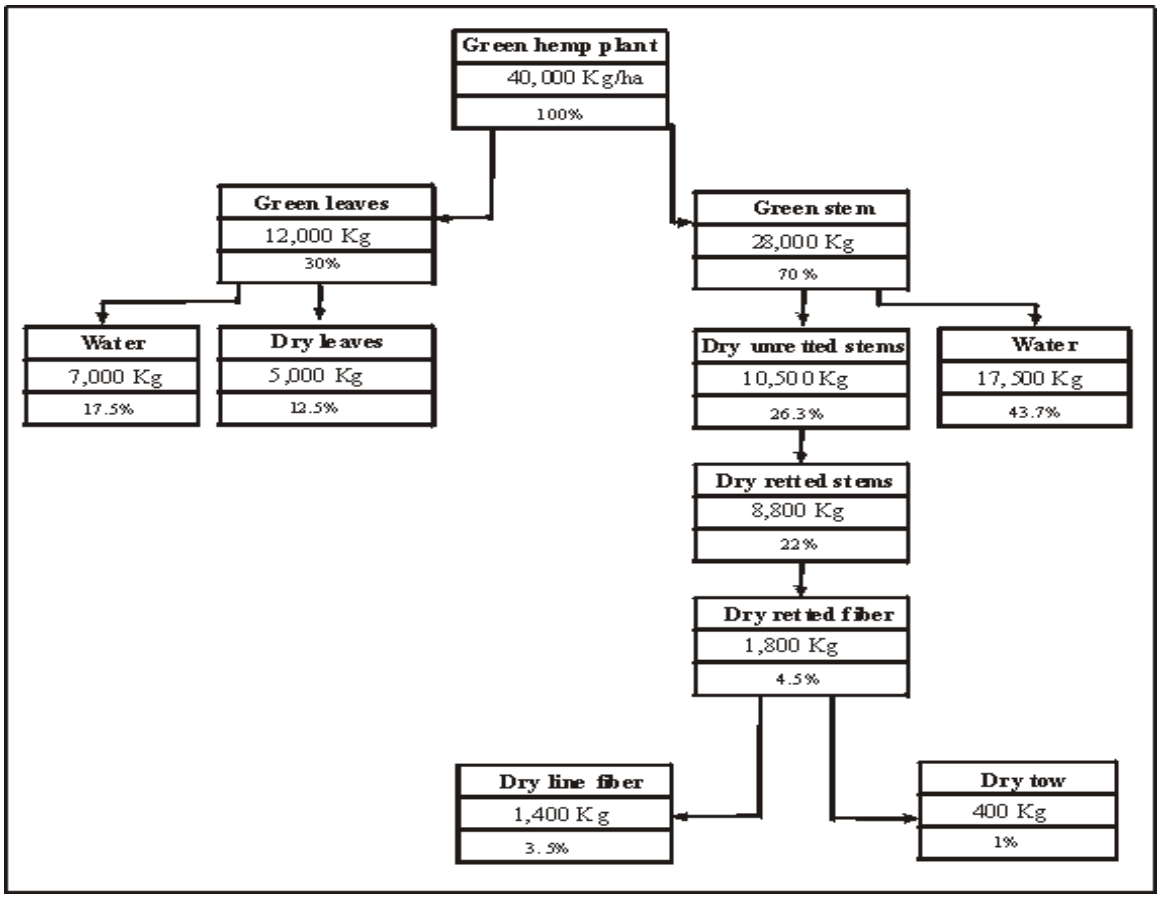


Fig 15: Breakdown of green and dried components of hemp (Dempsey M.J, 1975)

Harvest (for seeds)

Harvesting hemp for seed differs to that for fibre. The growth period for hempseed is 5 to 6 weeks more than that of fibre.
An important factor affecting the yield is the time of harvest: if it is too early the seeds will not be viable (planting seeds) or will loose their nutritional value (oil seeds); if it is too late the yield will decrease.
Since the seeds do not mature at the same time (the first ones to mature will be those lower down) there is an optimum moment for harvest. When the majority of seeds in the middle of the flowering head are ripe, harvesting should begin. After harvest, seeds need to be dried for storage to moisture contents lower than 12% (Bocsa & Karus, 1998).

Planted at different densities than fibre hemp, seed hemp is more difficult to harvest because the stalks are stronger and machinery can hardly cope with it . The cutting bar of the harvester must be raised so as not to cut the lower part of the plant because it is very thick and can be cut afterwards with a stronger machine.

Previously, the harvesting process was split in two parts: first, a drawn harvester-spreader was used to cut the stems and leave them in the field in piles for retting (Fig 16); afterwards a second machine collected and bound and the dried bundles were then delivered to the mill. Today, the principle remains the same, but the equipment used is more specialized.

Forage or sugar cane modified harvesting machines (Fig 17) can be used for unretted hemp stalk harvest (Wood & all, 1978; Quick & all, 1980). A new machine for removing the leaves and the heads of hemp at the same time as straw cutting occurs; it can take off 95% of the leaves. This resulted in more rapid and regular drying of stems than the ones with leaves and heads. Other studies have shown that chopping stems in 0,5 m sections also improves drying (MAFF Study, 1999).In the case of seed harvest axial-flow combines are very good for threshing and cleaning the seeds (Ehrensing, 1998).

Fig 16: A modern European forage chopper (Leson, 1996)

Fig 17: Harvesting hemp

Yields

Yield is a complex parameter and is related to all the factors influencing the crop (climate, soil, fertilization, weed control, pests and diseases). Nitrogen availability has a large impact on yields, and studies have revealed a direct relation between nitrogen quantities on the field and increased yield (fig. KK). According to MAFF, a quantity of approx. 200 kg N/ha is required for maximum yield.

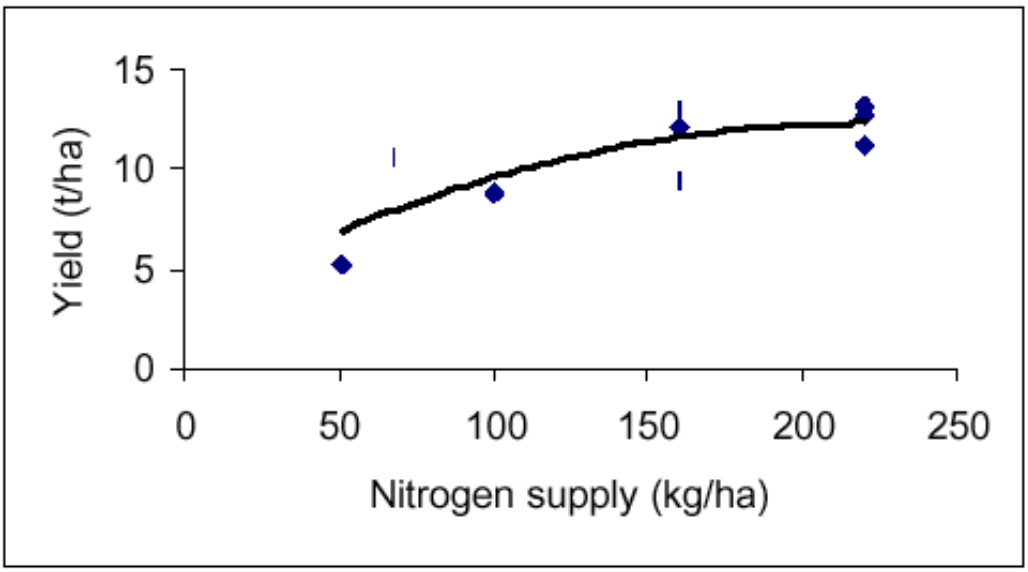


Fig 18: The relationship between mean yield and nitrogen availability UK MAFF, 1999

According to the same study, plant density has a minor influence on yield: the influence is in quality, not in quantity. Plants compensate by getting thicker (which leads to the similar yields, but of lower fibre quality). The optimal density established is approx. 115-130 plants/m^2, with a seeding rate of 180 seeds / m^2.Other studies focused on the influence of light quantity on the yield. The use of late flowering varieties could result in higher yields because late flowering allows for a longer growth period and delays flower and seed growth (Meijer et al, 1995).

Drying and storage

For avoiding disease and fungal attack, fibre hemp should be dried before storing (artificial drying should be used if it's not possible to do it naturally) and stored at specific humidity, moisture and temperature levels (Table 7).

Table 7: Parameters for storage (MAFF, 1999)

Crop	Parameters considered		
	Humidity	Moisture	Temperature
Hemp for fibre	65%	13-18%	10^0C

If kept in a dry, covered place, hemp bales can be preserved for a long time.
Hempseeds should be stored in dry, cool places to avoid loosing their qualities. For good germination, planting seeds should be kept at a temperature of approx. 1^0C (McPartland et al, 2000).

Transportation

Transportation is more a financial problem because unprocessed hemp is a bulky, heavy material and is therefore difficult and expensive to transport. That is why the further processed are the stalks the higher is their value on the market.

5. Hemp in the Crop Rotation

This part of our report brings together the knowledge we have gained of hemp as a crop, in order to assess where it will best fit into rotations, and tries to ascertain how hemp can best fulfil its functions within an organic system.

We have included in this section, for the first time in the report, some occasional information derived from the interviews we have made. Whilst we realise that these are only described in the next chapter of our report, we saw it fit to utilise crop rotations as a bridging theme between the historical and agronomic background of the crop and the "active research" we have carried out. We do so under the understanding that we cannot begin to look at the whole-system dimension of hemp without some input from the practical/real experiences of the hemp farmers we interviewed. Additionally it is still in part literature review, a research method which we will largely abandon for parts II and III.

Not a new Concept…

Rotations have formed the basis for agriculture in Europe from Roman times, and before, since human settlements were forced to become permanent. Our ancestors realised they had to adopt a system that allowed them to use land sustainably, as cultivating a piece of ground to exhaustion and moving on ceased to be an option. From those days on some form of rotation has been practised by those who have had the role to produce food and look after the agro-ecosystem surrounding humans.

Common rotations in the last few centuries tended to be based on relatively simple designs, with four courses covering the main foodstuffs that formed the basis of human nutrition. This progressed to more complex rotations with the increase of population, typically forming 6-year rotations during the 19th century and the early part of the 20th century (Lampkin, 1990; Soffe, 1995).

The advent of synthetic fertilizers and agrochemicals has removed the need for rotations to reduce the risks of mono-cropping in the same location, as the threats of soil fertility depletion and weed, pest and disease incidence were all overcome through artificial methods of control. This by-passing of soil and biological processes is not without its shortfalls (the discussion of which is beyond the scope of this report) and has been perceived by many as a less desirable way of land management. This is true for many farmers, organic or not, and is the reason why so many still practise rotations within their systems. The principles of rotation are, of course, of utmost

importance to the organic farmer, as he does not have access to artificial means of control. It is not, however, neither a new concept nor one that is exclusive to organic farming systems, but rather a well established and highly recommended tool of healthy farm management.

5.1. Hemp in the Role and Design of Rotations

A sound crop rotational system is of basic importance to the organic farmer (Newton, 1995) and those converting to it, if production is to be maintained and the viability of the farm is not to be endangered (Lampkin, 1990). Apart from all the agronomic benefits, the use of rotations reduces the financial risk that is incurred by the reliance on one or few crops and provides more interest for the farmer.

A crop rotation is the sequencing of different crops on the same piece of ground (field). This however is not a random process of alternation and it is not without a certain degree of knowledge and experience that one designs a rotation. Historically, rotations have been principally concerned with soil fertility, in order to prevent yields of following crops from declining (Soffe, 1995), but they are today valued for a number of other reasons, of particular relevance to organic farming systems. Apart from all the variables tied in with location and climate, the design must take into consideration the different advantages that a rotation brings to agricultural systems. With that in mind, we note the different functions provided for by rotations and what hemp is characterised for in them, which will largely define where it goes within the rotation.

Soil Health Enhancement

This is achieved through the ability of different interacting factors within it to function adequately together, namely the maintenance and building of fertility, structural stability and improvement of biological activity.
Soil fertility is not an easily definable concept, precisely because of this interactive nature in which one factor can enhance or inhibit embodied “fertility” (in terms of shear presence of nutrients in the soil). This is, of course, highly dependant on soil type, but principally on its management through good agricultural practise. Rotations help through sharing the soil on an alternate basis between crops that have: nutrient demanding or replenishing properties, positive or negative effect in soil structure, high or low amounts of crop residues. Hemp as a candidate for the rotation displays medium to high level of nutrient requirement (principally N), which can be considered as detrimental to the overall soil nutrient status.

However, hemp does provide high levels of biomass return and we have found it to be considered almost unanimously as a good preceding crop to cereals. Its deep and extensive root system brings benefits to soil structure, which has positive impacts on aeration, water movements and holding capacity and increase in cation exchange capacity, as well as increasing the soil’s buffering to leaching. It also means it is able to draw nutrients from the lower layers of the soil. It therefore performs certain functions in soil health that outweigh its relatively high demand for nutrients.

The use of hemp as a green manure, although professed by some to be of high value, has shown to be prohibitive to farmers due mainly to the price of seed, but also because the fibrous nature of the crop proves it impractical to incorporate. Also, and principally, licensing requirements restrict early incorporation and harvest (*vide supra,* pp 30).

Weed, Pest and Disease Control

The continuous cropping of a single species favours the incidence of pests and diseases, and encourages competitive weed populations to establish in fields. Rotations provide an adequate tool for controlling those through: allowing for different types and timings of cultivations, not leaving individual weeds species room to establish; alternating crops that are weed suppressant with those that are weed susceptible; reducing the threat of pests and diseases being passed over from one crop to the next through alternating host and non-host crops.

Hemp is generally tolerant to pests and resistant to diseases, excepting the fact that it is a host to broomrape (*vide supra*, pp 24), characteristic shared with oilseed rape. That is not of such high significance for the organic farmer, as it is not a common organic crop ["oilseed rape is hardly grown in organic systems because there is no specialist market for the crop and because of its high nutrient requirements" (Lampkin, 1990)], and should it be used it can always be fitted at adequate temporal distance from hemp. None of the farmers we spoke to had problems with broomrape. The Defra (2002) study on break crops reported no apparent damage to the crop from pests and diseases, without any treatment being carried out during the crop's growth. We note, however, that hemp should not follow wheat, as the latter is a vector for *Sclerotinia sclerotiorum* (hemp canker).

Hemp is a natural suppressor of weeds, but its success in performing that function is dependant on good management practises. This was made particularly clear to us when carrying out farmers and advisors interviews, as some farmers experienced serious weed infestation problems in their hemp crops. We believe this was mostly tied into poor management (e.g. the fact that the crop was not being rotated), and also dependant upon soil type and existing weed bank. When growing hemp for harvesting seed, extra care should be taken on weed management due to the fact that lower densities may give competitive plants an advantage. This is important in any crop, but especially for seed crops, as the contamination of these with non-crop species will reduce their value or mean the use of difficult separation processes.

Diversity and Stability within Systems

Crop rotations are used to encourage biodiversity within the farm system (Soffe, 1995), at the same time as they enable continuous annual cropping thus not disrupting the financial output of the system, if not even increasing it through minimising losses and risks involved in agricultural production. But, as with anything in whole systems evaluation, no individual aspect can be seen *per se*, but rather as an "organ" working together with other "organs" in a combined effort to make the "organism" function healthily, generating in this way benefits (or emergent properties, as described by Checkland) that would otherwise not be achieved. Lewin (1996) summarises this idea:

"the interaction of individuals in a coherent group performs functions beyond the scope of any single individual" – individuals being each component of the system.

So, whilst crop rotations are a fundamental tool in whole farm systems, they alone will not be able to make them healthy – that is dependant on a wider planning scope: an optimal agro-ecological layout over the whole farm will contribute strongly to the stability of the eco-system and support the functions of the crop rotation (Wijnands 1999). Some of the criteria to consider on this layout are: Field size and shape, proximity between fields and overall ecological infrastructure (e.g.: presence and adequacy of biotopes and linear features). Even then, it is helpful to remember that any agricultural practise is disrupting the processes of natural diversity and when we talk about enhancement it really means damage limitation.

In this function, hemp fulfils desirable characteristics: it is from a family that is not commonly used in organic crop rotations, provides an adequate break for pests and diseases, and has a high weed suppressing ability. It produces large quantities of leaf-shed and seed-drop of value to building soil fertility and organic matter contents, structural improvements which have a beneficial effect not just on the following crop but on the soil biota of the system. The seeds are also of high feed value for birds and possibly other wildlife, respectively.

It does, thus, provide an adequate break function and adds diversity at the beta-scale. However, it is a highly competitive crop that does not encourage other species to grow alongside it and does not offer particular habitat value (similarly to other monocrops) that we have seen or heard mention of. In some of our interviews and also from research undertaken by Defra it has been suggested that it may even have allelopathic effects. All this points towards little value at the alpha-scale diversity, but admittedly there aren't enough studies focusing on the biodiversity impacts of the hemp crop. Montford and Small (1999) found hemp to be "superior to most major monocrops in terms of limiting damage to biodiversity", based on a ranking system covering 26 criteria points chosen to measure biodiversity friendliness. Hemp for seed production and for fibre production both featured in the five most biodiversity-friendly crops out of 23 major crops analysed.

To enable the fulfilment of the above named functions (which explain the importance of rotations) the design should follow a number of principles (within the limitations imposed by the particularities of any system). The most basic concept of rotation design, as we have been highlighting, is tied in with alternating species with different characteristics; here we list some of those and what hemp has to offer within each (Table 8), as a quick reference tool when choosing where to fit it in the rotation.

Table 8: The impact of Hemp's characteristics on rotational design considerations (Source Various)

Important Characteristics for Design Consideration	Hemp Characteristics	Perceived Impact
Alternating deep and shallow rooted crops	Deep rooted	+
Including low and high biomass return crops	High biomass root system, easily decomposed. Large amounts of leaf shed	+
High and low nutrient	High nutrient requirement	-

requirements		
Level of weed suppressing capacity (= clean or dirty crop)	Good canopy, fast establishment.	+
Susceptibility to insect pests	Tolerant to most common pests	+
Susceptibility to diseases	Resistant to most common diseases	+
Times of sowing and harvesting	Not competitive for labour time No flexibility due to legislation	+/-
N- fixing/ N-demanding	Hungry crop	-
Use of catch crops, green manures and undersowing techniques	Highly competitive crop, does not favour alpha-scale diversity Cannot be used as green manure due to legislation	-
Associated Biodiversity	New family, significant feed value (seeds and crop residues), favours beta-scale diversity.	+
Labour requirements	Low maintenance crop; high requirements during retting	+/-
Commercial value	Processing and marketability not sufficiently developed, but good return for a short-term crop	-/+
Mechanised operations	(Same as labour requirements) Short cycle crop, avoids peak times	+/- +

Key: -negative, +positive

Please note the contradiction between some of the advantages and disadvantages of the crop [namely those which are determined through legislation (VIDE SUPRA pp….)], which are outside of the farmer's decision-making process (i.e. cannot be weighed against each other for choosing the best possible function).

We have opted by only looking at hemp in this chart under the assumption that the main characteristics of common crops in the context of rotational design are easily identifiable. Also, the next part of this work enters into further detail of comparative analysis between hemp and other crops, touching on many of these principles and thus providing a better insight into the interactions or choices between them.

5.2. Hemp vs Other Crops

The research carried out on this particular subject was varied and, very often, contradictory. Given the variety of different agronomical and whole-farm system functions a given crop can provide, we have chosen those that we believe are most relevant to both the chosen crop (Hemp) and target system (Organic Farming). As there seems to be concerns on the financial performance of the hemp crop, we offer a comparison between the gross margins of hemp and other common crops (Table 9).
Of main importance to an organic farming system are the break crop properties of hemp, as they represent the strongest functionalities it offers (Table 10).

We intended to also include a comparison chart for the assessment of hemp's value in terms of biodiversity, but could not find enough literature of sufficiently solid contents from which to start. Also, as will become clear in the interviews we have made, biodiversity has not come across as a particularly relevant factor to farmers. We have found most of them to be environmentally aware people, with relatively diverse farming systems. Whilst they were interested in the potential effects on biodiversity they were not relying on hemp to fulfil that role as a major player.

Table 9: Comparing Gross Margins (Adapted from Hemcore's Growers Guide 2003)

	HEMP			OTHER SPRING BREAKS			
	Low	**Average**	**High**	**Linseed**	**Peas**	**Beans**	**Rape**
Area aid (€)	316	316	316	316	363	363	308
Yield t/ha	3.75	5.5	7.5	1.8	3.7	3.7	1.8
Crop value (€)	154	154	154	224	119	119	210
Return (€)	892	1 162	1 469	719	802	802	693
Variable costs (€)	302	484	559	230	256	207	240
Gross Margin (€)	**474**	**678**	**909**	**498**	**533**	**596**	**452**

We note that Hemcore give the output (crop value) at €158/tonne and that price at harvest is actually €126, so the higher value includes a storage premium of €28/tonne. The gross margins would decrease significantly if the farmer did not have storage facilities or did not want to wait for the storage premium. They highlight the fact that the gross margins do not reflect factors such as reduced field operations, reduced workload and the fact that it is an ideal crop for those converting to organic farming. Also that figures quoted may not be accurate at the time of print, due to price fluctuations.

We would like to add that profit is not always the central consideration in organic farming systems and that many of the functionalities provided by a crop are not quantifiable in conventional economic analysis.

Table 10: Comparing break crop functions (DEFRA, 2002: The advantages and disadvantage of different break crops in organic grass/arable rotations)

	Soil Structure	Soil Nutrient Status	Weed Break	Pest & Disease Break	Financial Return[1]
Field Beans	+	++	+/-	+	+
Lupins	+	++	++	+	-
Soybean	+	++	-/+	+	-
Hemp	++	+	++	++	-
Rape	+/-	+/-	+/-	+	-
Potato	-/+	-	++	+	++
Linola	-/+	-/+	++	+	-
Carrot	-	-	+	+	++
Swede	-	-	-/+	+	++

[1] Compared to winter oats as standard.

Sugar beet	-/+	-	-/+	+	-
Winter oats	-/+	-	-	-	

KEY: - Detrimental effect, + Small benefit, ++ Large benefit

This study was done for the Department for Environment, Food and Rural Affairs (DEFRA) by a UK-wide project team lead by the Scottish Agricultural College (SAC), with partnership of the University of Wales-Aberystwyth (UWA), Henry Doubleday Research Association (HDRA) and Horticulture research International (HRI).
Some of their main conclusions relevant to hemp include:

- Hemp had positive effects on significantly reducing weed populations during growth stages (without any weed control after sowing) and in the subsequent cereal crop by comparison to the oat control crop.
- Hemp had almost no recorded pest and disease damage at any site, seeming to provide a good break from these to subsequent crops.
- Evidence suggests that hemp may provide valuable functions for soil structure

The report also rates hemp as having very low economic potential. However, having visited some of the trial sites (UWA and HDRA) and spoken to some of the scientists involved in the project we understand that this conclusion did not take into account current market prices as offered by Hemcore (and although contracts may be difficult to secure if the farm is located exceedingly far from the processing plant, the fact is that many farmers do sell to Hemcore from many areas of the UK). We suspect that if those prices had been taken into account the financial rating of hemp would have been somewhat higher (vide supra, table 9 p 39).

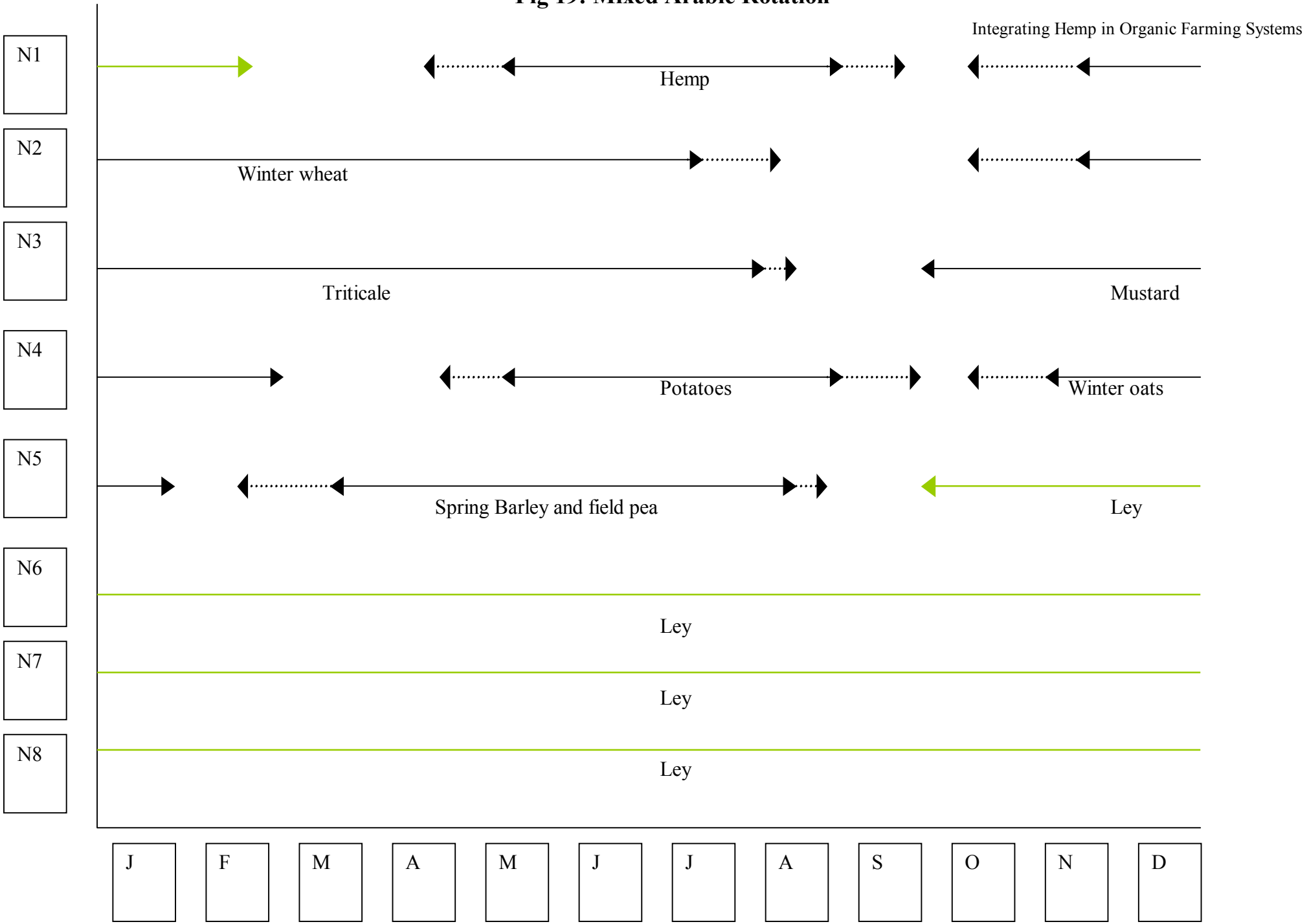
5.3. Examples of Rotations Integrating Hemp

It should be noted that no design is adequate for all farms, nor is it likely that a single rotation will be adequate for the whole of any individual farm. Implementing and managing a rotation requires flexibility, as the orthodox following of a pre-established timetable can lead to a number of different mistakes. Most farmers spend many years developing a rotation that is suited to their own individual circumstances. (Lampkin 1990) bearing that in mind and the design principles previously mentioned, we have created two examples of possible rotations including hemp; though they are essentially illustrative, we hope they are also useful in practical applications.
We have opted out of giving examples of primarily grazing or horticultural oriented production systems, as they fall outside the main scope of our course.
This is not to say that hemp would not be suitable for use in those systems, but rather to concentrate on combining the theory of our course with the experience of doing this report, both of which concentrate on predominantly arable production systems.

- **Mixed Arable Rotation (Fig 19)**

1. Hemp
2. Winter wheat
3. Triticale - followed with mustard as winter cover green manure
4. Potatoes
5. Winter oats,
6. Spring Barley/ Field pea mixture
7. 3- year grass/red clover ley.

Fig 19: Mixed Arable Rotation



OUR CHOICES EXPLAINED…

Hemp has been consistently recommended, from both the interviews and the literature, to follow grass-based leys and precede cereals. It benefits greatly from the nutritional and structural improvements of the pasture, giving a good break function to the cereal crop and effectively utilising residual nitrogen, as well as preventing some lower layer losses due to its deep rooting system. Its short cycle fits in well within the rotation, closing a gap over the summer whilst providing some economic return.
When growing hemp for seed, it is important not to have a previous crop residual seed bank in order not to contaminate the hemp seed harvest, as its price would be affected (need for separation). This also applies to preceding spice crops (like coriander) as they impart their flavour to hemp oil, as well as having small seeds that can easily contaminate the hemp crop.

Wheat is highly nutrient demanding and is susceptible to weeds, hence following hemp, which is a clean crop. Sufficient nutrients will still be available and it will benefit from the structural improvements of the preceding crop. Sowing a winter cereal will minimise losses and make the best possible use of the available space. It is a high value organic crop and contributes greatly to the economic stability of the production plan. We would recommend the use of older (taller) varieties, as these tend to perform better in organic systems due to the increased shading effect. They may not yield the same quantities as modern varieties, but will yield higher amounts of straw, which will be important in an organic farm.
In colder climates, the earlier sowing times may be a problem due to the long retting requirement of the hemp crop, but it should be feasible to sow it timely.

Triticale is a cross between wheat (*Triticum*) and rye (*Secale*). It provides the yield and quality of wheat and the low demand and winter hardiness of rye. In organic farming systems rye is most often found as a second cereal crop after wheat (Lampkin, 1990). It has a large root system, rapid spring development and long straw. These combined with autumn tillering have a significant effect on weed suppression and less demands on the soil. For these reasons we chose to follow wheat with Triticale, which we will then follow with mustard as a winter cover green manure (to protect the soil, avoid nutrient losses and replenish organic matter contents). It is also suitable as a concentrate replacement and has higher crude protein so at least part of the crop can be held back for on-farm consumption. It can also be used as a forage crop or green manure. Triticale is also drought resistant, an advantage throughout late spring and summer.

Potatoes will benefit from following a nutrient replenishing green manure, as they usually follow crops that have high levels of residual nutrients and organic matter. Are also unlikely to suffer from incorporation consequences (like inhibiting of germination), as they are tubers. They can be valuable as a preceding crop to winter cereals and are a good cash crop to include in the rotation. Again here the early sowing dates of colder climates could represent a problem, but early harvesting or the use of early-maturing varieties can overcome that. Root crops other than potatoes could incur high levels of weed control operations (which tend to be underestimated in organic systems).

Oats have deep rooting systems and tend not to be sensitive to low nutrient availability, which should mean that they will follow root crops easily. Despite the fact that organic oats are easily marketable, we will use them in this rotation as a winter cover crop, harvested for fodder in early spring and then incorporated. This will prevent too many losses and provide extra feed for stock, as well as some soil improvements for the following crop.

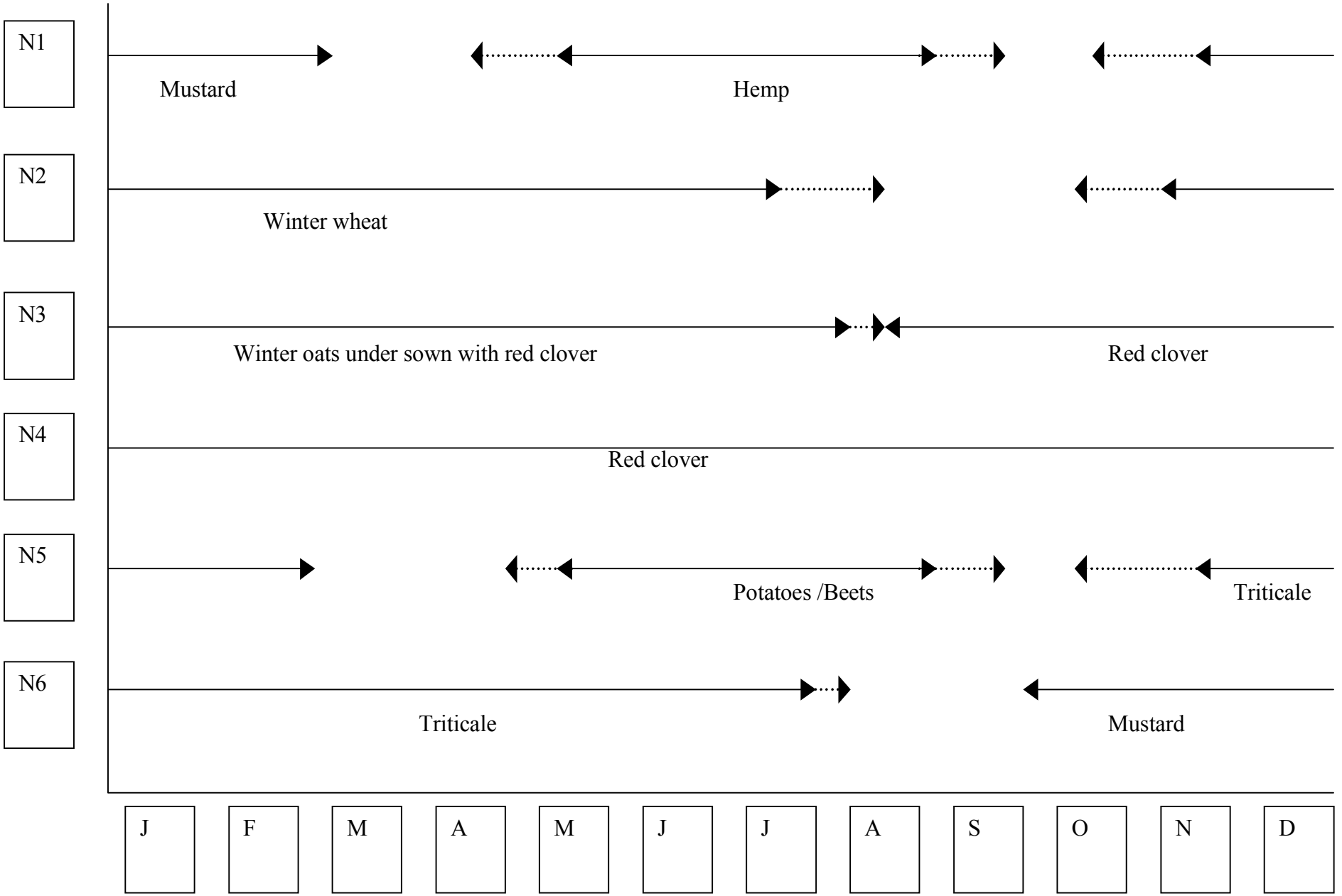
Cereal and grain mixtures have become more popular recently. The combination of crops brings increased cropping efficiency and improves pest and diseases control mechanisms. A barley and pea mixture provides support for the growing peas, marginal N fixation benefits and it may result in higher protein contents in the cereal (Lampkin 1990). Crops can be sown at up to 75% of their individual sowing rates, both having a good cash return.
Approximate harvest dates mean that the crop can be combined and later separated if required. Again part of the crop can be held back for stock consumption if required.

A **mixed ley** of 3-4 years is the central point of most rotations. It contributes fertility to following crops and performs the main break function within the rotation. Ideally suited to precede the hemp crop. We have also included other forage and fodder crops to provide bulky feeds to supplement animal nutrition at times when there may be a shortage of feed availability.
On a mixed farm with a ley/arable rotation, 30-50% of the tillable land will be devoted to the production of forage (Lampkin, 1990). We feel we accomplish that through the use of this ley, complemented by other crops that are partly or integrally used for fodder.

- **Stockless Arable Rotation (Fig 20)**

    1. Hemp.
    2. Winter wheat.
    3. Winter oats (undersown with red clover)
    4. Red clover
    5. Potatoes
    6. Triticale followed with mustard

Stockless Arable Rotation



The justifications of the choices made for this rotation are largely described in the previous one. We note the following differences in purpose or additional comments:

There is a relatively well-established market for organically produced **oats**, which give it a financial advantage comparable to wheat, thus increasing the financial stability in the rotation. Oats are eminently suitable as a second cereal crop (Lampkin 1990), and have the advantage to be more flexible than wheat or barley. We undersow them with **red clover** in an attempt to restore N levels in the soil, knowing that this particular crop will not suffer greatly with poor soils (or time it takes the clover to begin significant fixation). At harvest time, the clover is left on the ground to further establish and provide a one-year break, before being incorporated.

The use of mustard after Triticale follows the same reasoning as in the mixed rotation, this time attempting to provide the following hemp crop with a nutrient enriched soil. (Note: mustard would be incorporated relatively early, in order for decomposition and mineralisation to begin taking place.)

Incorporating a grain legume would have the advantages of providing significant levels of nitrogen fixation (if the crop grain is not sold off the farm) and structural improvements, but did not prove practical within this particular rotation, due to a combination of clashing cultural operations and excessive proximity to the red clover break. A longer rotation would have been preferable, but we went with the more widely used method of a 6-year rotation with the intention of making it more similar to those of potential hemp farmers, therefore easier to adopt. We also aimed for high economic return through the use of several cash crops and tried to balance these with system restoring crops.

Important to note that these suggestions can all be played around with, by utilising the main principles of rotational design (*vide supra*, table 8) using the comparative advantages of hemp within the crop rotation. This is applicable to both having hemp in different positions of the rotation and having different crops being produced than those illustrated in the examples [in fact this also applies, by and large, to different production systems altogether (e.g. vegetable production systems)].

PART II: Action Research: Our Interviews

1. Methodology

A systemic approach

As was previously stated in our introduction, our methodology is in fact perhaps as important as the actual content of this project. From the start, we knew we wanted to focus on getting the opinions and perceptions of farmers with regards to hemp as a crop. There are several reasons for this; first of all, a will to look at the practical agronomic aspects of hemp and we felt that farmers would be most knowledgeable in this regard; secondly, our belief in the importance of participatory research, and finally we wanted to look at hemp in terms of the whole agroecosystem; touching on the interactions between political, economic, social, ecological and agronomic aspects.

While the second motivation mentioned concerning our interest in participatory research will be explored page 68**,** the third point requires a brief elaboration, as it encompasses to a large extent the concept of participatory research. Central to our project is our effort to incorporate into our research a "systems thinking" approach. Systemic thinking recognizes the need for a more holistic understanding of the context of farming (Gibbon, 2002). We have done this by first of all moving away from a solely literature based research paper to speak with farmers, advisors and researchers in order to get a more encompassing picture of the entire system within which hemp production exists. Ideally we would have wanted to more fully involve farmers in our research, helping us to better define and orient our project, as we feel that farmer participatory research reflects such a systemic way of thinking. It should be highlighted that systemic is quite different from systematic, being in fact recursive, i.e a product of multi directional feedback (Bawden, 1990).

The analysis of our interviews also tries to employ such a methodology, as we sought to process the information using visual representations such as mind maps (Appendix 3), that enabled us to continuously be visualizing the system as whole, and the extent to which its various components interacted amongst each other. System thinking holds at its core the notion that systems as a whole have properties that are unpredictable from the known properties of the individual components (Gibbon, 2002). Such a perspective in fact reflects the founding principles of organic farming, where the agroecosystem as a whole remains the system within which crop production is considered and is therefore one of the motivating factors for us in adopting such a research methodology. It should be noted that employing such a soft systems methodology was done to the extent whereby our limited timeframe and experience with the topic allowed for it

Our choice of the UK, France and Denmark

A brief explanation is first required concerning the choice of countries in which our interviews were conducted. We had initially thought that the number of countries to be looked into would total 5, made up by the addition of Portugal and Romania, home countries of two of our group members, thus omitting language and cultural barriers. Also because Romania is the largest European producer of hemp and initial literature

reviews suggested Portugal to be one of the EU's most consistent producers of the crop.

Both of these lines of pursuit failed due to different issues:

- In Portugal there was a notorious lack of organized information and awareness on the state of hemp production in the country. We contacted the Ministry of Agriculture, the Regional department of Agriculture of Alentejo (the region where the production is allegedly higher), the Portuguese Association of Organic Farmers (Agrobio) and the Portuguese Farmers Confederation (CAP). None of the contacts made, although in person, yielded tangible results. There were no databases or detailed information on the growing of the crop and conflicting opinions were constantly expressed, leaving little room to pursue a line of investigation. Some hemp farmers phone numbers did eventually surface, but they were outdated and contacts were never established. As the visit to Portugal had time limits, the country was abandoned from the research.
- In Romania, information was also not forthcoming from the governmental institutions contacted. Farmers were eventually located and investigations were beginning to take shape. However, approaches had to be made through the phone as a visit to Romania was impractical at the time. It was made clear to us that Romanian farmers were not ready to discuss their growing of the crop over the phone and were guarded about the whole issue. We had felt that this was due to its connotations with marihuana. As this proved to be a consistent result, we opted out of including Romania in the project.

The choice of the final three countries was mainly a practical matter: Denmark was chosen because of our location therein, while the UK and France were the home university countries for two of our group members. Concentrating on these countries minimized potential language barriers and facilitated the task of securing interviews.

Finally, having only about six weeks in which to carry out the research, time constraint was a factor in our decision to limit ourselves to these three countries. The task of finding a hemp farmer was easiest in France, and was enabled through personal contacts. For the UK, several unsuccessful attempts were made before we were led to a research project on hemp located in Wales, where we were given the contact information for three different farmers. The task in Denmark was not an issue, as there is apparently only one farmer growing hemp at present.

The advisors chosen were the ones associated with the interviewed farmers. A few secondary interviews were also carried out with researchers in the UK and Denmark, most of which were found to be of limited value and go unmentioned in the project. Another determining factor was our desire to limit the amount of interviews conducted by telephone, as initial interactions over the phone had proven to be intimidating for farmers, thus not enabling us to get an accurate impression of the situation. Phone conversations in general were rather limited, as people were often hesitant to speak freely on the subject of hemp. Additionally, our decision to actually visit the UK was strongly encouraged by being unable to secure contacts in Portugal or Romania.

Formulating and carrying out the interviews

The actual interview was formulated as a group, with slightly modified questionnaires being prepared for current hemp growers, previous hemp growers, first time hemp growers and advisors and researchers respectively. The questionnaires were composed of approximately 20 questions which were divided into four sections: general information; agronomic; economic and social aspects. Emphasis was placed on the agronomic section, with such a focus being made clear with the interviewee before proceeding with the interview. Sample questionnaires can be found in Appendix 1.

We decided to use unstructured interviews in order to gain a more holistic and personal picture of the situation. Employing an unstructured interview allowed for farmers to steer the conversation into areas which might not have been explored within a structured interview. On the other hand, employing such a form of interview made it more difficult to analyse the qualitative data, and to establish definitive comparisons.

The method employed in conducting the interviews changed throughout the project, as we were continuously learning from previous experiences and adapting our strategies in consequence. The first interviews to be conducted were the ones in France, which were done in French, and which were recorded in written form. The interviews were later transcribed into English, and organized according to the questions that were asked.

The Danish interviews were the next to be conducted. The farmer interview was conducted by two group members, and was written down and transcribed similarly to the French interviews, with the added benefit of having been done by two individuals. The advisor interviews were also done by the same two individuals, but due to constraints on behalf of the advisors, these interviews were conducted by phone and transcribed by hand. It should be noted that the country's number one researcher/advisor regarding hemp was unwilling to take the time to speak with us, as she insisted that speaking with the farmer would be sufficient and that she did not have the time to be extensively interviewed. Given Denmark's lack of hemp growers at the moment, it was impossible to find another advisor working with hemp. It was thus decided to interview an advisor working with organic farmers in general and who had done some research on hemp. Both advisors were contacted by phone.

Given the amount of interviews being done in the UK, and the realization that certain information during the farmer interviews had failed to be taken down, it was decided to use a tape recorder. Though this made for a lengthier transcription, it did ensure greater reliability as well as for a more relaxed interview. The UK interviews were also carried out by two individuals. All interviews, except for that of the two Danish advisors, were done in person.

Also, examples of the questionnaires we used during our interviews can be found in Appendix 1. Tables 12 and 13 provide an overview of the growers and advisors interviewed in the different countries.

Transcribing the interviews

The French and Danish interviews were further transcribed in a similar fashion. Once the answers to the individual questions were written down, the transcript was further divided into a common format consisting of six dividing categories, which follow to a large extent the different themes encountered throughout our lecture period: systems ecology; biodiversity; technology; crop management; economy; human aspects and a miscellaneous category for additional information or striking quotes. Appendix 2 provides the analysed interviews in organised form.

Processing of the UK interviews followed a different method in order to save time. One of the interviewers paired up with another group member to transcribe the tapes, which was done by immediately classifying all of the gathered responses into one (or more) of the six categories previously mentioned. Doing the transcription in pairs allowed for a more rigorous classification of the information.

Analyzing the data

After having compiled all of the information into our six categories, the whole group got together to create what has been referred to as a 'mind map' or a 'rich picture diagram'. The method was introduced to us by Professor Sri Skandarajah, from KVL University, who provided us with valuable guidance and support on how to analyze qualitative data using this technique. After having been advised on some of the general parameters involved in mind mapping, we adapted the model to the project's own requirements.

Our group first laid out the basic skeleton of our thematic categories, in mind mapping style, whereby a central 'bubble' containing our main question "What is the political, economic, social, ecological and agronomic potential of fitting hemp into temperate organic rotations?", was branched out to six new bubbles representing our six categories. An initial brainstorm, with each of us referring to one of our own interviews, focused on placing the different topics covered during the interviews under the most suitable bubble (or bubbles if need be). For example, systems ecology was divided into several sub-categories/bubbles: pests and diseases; weeds; soil fertility; soil structure; biodegradability and additional services, with an interacting link with the biodiversity bubble. A second brainstorm then proceeded to look at each of these sub-categories, under which was written any relevant data found in our transcribed interviews. An ongoing analysis during the process aimed at finding areas where the farmers converged or diverged in their comments, in order to define what we felt to be the central points of interest.

Continuous analysis and discussion occurred throughout the exercise, not only with regards to the comparison of the different interviews, but also concerning the suitability of our different categories, which were continuously being adapted. During the process, information which was noted onto the mind map was highlighted on each of the interview transcripts. In this way we were able to verify at the end of the exercise if any information had been left out. Comments emerging from the process were taken down by one member of the group who would subsequently combine the notes and final rich picture diagram into a summary text which begins on page 53.

This summary text was then reviewed by all members of the group, discussed together and then modified where it was felt to be necessary. Part of our mind map diagram can also be found on figures 21 and 22. Analyzing the advisor/researcher interviews was done on the same mind map with a different colour, in order to compare the data obtained from advisors with that of farmers.

Fig 21: The main mind map driving our interview analysis

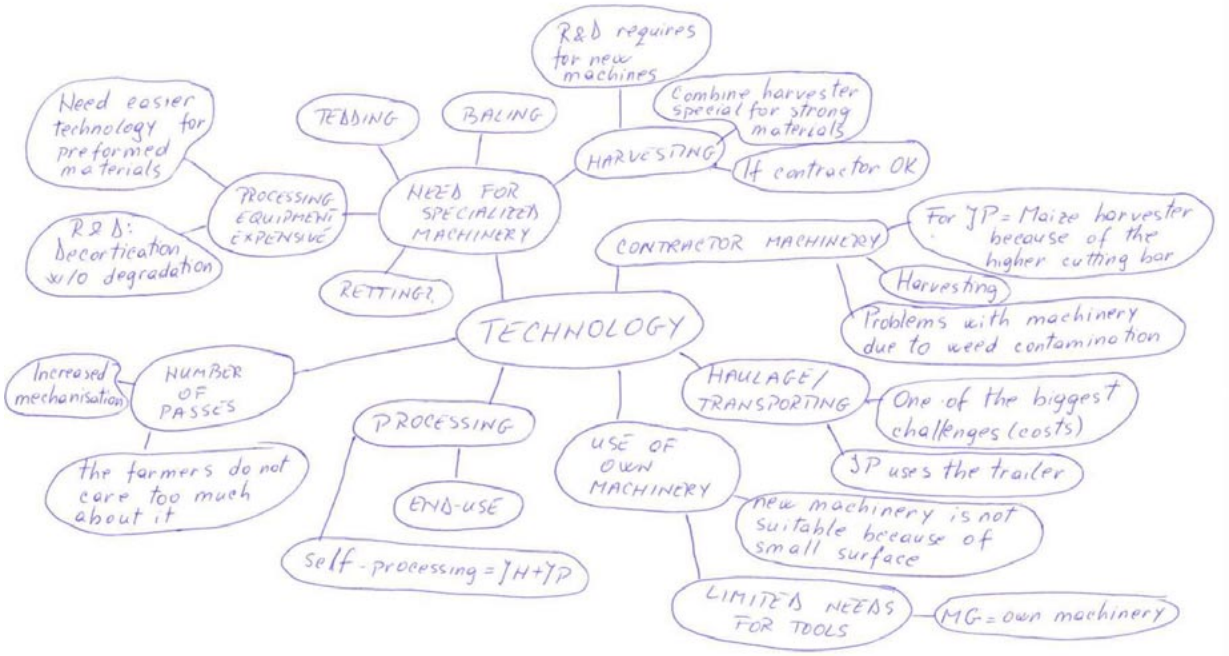


Fig 22: A detailed "mind tree" gathering the different reflections on technology

Our choice of categories

The choice to use the different categories in organizing and analyzing our data was only done after the interviews had been conducted, as a division was seen as a means of better organizing our data. Given our interest in using a systems approach to look at organic farming systems, we felt that organizing our data according to the structure of our course in Ecological Agriculture made logical sense. To them we added the categories 'Human Aspects' and 'Economics'. Though not explicitly touched upon during the course, we found that much of our data fitted under these headings, and felt that these categories remained intricate sub-systems of the larger agro-ecosystem. In bringing our findings back to the focus of research, which looked at the agronomic aspects of hemp, it is important to note that agronomic information was found under each of the mentioned categories. The challenge was not in finding data to fit into the various categories, but in being selective and deciding which information could be left out.

In analyzing our data we found that information pertaining to one category was often also relevant to a second category. For example, the topic of weeds, pests and diseases was found to fit under at least three different categories: systems ecology; crop management and biodiversity. Certain topics were even difficult to properly categorize, as was the subject of retting, which we felt belonged somewhere between crop management and technology. More generally, all aspects classified under 'systems ecology' would undoubtedly be found elsewhere as the former category necessarily incorporates all other categories. Although an especially large overlap was found to exist between 'systems ecology' and 'biodiversity', the latter's importance in terms of assessing hemps potential as a crop in organic agriculture explains our decisions to keep the two categories separate.

2. The UK, France and Denmark

The UK

Climate and Topography

The UK is a producer of fibre, as the climate is not conducive to seed production due to excess rain and unstable weather conditions. This also has an implication for harvesting and retting, both of which are highly dependant on favourable conditions. In Wales, altitude is a factor to consider as many farms are at a considerable height above sea level. This has proven to have an impact in crop height and nitrogen uptake; where the latter appears to be up-taken more than normally expected, due to sunlight and temperature being considerable limiting factors.

Subsidy and incentives

The researchers and farmers we interviewed in Wales were closely linked to a research project coordinated by the University of Wales in Bangor (UWB) *vide supra* pp 16. Part of the project's funding is given to the farmers in the form of a £320/ha subsidy for the growing of the crop, this being the main motivation for farmers to take up the challenge.

In many cases this is topped up by the arable area payment scheme, around £200/ha. Some farmers do not have Arable Registered Land and therefore miss out on the latter one.

Industry

Hemcore is the main processor in the whole of the United Kingdom, having contracts established with over 80 farmers, totalling around 3000ha for 2003. Farmers source their seed from them at a higher than market price, and bear the haulage costs to transport the baled crop to the plant. Hemcore pays €126/t for crop at harvest time and increases payment to €182/t as a storage premium. A large quantity of their fibre is utilized as horse bedding or is destined for the paper, automotive or insulation industries.

BioFibres was the processor in North Wales and partly responsible for motivating the farmers to grow hemp, as they were keen to develop a local industry thus providing ease of contract, cheaper transport, knowledge of crop movements and reliability. BioFibres unfortunately went into receivership last year, due to a combination of excess investment in specialised equipment, (world-class plant, often visited by foreign processors from France, Canada and others), and a slowing down of the market due to changes in the CAP subsidy scheme.

Legislation

Until 1995 it was illegal to grow the crop in the UK. After this, licenses issued by the Home office were the instrument of control for growing hemp. These incurred steep fees (€503) and were characterized by highly bureaucratic and time consuming processes, and strict conditions about the location of the fields where the crop was to be grown. The above represented economic, labour and planning pressures on farmers (who very often gave up before they started).

Since last year the licensing arrangements have changed in two very important areas:
-a relaxation of location requirements
-the ability of processors/contract holders to acquire a license for a number of growers and, undertake the responsibility for site inspection and the general fulfilment of licensing requirements.

This has meant that many farmers were now willing to grow hemp, licensed under either Hemcore or the Bangor project.

France

Hemp requires a temperate climate, which is why growing hemp is particularly well adapted to being grown in France. Hemp is grown in the North-West and North-East for fibres and in the South-West for seeds. In spite of a public support established in the early seventies, hemp growing survived in the seventies and eighties only in France and Spain on a surface of about 6000 Ha. In 2002, the cultivated surface in Europe was about 15’000 Ha (Fédération Nationale des Producteurs de Chanvre, 2002), 7700 of them being grown in France.

The Common Market of flax and hemp was organized in 1971 by rules of procedures fixing the conditions for obtaining aid. In order to receive such aid, fibre crop growers must provide details regarding sowing surface and harvest to the SIDO (Organisation of the Oil Seeds, Protein Plants and Fibre Plants), the official body which oversees the process. Concerning hemp, aid demands are entertained by the CEAPC (Hemp Production Economical Committee) working for the SIDO for precise tasks. The aid is paid directly to producer. In 1997 it was 730€ and since 2001, the subsidy is fixed regionally, following the formula: yield of dry cereal in the department x 7.563€. This corresponds to an amount ranging between 411 and 503€ depending on the department. Table 11 gives an idea of production costs and outputs in France.

Table 11: Production costs and outputs for hemp (FNPC, 2001)

Production 2001	**Fibre Harvest**			
Yield in Tons	**7**	**8**	**9**	**10**
Output for straw (€)	480	548	617	685
EU subsidies(€)	457	457	457	457
Global output(€)	**937**	**1005**	**1074**	**1142**
Fertilizers(€)	105	105	105	105
Seeds(€)	174	174	174	174
Baling and Haulage	211	228	245	262
Miscellaneous(€)	7,5	8,5	9,5	10,5
Global input(€)	**498**	**511**	**535**	**553**
Overall profit(€)	**439**	**490**	**540**	**590**

Denmark

More than 50% of Denmark's surface is used for agriculture, making it a large exporter of agricultural products. Although, as in other countries around the globe, Denmark's current industry for hemp fibre remains very small, no industry at all exists for the production of hemp seeds. In general there seems to be a lack of interest in the crop. Whether this is simply due to lack of publicity of the crop or tied to issues of previous prohibition is unknown.

Today there is only one farmer who is continuing to grow hemp for fibre production. He is responsible for part of his own processing. Fibres are then contracted to another processor of hemp insulation in Jutland. The poor quality fibres are further processed by the farmer and sold as horse bedding. There are two other farmers who also grow hemp but do so only for bird hunting benefits, and it is not harvested as a crop. The conditions for growth are well suited for Denmark. A possible concern is that the soil needs to be well drained, as too much water will drown the crop. Cultivation is carried

out using standard cereal crop machinery but there is a definite need to adapt these technologies to specially suit hemp's long, tough fibres.

Both market and legislation considerations make it very difficult for farmers to start growing hemp. The legislation is heavy and the proceedings to get a licence can take a long time, (the farmer we interviewed said that it took him three years to get a licence for hemp fibre crop), and relevant fields get inspected two to three times a year by the governmental authorities. The legislation doesn't allow selling the oilseeds, thus reducing the hemp market to only one for fibre. Certified seeds, complying with EU regulations, are attained from France.

There is no processing industry at the moment, (a processing plant used to function in Jutland, but due to financial problems it was closed 2 years ago), which has contributed to the reduced market for hemp in Denmark.

3. The Interviewees

Throughout the text the farmers and advisors will be referred to by their initials, as they appear in the tables. The tables provide useful background to the people interviewed and can be referred back to throughout the reading of the text. It is interesting to note that only three of the five farmers interviewed were organic farmers. Differing in hectarage and experience with hemp, all farmers had in common the incorporation of animals in their systems (Table 12).

Table 12: Summary of farmers and their farms

Farmers	Location	Organic	Total area (ha)	Crops grown	Livestock	Hemp growing status	Hemp area (ha)	Processor/ End use
Matthew Gee (MG)	Wales, UK	Yes	150	Hemp, grassland, potatoes, carrots, swedes,	Sheep(500), Beef cattle(40)	Second year	4	Tba
Arthur Parry (AP)	Wales, UK	No	170	Hemp, flax, grassland, whole crops (barley/oats/wheat)	Horses	Second year	10	Hemcore/ horse bedding, insulation, paper automotive industry
Richard Kellet (RK)	Wales, UK	Yes	305 acres	Flax (previously hemp), grassland, barley	Beef cattle(100), sheep(100)	1999-2002	25 acres	Hemcore/ see above
JP Andrieux (JP)	Britanny, France	Yes	6.25 ha	Hemp, wheat, vegetables, pasture	Donkeys(2), turkeys/chickens	10 years	1 ha	Self processing/ insulation
Jorgen Heggelund (JH)	Zealand, Denmark	No	80	Hemp, wheat, potatoes, hay, strawberries, corn	Had chickens	5 years	5 ha	Self processing/horse bedding, fuel pellets, insulation

Regarding the advisors, LB and G/J were directly involved with the French and Welsh farmers we interviewed. Having been unable to speak adequately with BP, we contacted a general advisor to organic farmers, SD, who had been involved with various hemp experiments. We also interviewed MH from the Biocomposite Centre in Wales in order to get a better understanding of market development aspects of hemp (Table 13).

Table 13: The advisors and researchers

Advisors/researchers	Country	Education background	Farmers/hemp farmers	Comments
Laetitia Brunnevalle (LB)	France	'ingenieur' in agronomy from INA-PG in Paris	616 hemp farmers (all hemp growers)	Involved in variety improvement
Svend Daverkosen (SD)	Denmark	Agronomist – KVL degree; 4 years organic advisor	80 organic farmers; none hemp grower	Many hemp research projects
Bodil Pallesen (BP)	Denmark	Researcher in plant production	0 farmers (not advisor anymore)	Limited agronomical knowledge
Geraint Hughes Jim Dimmock (G/J)	Wales, UK	Crop scientists with university degrees	28 farmers/8 hemp	Keen on participatory research, forward thinking
Mark Hughes (MH)	Wales, UK	Researcher at BioComposites Center; PhD on properties of hemp/flax fibres	N/A	Enthused and very realistic; not involved with hemp agronomy

4. Interview Analysis

At the heart of our question, in assessing a crop's potential within an organic farming systems, is the consideration of its place within the agro-ecosystem as a whole. Conway (1987) describes an agroecosystem as an agro-socio-economic-ecological system, where the basic ecological processes (such as competition, herbivory and predation) are overlaid and regulated by agricultural processes such as cultivation, subsidy, control, harvest, marketing and social welfare. In defining our six thematic categories of analysis, we hoped to approach our question from such an agro-ecosystem perspective. Nevertheless, having chosen to focus on the agronomic aspects of hemp cultivation, we were primarily interested in the areas of crop management, systems ecology and biodiversity. Each theme seeks to answer our starting research question, which is to assess "hemp's potential as a crop within organic farming systems". A summarizing table can be found in Part II.

Systems Ecology

The term 'systems ecology' remains in many ways the least defined of our six categories, but also the most important. In choosing this category we intended to bring together the main ecological processes associated with a cropping system, according to class lectures and readings, in order to better assess hemp's potential within an organic farming system. Fundamental to this idea is the notion that organic farming systems remain intricately dependent on the surrounding ecosystem processes, and acknowledges not only this dependence, but also the extent to which cropping practices themselves also influence such processes. Within "systems ecology" we chose to look at a variety of components: weeds, pest and disease, soil fertility, soil structure and additional services. Biodiversity remains an especially important dimension within this category, but was felt to warrant a category of its own. One must keep this in mind while reading this section. Furthermore, most of the sub-categories mentioned are also central to the "crop management" section.

Weed suppression

It was agreed by all of the farmers and advisors that hemp was an effective break crop, particularly because of its ability to suppress weeds. It was thus recommended to be put at the head of a rotation, and before a weed susceptible crop such as cereals. However, although most agreed on this in principle, several of the farmers had experienced substantial weed problems. Our observation was that those farmers that had favourable management practices were able to benefit from hemp's attributes as a weed break. By this we refer to the need to take preventative measures, such as creating false seed beds prior to sowing, and placing hemp in a proper rotation. The farmer (AP) who had the most significant weed problems was unable to rotate the hemp crop, due to legislative impediments. Planting hemp after pasture seemed to be a particularly effective method in avoiding weed problems and in ensuring adequate nutrients for the hemp crop.

Pest and Disease

Hemp's attributes as a break crop were also highlighted by the lack of pest and disease problems. No problems whatsoever had been experienced by the different farmers, making spraying unnecessary. One advisor (BP) did mention potential problems with broom rape as well as isolated cases of *sclerotinia* in the following wheat crop. Advisors also touched on the difficulty of producing seeds in wet climates, where secondary damage from moulds and disease restricted the viability of seed production

Soil health

Improvements in soil structure were assumed by all, and although such observations were not quantifiable, it was often assumed on the basis of the following crop's success. As RK explained "every crop that has followed [hemp] has been a good crop!" Farmers seemed especially confident with this assessment, even if it had not been scientifically documented. This impression was strongest for the farmer who had been growing hemp the longest (JP) as he explicitly stated that two of his main benefits from the hemp crop were improved soil drainage and decompaction. Advisors were also confident in this matter, even though they were unaware of any studies on the subject. They mentioned the ability of the crop's deep roots in aerating the soil and in bringing up nutrients from deep down.

Positive results from the crop following hemp were also taken as an indication of hemp's positive affect on soil fertility. Although hemp was recognized as being a nutrient demanding crop, it was felt that this was compensated for by its extensive leaf shed during the retting period. One of the researchers also mentioned being involved in a number of research trials which found hemp to be a beneficial green manure (SD).

Additional services

Additional services provided by hemp include the provision of stubble, which was used for grazing in a few cases, and which also contributed to soil organic matter. As mentioned earlier, hemp's ability to improve both the quality and yields of the following crop came across as a valuable additional service. In fact, the advisor from the Bangor Research Centre (G/J) remarked that "all good farmers use hemp to increase the margins on other crops."

Biodiversity

Within biodiversity, two important points emerged from the farmer interviews; first concerning the farmers' own views on hemp as a crop, and secondly, with respect to the interviewers' observations on the different farms as a whole. It was felt that the farmers interviewed were relatively diverse in terms of having multiple enterprises; be it a variety of crops, incorporating livestock on the farm, or having a horse riding business. Table 12 lists the livestock present on the different farms. The farmers interviewed also tended to value the biodiversity of their environment, as many of them mentioned the importance of a nearby wetland, lake or the existing wildlife.

In looking more specifically at hemp, the crop was virtually always mentioned as a means of diversifying their cropping system, both in the interest of incorporating a different crop and also a new family. In assessing hemp's potential in increasing general farm biodiversity, it is relevant to note that farmers often mentioned the plants important seed drop which was found to attract large quantities of birds. A story was even recounted to us about a Danish hemp farmer whose main interests in hemp was in fact to attract birds for the purpose of hunting! Also mentioned was the importance of the crop's residues as retting occurs on the fields, which we presume might increase the diversity of the soil biota.

It was mentioned that little seemed to be known regarding hemp's affect on biodiversity. Researchers at the UWB (G/J) agreed with this and recognized its importance, as one of the centre's areas of research for the coming season was going to be in assessing hemp's impact on biodiversity. One of the farmers (RK) in Wales was no longer growing hemp as he adhered to the Tyr Gofal subsidy scheme, which did not recognize hemp as a favourable crop in terms of its feed value, and therefore biodiversity in general. It did favour flax for such qualities however, which came as a surprise to the farmer, who felt this reflected a lack of knowledge on hemp's actual benefits in terms of biodiversity. Such lack of knowledge was reflected in the comments from advisors, who narrowed down the topic of biodiversity to simply include hemp's value as a new crop and family within the farm, and it consequent attributes as an effective break crop.

Crop Management

Advisors and farmers in the UK and France generally had very good relationships with their advisors and followed their recommended instructions quite well. It should be noted however that the farmers in the UK were part of a research project and were therefore required to follow certain management instructions. Table 14 presents some of the management considerations of the different farmers. The following discussion looks at some of the more significant issues that arose during the interviews.

Table 14: Hemp within the rotation

Farmer	Rotation	Comments
Arthur Parry, Wales	Flax-Flax-Grass-Cereal (Hemp separate)	Restricts Hemp to same fields due to licensing requirements
Richard Kellet, Wales	Hemp-Barley-Grass/clover (4 yrs)	Sometimes uses field turnips as break crop, has extensive permanent pastures as well
Matthew Gee, Wales	Hemp-Grass-Lettuce-Grass	Intends to follow hemp with field vegetables depending on its performance as weed break
J.P. Andrieux, France	Hemp-Wheat-Vegetables(2-3 yrs)-Grass(at least 3 yrs)	Uses short term leys for soil improvement purposes, mainly focusing on increasing the margin of vegetable crops
Jorgen Heggelund, Denmark	Hemp-Wheat, barley or potatoes	Does not follow a specific rotation, finds hemp easy to follow with any crop, except rape

In all cases, hemp was easily incorporated into the various farms. The farmers did not have to make any significant changes to their cropping patterns in order to cultivate the new crop, and it appears to fit quite easily into traditional rotations. It should be mentioned, however, that none of the farms had particularly complex rotations (refer to table 14).

More diverse rotations were not observed for a variety of reasons including:

- problems with the wetness of certain fields
- licensing restrictions prohibiting the growing of hemp on more than one specific field
- farmers' lack of knowledge and experience with other crops
- advisors' lack of knowledge regarding all three areas of organic farming, hemp production and farm diversification.

Advisors agreed in general that hemp was a favourable crop to have within organic systems, and that it should be placed at the head of the rotation. UWB advisors recommended that hemp follow a short ley pasture and be followed by an arable crop, as hemp is an effective weed break. They also stated however, that this should depend on the existing weed bank and on management practices. Although advisors were not very precise in their recommendations, they attributed this in part to hemp's strong flexibility within a rotation. As hemp shows no negative interactions with other crops, (other than oilseed rape), it remains easily incorporated into any given rotation.

It should be noted that although the two first year growers (MG and AP) had encountered major difficulties during their first season, the three other farmers that had been growing hemp for a longer period of time were adamant on the crop's ease of cultivation once established. As RK told us, "I just shut the gate and don't come back for three months". Similarly, when asked to describe hemp's cultivation practices, MG immediately responded "After sowing it, I just leave it!"

Sowing

Sowing dates varied from mid April to mid May, depending on the location and the weather. In terms of sowing rates, quantities ranged from 20 to 74 kg/ha, with a mean of 42 kg/ha. Higher rates were associated with better weed control, but also with better fibre quality. The lower densities were found in Denmark and the UK as a result of the high cost of hemp seed. One UK farmer (RK) relayed how his best crop ever, had been a result of him accidentally doubling his seeding rate. That seasons' crop he referred to as a "blooming good crop it was!" (RK) In general, seeding was done with a regular seed drill and followed by rolling.

Weed control

Weed control was touched upon in the section on systems ecology. Only one farmer (JH) used any herbicide, which we feel is at least partially related to him having to grow the crop in the same field. The other farmers used preventative measures such as false seedbed preparation and putting hemp in after a ley. The situation can best be summarized by one of the researchers who said: "Websites say hemp smothers all weeds… no, it doesn't and I can prove it". Hemp's potential as a weed break appears to be highly dependent on the associated management practices.

Fertilization

Fertilization was found to vary from farm to farm, with the general impression being that hemp has similar requirements to a corn crop. Advisors generally acknowledged that hemp was at least as demanding as a wheat crop in terms of nutrients. Trials at UWB testing hemp's response to nitrogen had even found that the crop still responded to levels of 250 kg/N/ha.

Additional benefits

In addition to the mentioned benefits of not needing any spraying and little weed control once the crop has established itself, a few other benefits were mentioned. The crops short life cycle means that it can be sown late and harvested early, and is therefore less likely to interfere with the cultivation of other crops. Irrigation was said to be unnecessary by most of those interviewed. However, the one farmer who had experienced a crop failure attributed it in part to a dry spring, suggesting the crops sensitivity to germinating under dry conditions. Farmers situated in Wales were also highly unlikely to require irrigation. One of the farmers (RK), however, mentioned finding that the crop could handle drought well, which is likely related to the crop's deep rooting system.

Challenges

The retting and tedding was mentioned as a problem for all of the farmers, and were identified as key problem areas by advisors. This was in part due to the jamming of fibres in the machinery's rotating parts during tedding; to being dependent on the vagaries of the climate in ensuring a proper ret, and to the fact that four weeks of retting meant being unable to sow the field's subsequent crop. It was interesting to note that on the issue of tedding was one of the few areas where discrepancies were observed between the farmers and the advisors. While UWB recommended tedding once a week during the four weeks, neither of the two farmers did this. It was not surprising that the advisors should mention consistent retting as one of the main problem areas with hemp! The advisors were in fact strongly advocating stand retting which is more consistent. However, stand retting takes longer, as it does not benefit from the soils moisture, and is also dependent on a herbicide, and can thus not be considered for organic farming. Advisors in general agreed that consistent retting and harvesting were definitely the main problem areas. Further discussion on other aspects of harvesting are discussed in the section on "technology".

Table 15: Various management considerations of the interviewed farmers

Farmer	Sowing date	Sowing rate	Weed control	Fertilization	Retting period /Tedding #	Harvest date	Harvest method	Yield
Matthew Gee	Beginning May	35 kg/ha	False seedbed (power harrowed)	"Like corn"	N/A	N/A	N/A	Expect 5t/ha
Arthur Parry	Mid May	37 kg/ha	Cultivation + Round up twice	130 kg/N/ha 60-79 kg/PK/ha	4 weeks /none this year	Mid-late August	Grass mower	5t/ha
Richard Kellet	Beginning May	34 kg/ha (had also tried 70 kg/ha)	False seedbed (power harrowed); follows pasture	Pasture with leftover manure	3-4 weeks /once	End August	Forage harvester with maize header	1.5t/ha
JP Andrieux	Beginning May	50-60 kg/ha	False seedbed; follows pasture	Pasture mineralization	None needed	Early September	Maize harvester and grass mower	7t/ha
Jorgen Heggelund	Mid April	20 kg/ha	False seedbed	Green manure; P (13kg/ha) and K (50kg/ha)	4 weeks/not known	Beginning September	Forage harvester	8-12 t/ha

* N/A: Non Applicable, as this will be the farmer's first successful year.

Technology

When asked what their biggest challenges in the production of hemp were, farmers most often mentioned harvesting and transportation. Second in importance was the need to develop more efficient processing techniques as well as better end uses. It was interesting to find farmers mentioning off farm processes in response to such a question, as we expected their immediate answer to concern their own agronomic practices. Such a reaction emphasizes the recognized importance of processing and product development for the growth the hemp market. Central to these issues was the need for the development of specialized technologies for the harvesting and processing of hemp.

Harvesting troubles

As one farmer (RK) put it "when it comes to harvesting, that's the worst thing with hemp…it'll drive a man to drink!" Problems were essentially concerned with wearing down of the machinery due to toughness of the fibres and straw getting stuck and jamming the rotating parts of the balers and tedding rakes. The particular problems encountered depended on the farmers' available machinery, his experience, and also the end use of the crop. For example, one of the farmers (JP) did not require a retting period, as his crop was being processed for insulation, for which it was beneficial to have a lot of air pockets in the fibres.

Innovative thinking

Common to all farmers however, was their perseverance and innovative thinking in the face of such challenges. One farmer explained that using older machinery had solved all his problems, as they were simpler (with fewer parts to clog), and did not go as fast, which seemed to increase the likelihood of problems. Using a single rotary rake positioned on a slant for example, was found to avoid the problem of hemp's tough fibres clogging the machinery during tedding. Adapting a forage harvester with a maize header was a recommendation that was often mentioned. In addition, adapting a forage harvester to cut and chop at the same time was found not only to improve the speed and ease of the whole process, but also reduced the retting process, which enables the hemp to be baled earlier. However, although this is what was recommended by the UWB advisors, only one contractor in the area actually had a suitably adapted harvester, which posed a problem in the likely situation that many farmers would want to harvest at a similar time. With regards to baling, a belt round baler was found to be the best solution in coping with hemp's tendency to wrap around the rotating parts of current commercial balers.

In general, the solution often advocated was the use of simple machinery with the least amount of rotating parts possible!

The scope for specialized machinery

Although it seemed that machinery could be adapted to suit the needs of hemp growers, the development of specialty equipment would be needed to improve the efficiency of the whole process. However, as was pointed out by the advisor in France, where machinery development was recently stopped, most hemp farmers are farming hemp on a small scale where it is not economic to use such specialty machinery. Furthermore, sharing such machinery among many farmers is also impractical as they are likely to require using the machinery at the same time, given the weather-dependency of the process. Developing specialty machinery therefore only makes sense once hemp is more widespread as a crop; yet more farmers will not begin growing hemp unless there is better machinery available! In fact, the one farmer we interviewed (RK) who was no longer growing hemp explained that he would consider growing it again, but only if better machinery was available.

One of the researchers (MH) familiar with the processing of hemp emphasized the need for special processing systems to decorticate hemp fibre without degrading it, and also to efficiently create pre-formed materials that are suited for the building of desired end products. However, he also pointed out that such innovations would appear to be highly dependent on a more developed market

Getting involved beyond the farm gate

Not only did the farmers we interview seem to persevere in the face of mechanical difficulties, they were also centrally involved in production processes further down the chain. For example, two of the farmers carried out their own processing. One of them was in fact processing the hemp of 200 other hemp growers in the area, for whom he would often pick up their crop by using his boat trailer! The other farmer/processor was also interested in developing some specialty harvesting machinery.

Energy use

One aspect we were particularly interested in finding out more about was energy consumption in terms of the number of mechanized passes required for a hemp crop, as opposed to other crops. We concluded that hemp requires approximately the same amount of mechanized passes than a cereal crop. Although one might save in terms of weed control, the tedding can require as much as four passes. When asked about machine passes, farmers often underestimated the number, usually forgetting to count the tedding procedures. This seems to suggest that farmers do not pay a significant amount of attention to their energy requirements. From the interviews, hemp would appear to require anywhere from seven to ten passes depending on the available machinery and various other management practices such as fertilization and weed control.

Economy

Background

All interviewed farmers were producing hemp for fibre, with insulation and horse bedding being the two most common destined end products. Interviewees confirmed the lack of a developed market for seed in the UK or Denmark. Only France presented a viable market, being the world's number one seed producer; but even it had no market for organic seeds. Although three of our interviewed farmers were growing hemp organically, there is currently no existing market for organic hemp.

When asking the farmers their motivations behind their decision to grow hemp, several of the farmers mentioned the crop's multiple end uses, which provided them with a means of economic diversification. Also emphasized, was hemp's contribution to the local economy. All of the farmers were also very positive in their belief in hemp's potential, as they felt that markets were opening up, new products were being developed, and society in general was becoming more receptive to hemp's attributes as an alternative crop.

Securing contracts

The importance of securing contracts was not a problem for the farmers with whom we spoke. More problematic was the unreliability of processing plants. High costs for the specialized machinery had in fact lead to the closing of processing plants in both the UK and Denmark, which had a severe impact on the numbers of hemp growers in the UK, and especially in Denmark. Overcoming such a dependence on processing was enabled by a similar initiative by two of the farmers who had acquired the necessary machinery to process the crop themselves.

Licensing and legislation

Although licensing costs had initially been mentioned as being a significant problem, the situation had somewhat improved, as licenses were now being purchased and distributed by processing plants, thus reducing the amount of "red tape" farmers were obliged to deal with. Reductions in both the costs and the complexities of acquiring a license had in fact encouraged two of the UK farmers to begin growing the crop. The frustration incurred by the whole process was expressed by one farmer (AP) who exclaimed "I can't understand why you need a license to grow it at all, grow it anywhere, just like any other crop!"

Farmers relayed their view that licensing restrictions were overly strict. As one farmer (JH) explained; not only did it take him three years of elaborate paper work to obtain the license and was checked upon up to three times during the season; but EU regulations also only allowed for certain low THC varieties to be grown, and require that half a farmer's crop have gone to seed before being allowed to harvest. The final constraint he felt to be the most injurious, as it prevented him from sowing his subsequent crop at an adequate time.

High production costs

In general the costs of inputs were described as being similar to those of other crops. Additional costs however were often mentioned with regards to the harvesting, transport and cost of the seed. Seed prices were highest in the UK and Denmark, which prevented the farmers from sowing at the favoured higher densities. Table 9 (pp 37) provides an example of some of these costs.

In securing contracts with processors, it was normally the farmers' responsibility to pay for the cost of transportation. A first problem was the low densities at which the crop is transported while processing finds itself requiring large volumes; and a second consisted in the large distances travelled to the processing plants. Such considerations were central to the farmers' interest in having a local processing plant.

With regards to some the crop's incurred costs (including processing); they are mainly related the market's underdevelopment, and thus to the use of inefficient or costly machinery. Hemp production has not benefited from the technological improvements that accompany economies of scale. However, as one researcher (MH) pointed out, the development of such a market relies to a certain extent on the development of appropriate technologies that will allow farmers higher returns on their crop. The situation remains a real vicious circle!

Yields and return on the crop

Yields were quite variable among the farmers, ranging between 1.5 to 12 t/ha. Although considerable yields were possible, such successes were far from consistent. Although the cost of inputs was deemed to be similar to that of other conventional crops (see table 9 pp 37), significant transport costs sometimes made it more economically viable for growers to keep the hemp and use it as bedding for their animals. Though the use of on-farm hemp for bedding appeared to be economically viable, buying processed hemp remains expensive, making its valuable characteristics affordable only for horse bedding.
Potential benefits in terms of animal welfare, which are regarded as central within the principles of organic agriculture, may thus be counteracted by economic considerations.

In terms of profitability, one farmer (JH) explained that the crops many added benefits compensated for it being less profitable than other crops. All of the UK farmers agreed that without UWB's subsidy, the crop would not be profitable. As one farmer (MG) succinctly put it "There's not an awful lot of money in it."

Subsidies

Various forms of subsidies were in fact being issued to the interviewed hemp growers. In addition to the subsidy being offered by UWB, growers in the UK with Arable Registered Land (ARL) were also able to receive an additional arable area subsidy. Two of the farmers interviewed were also receiving an additional subsidy for the processing of their own crop. Without these subsidies most farmers admitted they would be incurring losses. Researchers at UWB described the situation as being "all policy driven, at the moment, […] not in the hands of the market at all."

The market

MH from the Biocomposites Research Centre at UWB explained that although hemp fibres have the technical capacity to meet that needs of a wide variety of industries, the necessary processing infrastructure is still too expensive, and the market remains undeveloped. He felt that hemp's potential lies in the development of a variety of niche markets where limited volumes of the fibre would be required, but where there would be maximal added value. Composite materials, insulation and textiles were the areas he felt were most promising at the moment. In exploring the markets current limitations, he pointed out that "without a determined end use, it is difficult to see how a processing plant could survive." In the end, he emphasized the importance of integrating farmers and processors in the stages of product and market development.

Although concern was expressed that subsidies would be decreasing, all of the farmers were confident in hemp's viability. They felt that markets were opening up, new products were being developed, and society in general was becoming more receptive to hemp's attributes as an alternative crop.

Human Aspects

Innovative and perseverant farmers

Although two of the farmers interviewed had experienced crop failures during their first year, they were keen on giving it another try. Such a response reflects what we found to be common characteristics of the farmers we interviewed: their perseverance and their appreciation of hemp as a interesting challenge! In explaining one of his motivations in growing the crop, MG explained "If no-one else is doing it, then it must be different and difficult." Such innovativeness came across in their interest in being involved in R & D, in the machinery adaptations that they adopted to solve various problems encountered, and in initiatives such as on-farm processing.

A common characteristic of the hemp growers, was their long term perspective when approaching farming. They felt as though they were in many ways pioneers within farming. Feeling that a shift in agriculture from food crops to non-food crops was occurring, and that in order to maintain their business, they needed to be able to adapt to this new changes in order to secure an adequate future for their children. As AP put it; "We don't do different things just to be different, but as a way to move forward."

Choosing to grow hemp

Table 16 examines the motivations, benefits and challenges mentioned by farmers when they were first asked which factors were most significant for them. Figure 23 was derived from table 16, which categorizes the various responses into one, or occasionally two of the following categories: agronomic (which also included ecological considerations), economic and social.

Table 16: Motivations, challenges and benefits given by farmers

	Motivation	Challenges	Benefits	Comments
MG	Neighbor, subsidy, weed break, diversification, local industry, challenge	Harvesting and transporting costs	Failure last year	Feels that is a good crop for organic; attributes failure to late sowing + dry weather
AP	Easier licensing, local industry, subsidy, economic diversification	Weed control, Harvesting and transporting costs,	Good following crop, increased birds	Hemp always on same field which could explain weed problem
RK	Low costs, interesting, ease of production, read about weed break and soil improvement	Harvesting machinery, retting in moist climate	Weed break especially useful once organic, great following crop, bedding for cattle, local industry	Would grow again if subsidy higher or if could sell hemp as organic

	qualities			
JP	Good break crop	Harvesting ; on-farm storage; variable yields	Good following crop, weed break, decompaction of soil; ease of cultivation	Processes hemp for 200 growers
JH	Ecological and economic multi-functionality, ease of cultivation	Underdeveloped market; retting means can't sow next crop; seed cost	Good following crop; ease of cultivation; no inputs; challenging/stimulating	Conventional farmer but grown hemp organically; keen on expanding production

The large variety of motivations for farmers to grow hemp was rather unexpected, and exemplifies the complexity of factors affecting farm management decisions. It is interesting to note that while farmers seem to be strongly motivated by social and economic considerations, the main benefits they mention are related to the crop's agronomic/ecological characteristics. In addition to the crop's abilities as a break crop, it's contributions to the local economy and it's apparent ease of cultivation were repeated. As RK put it "I just shut the gate and don't come back to it for three months!"

Furthermore, economic considerations also reappear within the mentioned challenges, as harvesting, retting and transport costs were the most noted factors. Retting was problematic both because of its unreliability and subsequent economic costs, but also due to its agronomic impact in sometimes preventing timely sowing of the next crop. In terms of benefits, hemp's weed break ability and its positive effect on the following crop.

The farmers' emphasis on hemp's agronomy within benefits and challenges is not surprising, given that this remains their central area of work. While the lack of economic benefits received by the farmers did not come as a surprise to us, the lack of mention in socially related challenges was unexpected, as we had envisioned issues related to misguided public perceptions as being more of a problem

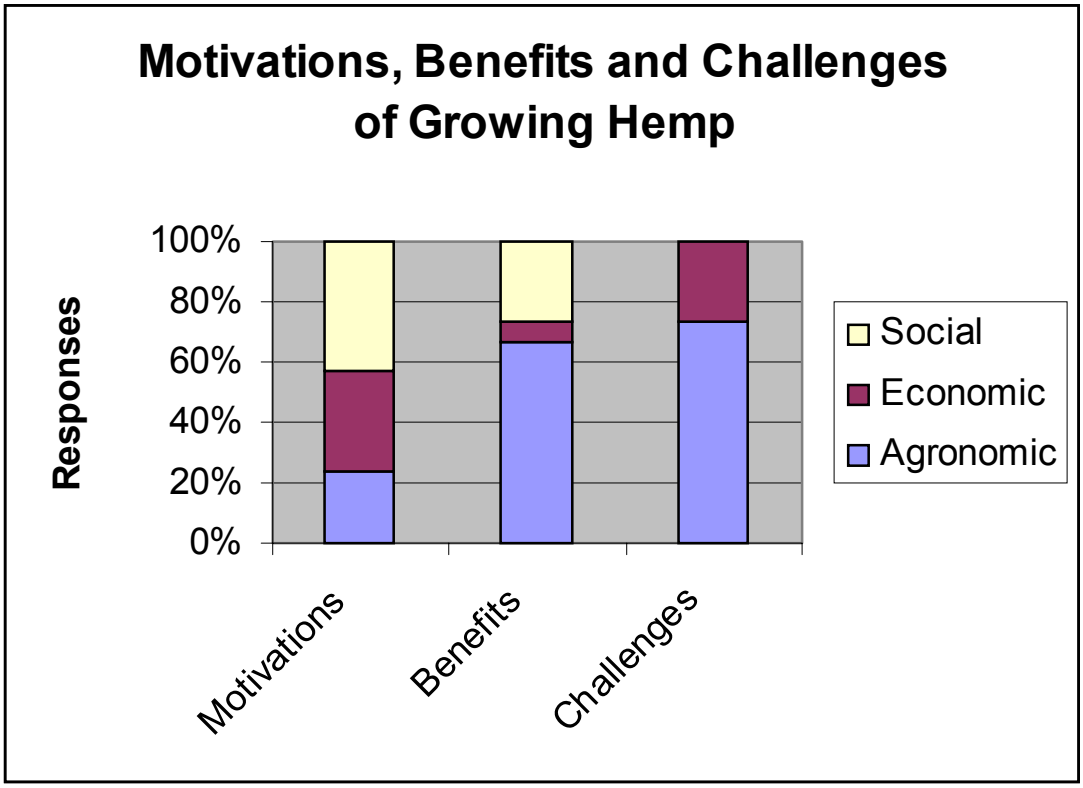


Figure 23: Motivations, challenges and benefits given by farmers

Knowledge

Farmers, researchers and advisors all agreed that available knowledge concerning hemp is inadequate and incomplete. Mentioned for example, was the lack of recommendations on the various varieties, or of hemp's performance in comparison to cereals. Farmers found little knowledge in books and were turning to the Internet as a source of information. One farmer was receiving most of his advice from a neighbour who had previously grown hemp. Farmers and advisors alike agreed that general advisory services tended to be rather old fashioned, and remained relatively uninformed and therefore unable to provide useful help.

Interested in the level of awareness of the farmers' community, we were surprised to learn that none of the farmers had reported having any trouble with their neighbours, in spite of hemp's common association with marijuana. If anything, their neighbours regarded the crop with amusement and joked about it in a friendly manner.

Research & Development

The scope for farmer-participatory R&D

The past decade has seen significant growth in the incorporation of participatory and systemic approaches to agricultural research. It is argued that such developments are especially important within organic agricultural research, which should strive towards a more holistic understanding of farming. Central to this aim is the use of farmer-participation, which can be defined as the active participation and partnership of farmers and other key stakeholders in the process of design, planning, implementing, monitoring and evaluating research (Gibbon, 2002). One of the questions during our interviews touched on this concept, and sought to get a better idea of how involved farmers felt within the context of research on hemp. We had not been aware prior to visiting UWB that their research was in large part participatory. Decision making for the project R&D was done through consultation with the farmers, adapting the original project objectives in consequence. Needless to say, the researchers were very supportive of participatory research methods, and felt they were most efficient, as they allowed to skip certain stages that might be necessary within more formal research scenarios. Participatory research was also felt to be very satisfying, as initiatives were always being brought back to the practical needs of the farmers. In speaking with the farmers, it was clear that they very much appreciated being involved in the R&D process, felt that their involvement was fully appreciated, and that it was a win-win situation where both researchers and farmers could benefit from the arrangement. As on of the farmers (AP) explained: "Researchers used to think at one time that they know everything and farmers don't know nothing, but these ones know that we know a lot, and they teach us things too."

In France, a consortium between farmers, researchers and processors was being planned to begin next year; organized by the FNPC. The initiative recognized the importance of involving stakeholders at all levels, in order to further hemp's introduction into mainstream farming systems. In Denmark the situation appeared to be a bit less promising, as the farmer we spoke to (the only one in Denmark at the moment) was not aware of the research currently being undertaken in the country. Given the farmers enthusiasm about hemp's potential, high interest in developing some of his own machinery, and his desire to grow more of the crop; we felt that it was a pity he wasn't able to be more involved with R&D. Although the Danish and French farmers were not directly involved with research institutions, their individual projects and initiatives made them feel as though they were a part of the R&D process in many ways.

Future R&D

As might be expected, farmers often mentioned the need for further R&D in the areas where they were experiencing the most difficulties. It was thus not surprising when one of the farmers experiencing weed problems mentioned weed control as a priority area. He also mentioned the need to develop varieties for both fibre and seed. Researchers at UWB mentioned a number of priority areas for research: better management, weed control, development of methods for fertilising the crop, and reliable retting. Apart from the Danish's comment on there needing to be more R&D regarding hemps' beneficial ecological roles; all other comments focused on

technological developments, either for the harvesting or processing of the crop. The latter category was more fully elaborated on by the researcher at the Biocomposites Centre in Wales, who explained that processing was particularly expensive, and that improvements should focus on decorticating hemp fibres without degrading them, and manufacturing pre-formed materials (i.e materials that are chemically and physically suitable for manufacturing of the end products). Development of specialized harvesting machinery however seems highly unlikely, for the various limiting factors that were previously mentioned on page 61. As one researcher we interviewed pointed out "We tend to look at research where there is funding for it, and there is no money in hemp" (Malcom Leitch, University of Wales, Aberystwyth, UK).

Our perceptions

Although the development of specialized machinery would prove to extremely useful, it is likely that it will remain economic to do so, until the market for hemp is more developed. This however does not mean that machinery will inevitably remain a problematic area, as the farmers we spoke to were finding innovative ways of solving their various problems. Solutions to machinery problems thus appear to lie in the adaptation of existing machinery and the sharing of experience and information among farmers and advisors.

Additional R&D, we feel, should thus be directed towards opening up the market for hemp. Combining favourable varieties with the appropriate management practices to obtain quality fibres desired by the industry; developing more effective and efficient processing methods; and further product development appear to be areas where further R&D can help improve hemp's marketability. Given the scope of such an initiative, we feel that it requires coordination between farmers, researchers, processors and the industry. Consortiums such as those for UWB's participatory project and the one being initiated by the FNPC in France, all give hope that R&D is moving more in that direction than it has in the past.

Such partnerships would be especially useful within the organic movement, as working with organic farmers would likely redirect certain aspects of R&D into areas that have yet to be explored. Two such areas that struck us as being particularly under-researched, were the effects of hemp on soil health and biodiversity more generally. Though most farmers attested to improvements in both the structure and fertility of their soil, such assumptions found no backing within the literature or the current R&D initiatives in which the advisors and researchers we spoke to were involved. Similarly to two of our farmers (JH and RK), we also agreed that further research was needed on hemp's impact on biodiversity. Such information was regarded as especially relevant, as it was found to influence subsidy programs such as that of the Tyr Gofal scheme. We look forward to following the findings of UWB's research in the area of biodiversity, which have just begun this year.

Looking at hemp in terms of its impact on biodiversity also revealed to us the importance of extending research to discussions with farmers, as they have a natural appreciation for certain long term considerations which might not be apparent to short term research projects or to advisors who are not necessarily working with the farm for a long enough period of time, or who simply are not focused on certain aspects of hemp production. In this regard, participatory research is intimately linked to the

adoption of systemic approaches to agriculture in general. This was made quite clear to us, as we began our mind mapping session, only to realize how speaking with farmers had vastly expanded the scope of our research.

5. The Interview Process in Review

Hemp and organic farming

In assessing the findings from our interviews, certain considerations should be made. First it should be noted that only three of our five farmers were actual organic farmers. Such data however remains quite useful, as it depicts what might be the more common circumstances of a hemp grower, and allows for a comparison with the organic growers. It thus becomes interesting to note the Danish farmer, who was not an organic farmer, actually chose to farm hemp without the use of any chemical inputs, and proved to have a very successful crop. The other non-organic farmer (AP) in the other hand, was having extensive weed problems and having to spray twice with glyphosate prior to sowing the crop. However, one of the Welsh farmers (MG), who had one of the more sound rotations, had experienced a total crop failure the year before.

Such observations emphasized the futility in trying to establish linear causal relationships, such as stating that the answer lies in organic, rather than conventional, systems. Not only were the crops dependent on a variety of climate and soil related factors, but large variations in climate must be taken into account depending on the country in question. Farmers' experience with growing hemp as well as their access to information and appropriate machinery, are equally important considerations.

Logistical considerations

The time constraint in finishing our project, after the interviews were conducted was a challenge. As it would have been impossible to decide upon a method of analysis prior to receiving the qualitative data; in retrospect we should have done the interviews earlier, in order to have more time to process and reflect upon our data. Additional time would also have been useful to follow up on interviews and clarify certain ambiguities such as questions regarding machinery use and precisions on the number of years for the different leys.

Although there is no doubt that the trip to the UK was both extremely fruitful in terms of the information gathered; as well as being a most enjoyable journey; the cost of the airfare and the car rental proved to be quite significant. Language constraints were also a considerable problem, as most Danish information was not available in English, and a fair amount relevant information written in German was thus also inaccessible to us.

The quality of our information

The particularity with some of our farmers should be noted, with regards to our UK farmers' involvement with UWB's research project. These farmers were less affected by economic factors, as they were highly dependent on the project's subsidy, and were likely to benefit more than most (both in terms of agronomy as well as intellectually) from being so involved in the R&D process. Although we might have found it interesting to interview farmers that were not involved in R&D in the UK, the situation of our farmers was in many ways quite beneficial, given our project's focus on the agronomic aspects of the hemp and on our keen interest in exploring the potential of farmer-participatory research within the development as hemp as an organic crop.

In speaking with the farmers, it was surprising how often they were unable to quantify the amount of manure applied to their crop; often simply referring to "a good dose"; or forgot to count a number of machinery passes when asked how often they went out onto the field. For us, this was an example of one of the challenges in on-farm research; as it evidently remains quite difficult to accurately control certain factors. However, realizing that farmers themselves perhaps do not carry out precise measurements, may indicate the need to further understand the factors influencing their decision making process. Observations such as this highlighted some of benefits in adopting a systems based approach when looking at organic farming systems, and the benefit of considering both the social and natural sciences within the research process

Working as a group

Inspired by the soft systems methodology (SSM), our method of analysis fully recognizes its inherent subjectivity, but tries to be as systematic and systemic as possible. Strengths of our analysis include the systematic way in which the information was processed, and particularly the fact of being five people carrying out the analysis and trying to make common observation, thus tempering a certain degree of individual subjectivity. Nevertheless, five students studying organic agriculture will inevitably have a common bias, given their educational background and interests, which will be reflected in their interpretation of the data.

The considerable amount of time gone into discussion and debate was one of the most rewarding aspects of our research project. In comparing ideas and opinions in order to arrive at common conclusions, we became very aware of how dynamic our own individual perceptions are, and of how valuable such a process of group discussion was to our personal growth. Conclusions arrived at not only reflect the feat of reaching common ground, but also the creation of something larger than what could have arisen from a project based on the assembly of fragmented research initiatives.

Our analysis in review

Transcribing directly into the six categories was found to be very useful. First because of its time saving benefits which was an important consideration for the group; and secondly because it helped in organizing an extensive amount of data. Given the unstructured nature of our interview, answers for a particular question were often found in other parts of the interview, which made it impractical to analyze the data on a question by question basis. Deciding on categories thus enabled us to put all the relevant information together, and was a first step of analysis on its own.

We considered trying to create scales in order to analyze some of the data, but were counselled not to quantify qualitative data. Other methods of scaling, such as spider diagrams, intrigued us, and we were sorry that we did not have the time to look more fully into them. We did create one visual diagram, which we feel summarizes our own perceptions of hemp's potential as a crop within organic farming systems; which derives from our understanding of the literature as well as our interviews.

Our section on methodology mentions some of the challenges encountered in categorizing our data according to our six themes. Particularly striking was the degree to which our information overlapped on two, if not more, categories. Observations of this kind brought us to appreciate that although our approach attempts to be as holistic as possible; any form of categorization inevitably simplifies reality to a certain degree and thus overlooks a large number of the existing dynamics and interactions. Overall, the exercise confirmed our belief in the importance of a systems based approach to agricultural research. Not only are an incredible variety of factors affecting the farmer's decisions in growing hemp, but these factors are constantly interacting and changing themselves.

PART III: Bringing it all together

In this final part of our report we give a summarised account of what we have learnt about hemp and how it fits in to organic farming systems.
Hoping not to repeat ourselves too much on the work already presented, we have decided to produce two concluding pieces that bring together our reflections from the work we have done and the experience we gained in our various research methods. They are:

- SWOT analysis of the value of integrating Hemp in Organic Farming Systems as we perceive it
- A 10-step guide for the cultivation of organic hemp, reflecting the practical information and advice we have gathered

We believe that in this way we will be able to summarise and put into context our learning experience, as well as produce a document of some practical value to potential hemp farmers.

1. Integrating Hemp in Organic Farming Systems: a SWOT analysis

Our central focus in this project has been to assess the integration of hemp into organic farming systems. We wanted to find a way of bringing together all the things we have learned and opinions we formulated in a way that reflected the holistic nature of farm systems analysis. The first conclusion we came to was that it was yet another part of our report that had to be done between all of us, as the result of a series of brainstorming sessions followed by refinement sessions.
So this has been pretty much the final phase of our work and summarises our own perceptions and knowledge gained throughout this investigation.

We decided we would adopt the SWOT model as an adequate tool for whole systems analysis. It took us some time to decide what format to adopt for this exercise and we have agreed on the use of tables to be able to continuously relate the SWOTs to their relevance in organic farming and the reasons why we see them as so. We felt that continuous text would be hard to follow and inevitably repetitive, as many factors are closely associated and/or relevant to the same principles.

The final challenge we encountered was to define what Strengths, Weaknesses, Opportunities and Threats actually meant to us. We agreed on the following definitions:
Strengths: inherent qualities of the crop, and its functions within the agro-ecosystem
Weaknesses: are intrinsic to the crop within the agro-ecosystem and are not likely to change in the near future
Opportunities: likely to give rise to further development of the crop and its potential
Threats: are external to the crop characteristics, they depend on socio-economic factors; are susceptible to changing in time

Many of the characteristics of Hemp are relevant to different principles of organic farming; we have chosen to attribute them to the principle we thought it was most relevant to.

Table 17: Strengths derived from the interview analysis

STRENGTHS	Principles of Organic Farming[2]	Comments
• No requirements for agrochemicals • No requirements for synthetic fertilizers	• To avoid all forms of pollution that may result from agricultural techniques • To work as closely as possible in closed cycles and using local resources	• Ideally suited for hardy and dynamic organic systems
• Tolerance to pests and diseases	• To work with natural systems rather than seeking to dominate them	• Optimisation not maximisation • Increase in widespread resistance of crop pests and diseases
• Good weed break • Easy to integrate into the system	• To allow agricultural producers an adequate return • Encourage and enhance biological cycles within the farming system (….)	• Favours following crop • No negative interactions with common crops
• Improvements to soil structure	• To maintain and increase the long-term fertility of soils	• Facilitates growth and development of following crop
• Alternative crop, new family • Increases Beta scale diversity	• To maintain the genetic diversity of the agricultural system and its surroundings including the protection of plant and wildlife habitats	• Provides feed value for birds and soil biota • Increased economic and ecological stability of the system
• Tends to work within a local economy	• To use locally organised agricultural systems • To consider the wider social and economic impacts of the farming system	• Nearness principle • Favours crop traceability and closed cycles
• High biomass return	• To work as much as possible within a closed system with regard to organic matter and nutrient elements.	• Restores nutrient balances (compensating for high nutrient requirements)
• Use of simple and existing machinery	• Reduce the use of non-renewable resources in agriculture	• Decreased fossil fuel consumption as lower HP

[2] Sources: DARCOF and IFOAM

(except for harvesting)		requirements • Reuse, reduce and recycle! • Increases self reliance
• Challenging and stimulating enterprise	• To allow agricultural producers an adequate return and satisfaction for their work	• "We don't do different things just to be different, but to move forward (AP)"

Table 18: Weaknesses derived from the interview analysis

WEAKNESSES	Organic Farming Principle Challenged	Reflections
• Variable yields	• To allow agricultural producers an adequate return (…)	• Variable quantities between different years and homogeneity within the crop
• Lack of information and knowledge on the crop	• To consider the wider social and economic impacts of the farming system	• Insufficient advisory services, no recommended list of varieties
• Reduces alfa-scale diversity	• To maintain the genetic diversity of the agricultural system and its surroundings, including the protection of plant and wildlife habitats	• Competitive nature of the crop
• Nutrient demanding	• To work as much as possible within a closed system with regard to organic matter and nutrient elements	• May require supplementary inputs
• Lengthy retting period	• Work as closely as possible in closed cycles (…)	• Prevents timely sowing of following crop
• Harvesting difficulties	• To allow agricultural producers an adequate return and satisfaction for their work	• Time consuming and straining to machinery

Table 19: Opportunities derived from the interview analysis

OPPORTUNITIES	Relevance to Organic Farming	Reflections
• Multiple end-uses • Relaxing legislation	• To allow agricultural producers an adequate return and satisfaction for their work	• High market possibilities • Facilitates integration of the crop
• Farmers participating in R & D	• To consider the wider social and economic impacts of the farming system	• Provision of more agronomic information; market development; farmer satisfaction
• Growing public environmental awareness and use of environmentally friendly products	• To consider the wider social and economic impacts of the farming system	• Concerns include deforestation (paper and pulp industry), agricultural pollution and sustainability.
• Increasing health conscious society and interest in alternative foods	• To produce food of high nutritional quality and in sufficient quantity	• Hemp seeds' high nutritional value, unknown potentials and diversification of farm and plate.
• Overproduction and falling prices in cereal, increased support for non-food crops	• To allow agricultural producers an adequate return … • To maintain the genetic diversity of the agricultural system and its surroundings …	• Alternative crop with good prospects in long-term economic stability and agricultural sustainability
• High quality as stock feed and well suited for bedding	• To give all livestock conditions of life that allow them to perform all aspects of their inate behaviour	• Animal welfare benefits maybe counteracted by economic viability issues.
• On-farm processing potential	• Reduce the use of non-renewable energies, including fossil	• Decrease transport cost • Increased added value

	fuels • To work as closely as possible in closed cycles and using local resources	

Table 20: Threats derived from the interview analysis

THREATS	Principles of Organic Farming	Comments
• Unreliable retting	• To allow agricultural producers an adequate return (…) for their work	• Affects fibre quality and therefore economic stability
• Specialized machinery for processing is expensive	• To allow agricultural producers an adequate return (…) for their work	• Not conducive to market development
• No specialised organic market	• Same as above	• No additional premium
• Seed price	• To allow agricultural producers an adequate return (…) for their work	• Limited economy of scale and complex seed cleaning • Limited seed producers: nearness principle
• Transport costs	• To allow agricultural producers an adequate return (…) for their work • Reduce the use of non-renewable energies, including fossil fuels	• Unless integrated within the farming system (bedding, green manure, silage)
• Subsidies	• To allow agricultural producers an adequate return (…) for their work	• Decreasing subsidies and reliance on subsidies
• Unstable market	• To allow agricultural producers an adequate return (…) for their work	• Lack of knowledge, awareness and encouragement
• Existing legislation	• To allow agricultural producers an adequate return and satisfaction for their work	• Exaggerated, unrealistic and discouraging
• Limited Knowledge	• Awareness of organic principles! • To consider the wider social and economic impacts of the farming system	• Limited resources, advice and support

The "hemp hourglass" (Fig 24) represents the conclusions that were reached within the SWOT analysis. After completing the analysis, each group member was responsible for rating each component strength, weakness, opportunity and threat according to the importance attributed to the component's given role within the context of hemp's potential as a crop within organic rotations. 0 was given if the component was felt to be of no significance, + (for strengths or opportunities) or – (for weaknesses or threats) if the component was felt to be significant, or finally ++/-- if the component was thought to be very significant. Such rating was done independently by each of the five group members.

For example, hemp's quality as a good weed break was deemed to be very important as a strength in organic farming systems by all group members, who each rated it with ++, thus giving that component a total score of 10 points. Each component was thus weighted by its significance for our group as a whole. The score of each category (strength, weakness, threat or opportunity) was then determined based on the summation of the categories' different "points". From this was determined each of the categories' relative proportions. Strength thus received 37% of all points, weaknesses 14%, opportunities 23% and threats 25%. This in fact reflected our unanimous opinion that hemp's potential within organic farming is promising. The slanted arrows on the diagram depict this view.
Strengths and opportunities are on the rise while weaknesses and threats are decreasing in importance!

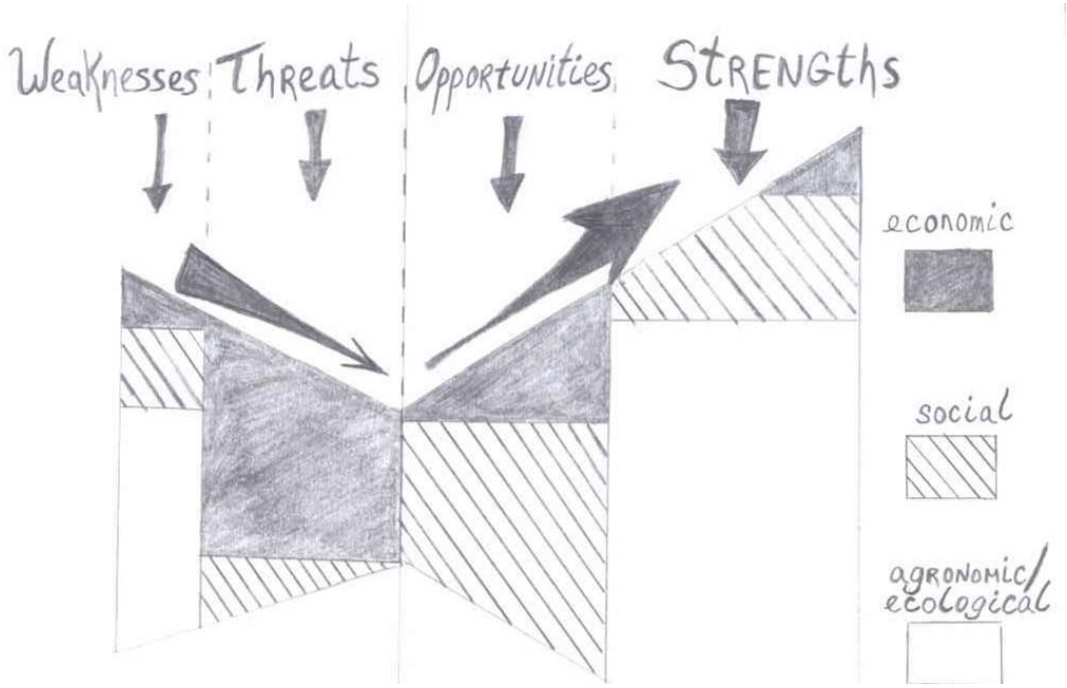


Fig 24: The SWOT Hourglass

The next step involved determining the relative importance of agronomic/ecological, economic and social factors within the different categories. Each component was qualified as being either agronomic/ecological, economic or social in nature. This was done as a group. Similarly to figure 23, certain components were placed within two groups. A similar exercise was then conducted for each category. In other words, all "social" components within the weakness category were added up, from which the

relative importance of "social" contributions to hemp's weaknesses, for example, was determined. In that case 20% of weaknesses were social in nature. It must be recognized that the figure's drawing was done in rough approximation of these numbers. Precision in the figure's depiction was not seen as particularly important given the qualitative nature of the data.

The figure reflects some interesting conclusions. First, it is not surprising that most weaknesses and strengths are in the agronomic/ecological category, as weaknesses and strengths were described as being components seen as intrinsic to the situation (i.e thus often being unchanging crop characteristics). Threats and opportunities were more dynamic in nature, and were therefore more likely to include economic and social components. It is interesting to note that most threats are economic ones, while most opportunities are social. Our impression thus represented by the figure is that current market and legislative constraints will be overcome due especially to increasing social concern and awareness over environmental issues.

It also becomes interesting to compare this figure to figure 23. Both figures agree that strengths/benefits and weaknesses/challenges are mostly agronomic/ecological in nature. The significance of social considerations as a motivating factor in deciding to grow hemp reflects our perception of important and increasing "social" opportunities.

2. 10 Steps to Becoming a Successful Organic Hemp Grower

The last "straw": a grower's guide to hemp. The most practical and important things to retain about the management of this crop, as seen by our group, are described in short sentences. From the very first outlines of the project that this item has remained unchallenged: we all wanted to produce a document that could be used as a leaflet for farmers considering growing hemp, as this would have been what we would have wanted ourselves as an initial step.
We have found that grower's guides and advice sheets to the crop were few (by comparison to other, more widely cultivated species) and very often produced by processors and others with vested interests in the crop being grown. They were also often restricted to particular conditions or purposes, not leaving much room for thought about different choices in crop management.

1. Take off your rose-coloured glasses: Hemp is not a miracle crop…

When considering growing the crop, remember that if you are having problems with weed control, soil structure and fertility or pests and diseases, hemp can be one of the remedial tools, but not considered a sole solution. Common perceptions are often misguided, as they tend to over-emphasise hemp's ability to thrive under any conditions. This is not true and it takes planning to use it to its full potential.

2. Secure a contract

Look into your country's legislative requirements, as there may be restrictions that apply to you. It is important to be informed of the subsidies you may be entitled to, which may require proof of contract. Given the market's instability, sourcing a contract in advance remains fundamental to financial security.

3. Use your long-sighted glasses: get your management right!

Central to any organic farming system are whole-farm management considerations. Relevant practices include timely cultivation and incorporation of bulky organic matter, the use of stale seedbed preparation, general cultural practices that prevent the build-up of weeds, pests and diseases and adequate soil management.

4. Fit hemp where it will make your farm happiest

Assess your system's status and determine where hemp's potential can be best be expressed and where timing considerations are suitable. This will determine its place within your rotation. It has often been suggested, that hemp is best utilised before your most valued cash crop. "Every crop that has followed it has been a very good crop" (Richard Kellet, organic hemp farmer, UK)

5. Adjust sowing dates and rates

Subject to climatic conditions, location and contract limitations.
Depending on the crop's end use for seed or fibre, your seeding rate will vary between 20 and 70 kg/ha. Although seed prices are high, high densities improve the fibre's quality and the crop's weed suppressive abilities. For seed production however, lower densities are required. Different varieties will offer a range of possibilities to suit your needs.

Sowing dates are not a major consideration due to the photoperiodic nature of hemp. Considerations range from threats of early frost to excess drought during establishment.

6. If you followed all the steps so far, put on your sunglasses. If you are experiencing problems, go back to step number one.

This stage is probably responsible for hemp's miraculous reputation. Due to its rapid establishment and high competitiveness, low maintenance requirements follow good farming practices. This has been confirmed by all research we have found. "After sowing hemp I just leave it to it." (Matthew Gee, organic hemp farmer, UK)

7. Take harvesting easy

"When it comes to harvesting time, that's the worst thing with hemp…it'll drive a man to drink!" (Richard Kellet, organic hemp farmer, UK)

The 3 S's: Simple, Slow and Suitable

Don't underestimate the strength of the hemp fibres, use simple machinery (with fewer rotating parts), drive slowly and use suitable equipment which is adapted to deal with the crop's height and strength.

8. Reliable Retting, Tactful Tedding!

Retting is highly dependent on weather conditions, as over retting will damage fibre quality and under retting can result in an incomplete process, making the fibres unsuitable for sale.

Tedding is required for proper retting to occur, but must consider its inevitable damage to fibre quality. The frequency and method will determine the extent to which this damage will occur.

9. Baling and Beyond

Not to be repetitive…but once again, multiple rotating parts should be avoided where possible.

Adjust machinery to tight baling, as maximizing bale density will reduce transportation costs.

Early baling ensures field availability for subsequent use.

10. And then…there are people!

The market for hemp is underdeveloped and non-existent in organics. But don't give up…market's are opening up, new products are being developed and there is increasing interest in environmentally friendly and sustainable crops.

Hemp's potential lies in the development of niche markets, so be creative, innovative and persistent!

Good luck!

Conclusion

Having explored the subject of hemp through a revision of the literature, an extensive interview process, and much debate and discussion as a group, the question arises: have we answered our research question, "Why integrate hemp into temperate organic rotations? And what are the challenges faced in doing so?" Furthermore, how do our findings compare to our initial hypothesis being that although "hemp's high versatility make it a prime candidate within organic farming systems, it's entrance into mainstream markets is currently challenged not by its agronomic characteristics but rather by a variety of political, social and economic forces".

Assessing our project in terms of its more defined objectives will enable a more focused appraisal. Our first objective was to establish the different agronomic characteristics and assess the benefits of hemp as a crop. The functionalities we had initially perceived were to a large extent met, namely in terms of hemp's limited input requirements, effectiveness as a weed, pest and disease break, and contributions to improvements in soil health. Rather unexpected, was the degree to which farmers emphasized its contributions to increasing the yield and quality of the crop it proceeded. Also highlighted was how stimulated the farmers appeared to be, by the challenge and novelty of growing hemp.

On the other hand, expectations in terms of biodiversity enhancement were not met. This was established both from the practical evidence witnessed on the farms we visited, but also as a result of the limited studies that have been done on the topic. An important final insight to be mentioned was the fact that although hemp's weed break functions were clearly underlined, this was subject to adequate management practices. This observation we felt was essential in dismissing the myth regarding hemp's ability to thrive under any conditions.

Our second objective sought to assess the suitability of hemp for use within organic farming systems, with a focus on the UK, France and Denmark. As detailed quite clearly in our SWOT analysis, hemp's characteristic functionalities were found to meet the requirements and established principles of organic farming systems on various levels: ecological, agronomic, social, economic and scientific. The relative significance of these different domains was found to vary, and is clearly expressed in our SWOT hourglass. Unexpected to this inquiry, was the importance farmers attributed to hemp's contributions to their local economy. Although examining hemp R&D reinforced its suitability for organic systems, its relative infancy also came across as being a limiting factor to furthering the crop's expansion within the market.

Our third objective was to evaluate the limiting factors influencing hemp's entrance into mainstream markets. Limited technologies, encumbering legislation and an underdeveloped market were the main challenges limiting hemp's potential growth. Speaking with farmers in fact demystified our initial impression that issues of public perception regarding hemp's association with marijuana significantly contributed to the crops limited adoption. However, there seems to be a huge gap between general public perception and the legislation still in force. However, although larger economic and legislative barriers stood out when considering the general societal context, it should be mentioned that for the farmer, agronomic considerations were most frequently cited. All things considered, we see strong potential in the further growth

of hemp, though this remains tempered by a need for relaxing legislation, more developed markets and increased consumer awareness.

In addition to our acquired knowledge regarding hemp's place within organic systems, a tremendous amount of learning was done regarding our research approach and also in terms of group dynamics. Mention of our methodology and analysis should first be made. Both elements underwent continuous review and adaptation throughout the project, a consequence of the inevitable learning process but also we feel, because of the very human dimension of our research. This was felt both during our interviews as well as throughout the project's extensive group work. Much like intercropping practices, we have found that group work results in increased overall efficiency and output, through the optimization of niche resources! Also, although our initial intent had been on following a rather divided approach whereby the interviews would be conducted subsequently to a review of the literature, the final outcome revealed a much more dynamic process which involved continuous oscillation between the two.

Employing active research methods we found contributed to a steeper learning curve than would have otherwise occurred, and fostered a more systemic approach to our research, which we regard as being central to organic farming analysis. Our research experience brought us to more fully understand the extent to which research ultimately remains quite subjective, and to reflect on the challenge of approaching such subjectivity with systemic and systematic rigor. In retrospect, we feel confident that although having opted for a more subjective pathway may have contributed to limitations in terms of statistical precision, it added that fascinating human dimension, so often underestimated in agricultural sciences.

On a more personal level, we finish this project, having been challenged by, and wishing to pursue problem solving thought patterns, within a farming context. Having gained further insight into the dynamics involved in farmers' decision making processes, we remain keenly interested in integrating this newfound perspective into our future work.

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Appendix 1

Sample questionnaires asked to farmers and advisors

Questionnaire for current hemp grower

Intro: who we are, title of our research project, would like to focus on agronomic questions

General information

i) Name, locality, hectarage

ii) What crops do you grow?

iii) How long have you been farming?

iv) Why have you chosen organic farming?

Agronomic

1) When and why did you start growing hemp?

-> Why hemp instead of another crop?

2) Where do you source your seed?

3) Could you provide a general description of your cultivation process?

- soil preparation and sowing
- crop establishment and maintenance
- managing weeds, pests, disease
- irrigation and fertilization
- machinery
- the rotation
- timeframe of the procedures

4) How does growing hemp affect your soil's structure and fertility?
5) From your experience, what benefits do you see from growing hemp?

6) From your experience, what problems do you see in growing hemp?

7) What are your expectations from growing hemp?

Economic

8) Do you know what happens to your crop once it leaves your farm?

9) Is it difficult to secure contracts?

10) What are your yields like? At what price do you sell your crop for? Are prices relatively stable?

11) Approximately how much are the costs of your inputs (seeds, fuel, machinery, labour)?

12) What is your overall profit on your hemp crop?

Social

13) What is the source of your knowledge about growing hemp?

14) Do you know of other hemp growers in your area? Did that influence your choice of growing hemp?

15) What do your neighbours/community think? How does this make you feel?

16) How do you see the future development of hemp?
    a) for you?
    b) for the market place as a whole?
17) Do you feel involved in the decision-making process regarding r&d into hemp? In what measure?

18) In your opinion, what should be the priorities in hemp r&d?

Questionnaire to previous hemp grower

Intro: who we are, title of our research project, would like to focus on agronomic questions

General information

v) Name, locality, hectarage

vi) When did you grow hemp? For how long?

vii) What crops do you grow now? What crops did you grow when you grew hemp?

viii) How long have you been farming?

ix) Why have you chosen organic farming?

Agronomic

1) Why did you start growing hemp?

➔ Why hemp instead of another crop?

2) Where did you source your seed?

3) Could you provide a general description of your cultivation process? (what you remember)

- soil preparation and sowing
- crop establishment and maintenance
- managing weeds, pests, disease
- irrigation and fertilization
- machinery
- the rotation
- timeframe of the procedures

4) How did growing hemp affect your soil's structure and fertility?

5) From your experience, what benefits did you see from growing hemp?

6) From your experience, what problems did you find in growing hemp?

7) What were your expectations from growing hemp?

8) Why did you stop growing hemp?

9) Would you consider growing hemp again? Why, why not?

Economic

8) Where did your crop go once it left your farm?

9) Was it difficult to secure contracts?

10) What were your yields like? At what price could you sell your crop for? Were prices relatively stable?

11) Approximately how much were the costs of your inputs (seeds, fuel, machinery, labour)?

12) What were your overall profit on your hemp crop?

Social

13) What was the source of your knowledge about growing hemp?

14) Did you know of other hemp growers in your area? Did that influence your choice of growing hemp?

15) What did your neighbours/community think? Did this affect you at all?

16) How has the situation changed since you stopped growing hemp?

- more or less hemp growers?
- easier/more difficult to be a hemp farmer?

17) How do you see the future development of hemp?
    a) for farmers?
    b) for the market place as a whole?

Questionnaire for Advisor

Intro: who we are, title of our research project, would like to focus on agronomic questions

General information

x) Name, educational background
xi)
xii) How long has he/she been an advisor?

xiii) How many farmers does he advise? In general, what kind of farmers are they?

xiv) What proportion of them are organic farmers?

Agronomic

1) How many farmers do you know that are growing hemp?

2) Why do you think they decided to grow hemp?
-> Why hemp instead of another crop?

3) Would you say there are certain characteristics, of a farmer that chooses to grow hemp?
- Education? Values? Crop selection?

4) In general, how do farmers source their seed?

5) Could you provide us with some of the particularities in the cultivation of hemp?

- soil preparation and sowing
- crop establishment and maintenance
- managing weeds, pests, disease
- irrigation and fertilization
- machinery
- the rotation
- timeframe of the procedures

6) From your experience how does growing hemp affect soil structure and fertility?

7) What benefits do you think farmers receive in growing hemp?

8) What problems do they encounter in growing hemp?

9) What are farmers' expectations from growing hemp?

10) Why do you think there are not more farmers growing hemp?

11) How do you feel about the role of advisory services with regards to farmers incorporating hemp into their rotations?

- Supportive/unsupportive? Does it need to be improved? If so, how?

Economic

12) In general where do hemp crops go once they leave the farm?

13) Is it difficult for farmers to secure contracts?

14) What are yields usually like? At what price do farmers sell their crops? Are prices relatively stable?

15) Are input costs in growing hemp expensive? Can you specify what they are (seeds, fuel, machinery, labour)?

16) How profitable is hemp?
- Numbers?

Social

17) What is the source of your knowledge about growing hemp? Where do you think farmers growing hemp receive their knowledge?

18) What do you think influences farmers' choice of growing hemp?
- Neighbours?

19) How do you see the future development of hemp?
a) for farmers?
b) for the market place as a whole?

20) Who is involved in the decision making process related to your r&d into the hemp crop?

-Who r the main funding bodies?

21)Would you describe your research methodology as farmer participatory?

-What is its place within the r&d framework?

22)In your opinion, which areas would you say are priorities for r&d in hemp?

Appendix 2

Interview analysis

INTERVIEW ANALYSIS

Overarching question**: What are the functions that a crop incorporated into an organic farming system fulfils?**

1. **SYSTEM ECOLOGY**

Scale: number of functions mentioned by individuals

a. Soil structure
b. Biodiversity
c. Pest and diseases break
d. Soil nutrient status
e. Weed break

2. **BIODIVERSITY**

Scale:

Rotation analysis (B level)
Questions unanswered yet:
- How to assess the rotation
- Do we incorporate α and β scale

3. **TECHNOLOGY**

Scale: number of mechanical operations per season

4. CROP MANAGEMENT

Scale: $/tonne against rape as standard crop and substitute to hemp

5. **HUMAN ASPECTS/SOCIAL FUNCTION**

Scale: number of functions fulfilled, based on our personal assessment

a. Enjoyment
b. Ease and cultivation
c. Contact/connection/community
d. Red…?
e. Involvement/awareness of being part in cycle
f. Involvement in r&d
g. Decision making

INTERVIEW ANALYSIS MATTHEW GEE

- DESCRIPTION

Llanllir, Talsarn, Lampeter. Circa 150 ha area.
Grows grassland, hemp (this year 4 ha, last year 30 ACRES), occasionally field vegetables (not this year). Doing some potatoes, carrots and swedes. Arable silage. Sheep (500 ewes and lambs) and beef cattle (40 heads).
Has been farming for 21 years. Educated to degree level (Bsc Agriculture).
Chose Organic Farming as his system was always extensive and kept inputs to a minimum, also feels he is environmentally aware. Had customers request for organic produce.(organic for the last 5 years.
Started growing hemp last year, mainly because of the Bangor Research project, the subsidy from which allows for this as his land is not ARL. He also likes to do something different from his current crops and likes the fact that hemp is a clean crop, but biggest influence was a neighbour who has grown it for 10 years.
Sources his seed from Bangor project, believes last years seed came from Canada.

- SYSTEMS ECOLOGY

Didn't notice any effect on soil structure and fertility due to failure, but expects it to suppress weeds, which he sees as the main benefit if growing it. It was a small step to convert an already friendly system. Different family to other crops.

- BIODIVERSITY

Has a field of 8-12 ACRES of marshland (stream going through it), with lots of wildlife. Locals don't understand why it is not drained.
RSPB requested to carry out bird counts on his land. He reckons they have around 60 different species of birds on the farm at different times of year (including partridge).
He hopes the hemp crop and especially seed drops will provide feed for birds.

- TECHNOLOGY

Has used his own machinery and labour: no contracting
Harvesting and transporting are some of the biggest challenges. So is finding a reliable end-use products with necessary quantity demands. Hopes processing can be more efficient as he sees a lot of end-products suitable to be done from hemp.

- CROP MANAGEMENT

Cultivation Process: plough, power harrowing, (repeated if necessary 4 weed control), sowing to density requested by project: last year seeded one area at 75kg/ha and the other at 35kg/ha, this year hasn't sowed yet. Sowing is done with a regular cereal drill (last year it was broadcast), normally in the first weeks of May, followed by rolling.
Doesn't expect to have to cultivate for weed control due to it's suppressive capacity.
Has applied some manure before ploughing: he describes it as "a good dose", as he applies either "light" or "heavy" – for hemp it was "heavy". Hasn't yet been in the position of harvesting, but process would then also include cutting (normal mowing), tedding and baling. May have to cut the stems also, depending on project requirements.
Rotation: hasn't yet put it in rotation, but the choice of a crop which also fits in well with organics (as it is not related to any of the crops he is growing) was a factor in considering growing it (=advantage).

Last year sowed it after lettuce and followed with grass in one field, and sowed it after grass in another field, which he will follow with hemp again this year. Intends to follow with grass, but that depends on what the crop will do this season (If the hemp succeeds in suppressing weeds he will follow it with field vegetables).

- HUMAN ASPECTS

Challenge of a new crop was important for him, as well as suitability within the organic system.
Liked the idea of having a local processor (Biofibres) and being able to contribute towards developing regional industry. Idea of pioneering the growing of the crop and help finding new technologies (for harvesting in particular) is attractive.
Knowledge gained from books was limited, Bangor project workers helpful, but biggest influence was a neighbour who has grown it for 10 years. He didn't have ARL or quota, so decided to grow hemp. Was an inspiration, as his management practices were good and showed positive, reliable results.
Neighbours and local community regard his growing of hemp with amusement, but are used to seeing them as innovative and different from most farmers in the region. In his area, farmers still follow maximization and not optimisation principles.
R & D: Feels researchers are interested and take note of farmers' opinions and experience to use in the experiments' design. Finds researchers interested and enthused by their work, feeling involved in the investigating process . Thinks priority areas for r & d are harvesting and improving processing methods to enable an opening up of the market.

- ECONOMICS

Without Biofibres, new processor is necessary as the cost of haulage is prohibitive.
Utilising the crop for bedding is possibly more viable than selling it and importing straw – probably producing enough to cover all bedding needs.
If he does sell it, he doesn't really know what market environment he will find.
Expects yields to be around the 5t/ha bracket, but that is not certain. Price expected to be around £5 per bale (SEE HOW MANY BALES PER TONNE).
Cost of inputs worked out to be profitable when offset against subsidy (in fact, could even afford to do it for less). Subsidy provides additional income, would cover the fact that it is not sold.
Inputs on a par with other crops, excepting maybe extra cultivation for weed control on other crops – extra machinery and labour. Would expect the crop to be less profitable than his average crops (note: vegetables more profitable than arable crops in any case AND he does not have ARL, thus no arable aid).

- MISCELLANEOUS

Last year's hemp suffered almost total crop failure, reasons for which are not entirely clear, but Matthew believes it was a combination of late sowing (late May) and dry periods after germination, which led to very patchy fields – they were empty at the end of the season.
"After sowing, I just leave it"
"There's not an awful lot of money in it"
"It's a different way of farming the land"
"If no-one else is doing it, it must be different and difficult"

INTERVIEW ANALYSIS ARTHUR PARRY

- DESCRIPTION

Phwellyn, Llyn Peninsula. Circa 170 ACRES of area.
Grows hemp (this year 10ha), flax (since 1995), whole crops. Arable silage, some grassland for the horses. Highly diversified farm, with cottage enterprise and pony and horse riding centre, as well as wildlife walks, etc
Has been farming for 33 years, initially with brothers and father.
Started growing hemp last year, mainly because of the changing of Home Office licensing legislation – his farm is too near the main road and has too many people, so was not allowed to before – been trying since 96. Was enthused by the Biofibres initiative and the prospect of a local industry for the processing of hemp and flax fibres. Also chose the crop because of the Bangor Research project and it's subsidy.
He also likes to do something different from his current crops and since the BSE crisis, when he incurred many losses, he had often wondered about alternative products. Started by growing flax 4 years ago.
Sources his seed from Hemcore, who choose the varieties.

- SYSTEMS ECOLOGY

Too soon to say about any effect on soil structure and fertility, but expects it to improve these as cereals tend to do well after a hemp crop. He did notice that hemp "rebuilt the soil". Grazes the stubble with sheep and horses.
Crop residues incorporated/composted by the new season.

- BIODIVERSITY

Has a field of 20 ACRES of wetland and lake, with lots of wildlife.
He knows the hemp seed drop provides feed for birds, as he has witnessed the fields with more birds throughout the seasons.
Believes hemp will attract other "wildlife", like beetles and invertebrates.

- TECHNOLOGY

Has used his own machinery and labour for most operations, only requiring contracting for harvesting.
Harvesting and transporting are some of the biggest challenges. Last years contractor experienced many problems with his machinery as weeds in the crop kept immobilising the rotating parts. This year will use a mower.
Important: reliable end-use products with necessary quantity demands. Hopes processing can be more efficient as he sees a lot of uses for hemp.

- CROP MANAGEMENT

Cultivation Process: plough (although this year they decided not to plough = no till), power harrowing, spraying with roundup (2lt/ha) twice followed by light cultivation and sowing in mid May, to density requested by project: last year seeded at 37kg/ha and this year will do the same. 5INCHES between rows
Sowing is done with a regular cereal drill, followed by rolling.
Fertilisation at 130kg/N/ha and 60-70kg/P,K/ha at the same time as sowing.
Harvesting in mid to late August, cutting (normal mowing), chopped it in 18INCHES lengths leading to a 10% shiv loss due to fineness , tedding and raking and baling in early September.

This year intends to just cut it, leave it to ret for a month and then bale it – no tedding. Will then store the bales for later sale.
Thinks crop is similar to others in terms of ease of management
Had problems with weed control (and says this is the main challenge in growing hemp), as the crop took time to establish due to cold weather – FEDORA? 17 did very well but the other variety was not so good. University involved in doing research on weed control, as there is currently no herbicide safe for use in hemp.
Has found that hemp stands periods of draught well and likes it hot.
Rotation: has grown it in the same field for the past two years, admits need to go into rotation but the license restricts it to those fields.
Current rotation: Flax-Flax (40ACRES)-Grass (70ACRES)-Whole crop(40ACRES)
Intends to follow grass with hemp, and follow it with cereals (oats, barley, wheat).

- HUMAN ASPECTS

Expects agriculture to have a major shift towards non-food crops, which will change the dynamics of the market and give hemp a place of honour. It is important to him to think he will start something which will be able to maintain his children in farming.
Liked the idea of having a local processor (Biofibres) .
Neighbours and local community regard his growing of hemp with amusement, saying "it should put a smile on your face after you've been working". Everyone knows it is different to marihuana, so no problems.
R & D: Feels researchers work very closely with farmers, valuing their opinions and experience. Finds researchers give very useful advice, and treat him as an equal. Finds the participatory research faster and more effective than traditional methods. Feels included in the whole process. Thinks priority areas for r & d are weed control and the development of varieties for both seed and fibre (!).

- ECONOMICS

Receives £360/ha from the Bangor project plus £200/ha of Arable Aid
Expects crop to become more viable with opening of the market and then be able to pay itself. Crop is sold to Hemcore for processing, and he is responsible for the haulage to the processing plant. Securing the contract was easy. Prices range from £90 and £130, the higher bracket being for hemp at later parts of the year to maintain plant in work (=farmer storing it, which is what he will do to get higher price).
Utilising the crop from last year for bedding, as it was contracted to Biofibres (went bust) and Hemcore wouldn't have it as it was contaminated with too much stone due to excess handling. Yields around the 5t/ha (25 bales, 5 bales per tonne).
Cost of inputs : seed £4/kg @37kg/haX10ha, other inputs generally on a par with other crops.

- MISCELLANEOUS

"I wanted to try it, that's why"
"Nobody said nothing about us growing it"
"We don't do different things just to be different, but as a way to move forward"
"Researchers used to think at one time that they know everything and farmers don't know nothing, but these ones know that we know a lot, and they teach us things too"
" I can't understand why you need a license to grow it at all, grow it anywhere, just like any other crop!"

INTERVIEW ANALYSIS MALCOLM LEITCH

- DESCRIPTION

Crop scientist. Grew the crop in the context of the SAC break trials for two years in the Frongoch organic farming unit, part of the University of Wales, Aberystwyth.

- SYSTEMS ECOLOGY

Provided adequate weed break for following crops through heavy shading.
Believes that the variation within the crop can be a useful indicator of soil deficiencies, but equally be very sensitive to variability in nutrient availability, therefore affect yields.

- BIODIVERSITY

- TECHNOLOGY

Harvesting was done with an alan scythe, due to it being very small area. No problems experienced.

- CROP MANAGEMENT

Cultivation Process: Plough, power harrow twice, drilling, harvesting
Seed sourced from SAC. No fertiliser application.
Fast establishment, grows very well and tall, no need for weed control due to suppressive ability.
Experienced no problems with pests and diseases, no apparent damage to the crop and seemed to provide an adequate break for these to the following crop.
Crop rotation: was grown between cereals, as this was the trials purpose. Was left fallow for the winter and followed with spring barley.
Proved easier to grow and better in weed suppression than other break crops.

- HUMAN ASPECTS

R & D: Would describe his research as not participatory at all. Thinks it is a useful tool, but very dependant on the type of research (ie: not suitable for certain investigations). Mostly valuable for whole system analysis
Regards as priority the end use of the crop in order to generate a solid market.

- ECONOMICS

Second year's yields were not as high as first year (see report).

- MISCELLANEOUS

"I got the impression that, because it grew so well (…) it could have been the shading that made it effective in weed control, but there may be an allelopathic effect too"
"We visited it and looked at it, but there was no need to do anything "
"We tend to look at research where there is funding for it, and there is no money in hemp"
" (participatory research)… is very suited to whole systems analysis and development."

INTERVIEW ANALYSIS GERAINT & JIM

- DESCRIPTION

Crop scientist / field manager. Grow the crop in the context of the project of University of Wales, Bangor. Three years running.
Service across Wales and UK as whole, advised 15 hemp growers so far. Around 20-25% organic farmers. Many organic growers enquire, not all follow up (hippy factor! influences interest).
Currently working with 8 hemp growers in Wales, numbers have been falling due to change in subsidy amounts.
R & D: Project currently funded until 2004, high possibility of further funding, which would expand the project, both in size and scope.
Regard as priority the processing and end use of the crop in order to generate a solid market, as so far concentrated on the agronomy.
Decision making on the project r & d is done through consultation with the farmers, adapting the original project objectives.
Would define their research as farmer participatory, believe that it is more efficient as it skips stages in the process.
Priorities are: better management, weed control, develop methods of fertilising the crop, and reliable retting.

- There are no recommended lists of varieties, and little knowledge of the crop when compared to, say, wheat.
- Have seen some bad/unhelpful advice from advisory services in regards to the cultivation of hemp.

-Services old fashioned. Adequate structure, but not enough knowledge

- SYSTEMS ECOLOGY

Good farmers use hemp to increase the margins on other crops.
Provided adequate weed break for following crops through heavy shading.
No comments on soil structure from farmers, but have had comments of increased yields and quality on following cereal crop.
Deep-rooted crop, aerates the soil and draws nutrients from lower layers of the soil.

- BIODIVERSITY

Farmers want to try something new and diversify. It's an interesting crop to grow, seen as an alternative.

- TECHNOLOGY

Harvesting was done with a forage harvester.
Need for specific machinery to adapt to height of crop.
Used a rotary rake for turning.
Hemp needs more mechanised operations than other crops due to repeated need of turning during retting period.
Equipment for processing is expensive.

- CROP MANAGEMENT

Cultivation Process: Plough, power harrow, drilling (35 to 40kg/ha) at end of April to early May – have found that early sowing is not advisable as it likes warm soils. Row spacing 12.5 cm.

Very hungry crop, needs as much fertiliser as a wheat crop (£160-180kg/N/ha). Have not yet found a plateau for fertiliser application (up to 250kg): the more they put on, the more it grows.
Fast establishment, grows very well and tall, need for weed control is limited but safe chemicals need to be found for when it is a problem. High variance between varieties.
Harvesting mid-August. Consistent retting is a problem area. 4 weeks retting, with one turn a week. Tried stand retting last year, very effective, more even and reliable but longer process as it does not benefit from the moisture in the soil. Baling

Seed sourced from processing plants in the past (£3.50/kg), this year source it from them (£3/kg), they get it from France and Poland.
Climatic restrictions on the viability of seed production, excess water being the main limiting factor – secondary damage from moulds and other diseases.

Experienced no problems with insect pests or diseases (although have received reports of problems with *Sclerotinia*), no apparent damage to the crop and seemed to provide an adequate break for these to the following crop.
Crop rotation: hemp should follow short ley pasture (with red clover, for example) and be followed by arable crop as it should have provided good weed break, although that is dependant on existing weed bank and management practices. So: grass, grass, grass, hemp, arable crop.

- HUMAN ASPECTS

Before 95 was not allowed, then steep licensing prices and tight arrangements. Since last year licenses have relaxed.
Those who get involved with hemp are more pioneering and innovative – there is also the hippie sort.

- ECONOMICS

Difficult to justify choice of hemp on an economic basis, infancy in industry as processing needs further development.
Subsidy from the project has been the motivation to grow the crop – makes it competitive.
Yields of 6.5t/ha DM. (about 5t/ha for organic, but bigger range)
Some farmers have just used the crop for bedding.
Project funded by EU objective 1, Welsh Development Agency, National Assembly of Wales.

- MISCELLANEOUS

- .

"Good farmers use hemp to increase the margins on other crops"
"It's all policy driven, at the moment, it's not in the hands of the market at all."
"There has never been a situation where the farmers (we work with) have grown the crop for money, so price hasn't been a major issue."
"We are learning together (farmers and researchers)"
"Websites say hemp smothers all weeds… no, it doesn't and I can prove it"

INTERVIEW ANALYSIS RICHARD KELLET

Near St tassel, north Wales500 feet above sea level
Light loam
Rainfall: 50 inches/year
106 ha: part still in organic conversion
barley, hemp, grass and red clover (4 year ley…5 year crop rotation)
beef (interesting crosses) 100
lamb dropped from to 800 to 100
only able to sell 50% corn as organic this year, demand for barley not there

305 acres total; 160 acres in rotation (50 acres crops: 25 acres hemp/25 acres barley; and the other 100 acres is a red clover/rye grass fro silage/forage); the rest (145 acres?)is permanent pature for grazing (white clover/mixed grass)
used to grow corn

second generation farmer, been on farm 36 years
education: agricultural college

been farming 8 years, organic for 4 years (in order to increase cash flow stability)
also encouraged by health reasons

began growing hemp 4 years ago cause thought was interesting idea, lack of inputs (could save money)

1. Systems Ecology

Weed suppression and plants "vigor" ability motivated him to grow
Weed suppression became especially useful once turned organic
Read about hemp's long tap root that aerates the soil and brings up nutrients from deep down "Can't really measure (light soil) affects on soil structure…but what I do know is that anyone who has grown a corn crop after hemp has had fantastic results"
Leaf shed maintains fertility
another benefit. If can't sell to factory than can use as bedding under his cattle (full cycle!)

2. Biodiversity

Flax better syas Tier Gorval (?) scheme though he agrees that hemp has lots of favourable seeds
Diverse farm:
-Mixed farm (and traditional breeds and interesting crosses of beef)
-Some interest in vegetable production (did last year)
-After harvest can then seed grass/clover mixture or turnips as a break crop

3. Technology

7 machine passes he reckons (plou, culti/drill, roll, may subsil, cut, bail) what about tethering and turning 3 times!

Thought was same number of passes as for cereals
problem is that it wraps around machinery once has retted (bailer especially)
belt round bailer good solves problem though

Need a good acreage of hemp before it is worth investing in new machinery
Would only grow hemp again if there were better harvesting techniques (getting it in on time given the weather); also can't scatter it like hay cause couldn't reassemble (if could would dry faster), and strain on the tedding machine

4. Crop Management

Not a hungry crop for P and K cause leaves go back to soil
Long root system makes it good for aerating soil attractive
Plan was to have it as head of rotation before corn/barley or oats (weed suppression and aeration)
"Every crop that has followed it has been a very good crop"
temporary ley-hemp-corn/barley
seed sourced by Hemcore, than biofibres from France
disadvantage was seed cost 60 pounds/acre
seeding rate…ask Geraint (think 34 kg/ha)

cultivation process:
Need to watch frost end April, beginning May
Plowed, powered harrowed, drill 10 cm spacing, conv drill not precision drill
Rolled with light roll (if ballast roller then without water) as just want to seal the top cause don't want to compact it..similar to maize
Can subsoil if compaction problems
"just shut the gate and don't come back to it for 3 months!"
soil test to decide what needs to be applied:
he has sowed at low pH of 5.5 ..ideal is 6
limes with calcium lime every year cause rain washes it all though (he ut a bit of lime before growing the hemp)
want not less than 1 for P and K levels
harvst end of august…when begins to seed
"june -july growing about a foot a week"
does not apply fertlizer (says if did could grow up to 14 feet)
can harvest it either mow with a grass mower that drops it into swaths, and then turn it with silage tether rake…6 –8 weeks to ret, turn it 3 times
recent method changes layout of self propelled forage harvester with maize header on front that chops it into 1 foot lengths that are thrown back on ground…cuts retting down to 3-4 weeks and only have to turn it once
squre or round balled depending on convenience
problem is that it wraps around machinery once has retted (bailer especially)
belt round bailer good solves problem though
after harvest can then seed grass/clover mixture or turnips as a break crop
7 machine passes he reckons (plough, culti/drill, roll, may subsil, cut, bail) what about tethering and turning 3 times!
Thought was same number of passes as for cereals
Disease? Doesn't think so… but variations in heights (aware of potential beetle that affects seedling for which might have to spray)…but never affected him
No pbs at all with weeds…especially because weed bank low after ley

Tried to undersow hemp with white clover one year...but didn't have a chance!
Yield losses if over rets…
Special machine from essex came up to harvest
Increase in premium if stored hemp not worth it to him

One of his best years was when he doubled the seeding rate…but too expensive, otherwise would have done it more.
Says that higher density means better fiber and easier to ret and harvest, but need to avoid lodging. However, says that even if lodges, can just bend back and keep growing.
1.5 t/acre for organic
4 t/acre for conventional
inputs: same as corn minus spraying if conventional (4 pounds/acre to tine harrow for organic corn) organic corn
sheed cost is the biggest cost difference for hemp (60 pounds/acre for seeds)
he does his own ploughing and rolling (10 pounds/acre) but hires a contractor to do the sowing and cultivation (14 poounds/acre for power harrow), harvesting (30 pounds/acre) with forage harvester done by contractor

5. Human Aspects

No market for organic hemp
Arable Aid from EU and research subsidy from Bangor ave good profit and is why is growing it and when in conversion couldn't sell as organic anyway

Once converted…hemp started to drop away in profitability
No longer growing it because Tier Dorval Scheme only subsidiing hemp this year
To him taste/health ect of organic very important
Critical of consumer ignorance and that buy untasty "tomatoes"
Ease of production was a motivating factor in growing hemp
Well read farmer
"Nice to have a local factory and to be seeing the end product produced locally..a bit of the profit cming back to the farmer"
pith goes to horse bedding, fibres for ´mulck mats for hanging baskets
thinking of trying something new maybe soon…

Would grow again because is useful for organic farming, but would need :

a) better harvesting methods to make it more reliable
b) increase payment to 100 pounds/ acre if no Bangor subsidy

most advisors are useless, help from Hemcore was crap, in part because of their distance
most of his knowledge came for reading, internet
he wanted to encourage other farmers to grow hemp
one other hemp grower he knows of (but didn't when he began) about 15 miles away
only friendly joking from neighbours
He feels that it is easier today to be a hemp farmer than when he began, as machinery is a bit more developed. But he feels that its end uses are under-publicized and that

there is stigma associated with its relationship to marijuana; and that there isn't much encouragement to grow hemp ,a s there is more focus on coppice and biofuels.
He also sees hemp's development as SLOW. If the new CAP reforms give subsidies per farm and not for having animals, than people may consider growing more hemp, and its benefits will be more explored.
He does feel involved in directing research, as have a say in decisions made with their Bangor partners. Feels that further R&D should focus on harvesting….

6. Economics

Motivated to grow crop because lack of inputs would save money
"Nice to have a local factory and to be seeing the end product produced locally..a bit of the profit cming back to the farmer"…one of the attractions of the crop
pith goes to horse bedding, fibres for ´mulck mats for hanging baskets
55 pounds/ton form biofibres Hemcore 90pounds/t
another benefit. If can't sell to factory than can use as bedding under his cattle
One of his best years was when he doubled the seeding rate…but too expensive, otherwise would have done it more.
Hemcore payed 70 pounds/t when began but increased to 90 pounds /t when some farmers moved to biofibers
inputs: same as corn minus spraying if conventional (4 pounds/acre to tine harrow for organic corn) organic corn
seed cost is the biggest cost difference for hemp (60 pounds/acre for seeds)
he does his own ploughing and rolling (10 pounds/acre) but hires a contractor to do the sowing and cultivation (14 poounds/acre for power harrow), harvesting (30 pounds/acre) with forage harvester done by contractor
in part stopped growing because of the lack of a stable market (biofibres was shutting) and the transport costs to Hemcore were substantial
Hemcore would have to pay 100 pounds/t if there is no Bangor subsidy to make it worth while
Can't compete with organic corn this year (170 pounds/t for organic corn vs 70 pounds/t for conventional corn)

7. Miscalaneous/Quotes

<u>Ask Geraint if measured affect of hemp on soil's structure and fertility</u>
Why tier Gorval scheme no longer subsidizing hemp? More seed value (?) with hemp in terms of wildlife better
what about tethering and turning 3 times! For # of machine passes?
Licensing: 300 pounds for visit by Home Office inspector (their worry was tat it encouraged children to "look into it") 300 pounds for nothing! Never did samples either.
Biofibres later purchased license on behalf of farmers, so easier
Some neighbour gossip, a little curiosity
North Wales climate ideal for growing hemp
pbs: harvesting (fibres getting caught and making sure doen't get over retter with this climate)

"Every crop that has followed it has been a very good crop"
"Hemp's properties really prepare the soil for a good corn crop"

"just shut the gate and don't come back to it for 3 months!"
"june -july growing about a foot a week..incredible"
"when it comes to harvesting…that's the worst thing with hemp...it'll drive a man to drink!"

"Can't really measure (light soil) affects on soil structure…but what I do know is that anyone who has grown a corn crop after hemp has had fantastic results"
"at harvest my stress levels are going up"
"obviously being organic I wanted to preserve fertility in my soil, not being able t bring it in from outside… hemp fits that criteria" (but no resources to measure soil fertility)

Notes:
These aren't "real" farmers in many ways, as they don't' have to secure a market
And probably feel more involved than usual in R&D
My reaction: Hemp is no miracle crop if your management's crap!
Most advisors don't have a clue about hemp

INTERVIEW MARK HUGHES: BIOCOMPOSITES CENTER

Description

They do post processing work, research contracts university, with industry (40-50% of contracts with industry) (ex: pulp and paper)…very interdisciplinary
Focus on wood processing and general conversion and utilization of biomas
Two general research areas:

1- product development
2- creating markets for products

Main areas of work are 2 and 3, future would like to do more with 1:

1) horticulture/geotextiles
biofibres worked in this area but went under because market was not developed enough

2) insulation
based on flax/wool that are commercial
would be ideal for hemp's composite

3) composite
mainly for automobile industry

Working on vegetable oils as resins and plastics (cashew shells, linseed oil, rape)

1. Systems Ecology

2. Biodiversity

3. Technology

Need easier technology to process pre-formed materials(go from the fibre to a format where it can be used for insulation panels of other end products.)
Fibre damage needs to be reduced (though individual fibre is as strong as glass or carbon fibre, in reality it looses a lot of its strength after being grown and processed.)
Thus special processing systems need to be put in place…but how is that accomplished withouth the market?
Also, processing requirements are different for textiles than they are for composites for exmple

Need more R&D:

1- decorticate fibre without degrading it
2- develop ways to make the fibres physically and chemically suited for the building of the end product (i.e pre-formed materials)

4. Crop Management

5. Human Aspects

Educating people on buying products that are "sustainable" is important to the development of the hemp market.

6. Economy

"Without a determined end use, it is difficult to see how a processing plant could survive"

A main challenge with fibres in general is that they are much bulkier than wood transport for MDF boards. Thus, though technically feasible…economic and infrastrure pbs

What if local processing plant?

Not enough added value products for hemp; MDF is a commodity product (no value in it being made from hemp…people don't care.)

Thus….need product requiring limited volume but maximal added value! Perhaps through composite materials, insulation, maybe textiles. A bit of everything is best, as the ,market is variable.

If hemp can be grown competitively, he doesn't see why it couldn't be more widespread. It has good attributes in terms of technical characteristics. He also feels it is a perception thing.

They carried out an interview with various companies on their feelings on using more biomass as resources. Barriers that were mentioned were: Lack of info, lack of dvelpt of supply infrastructure, lack of technical knowledge about their performance, costs, and legislation. Conclusion: though they are interested, there are too many barriers. Article at www.suscomp.net "RR for sustainable materials".

Legislation would be a good tool to open the market.

Niche markets will be the starting point.

They have done more work with flax because:

1- the university does a lot of agronomic research on flax
2- weavers/spinners are set up to spin flax

Issues:

1- economy/uncertainty
2- transportation
3- price
4- legislation
5- public perception

Not issues:

1- performance
2- technical feasibility
3- varied application

Miscelaneous/Quotes

"Without a determined end use, it is difficult to see how a processing plant could survive"

What must come first? The R&D or the economy of scale? …or maybe just a better subsidy system!

"Ideal type of material: the fibre is very adequate for insulations and the potential for easy, large-scale local production is there!"
"Legislation would be a good tool to open the market.
Niche markets will be the starting point."

Notes: should speak with Gary Newman

INTERVIEW ANALYSIS JØRGEN HEGGELUND

1. Description:

Jørgen Heggelund, Ejbyvej 105, 4632 Bjoeverskov, farmer – 80 ha, cultivated with wheat, potatoes, hay, strawberries, corn and HEMP (5 ha). He started growing hemp 5 years ago.
He is being a farmer since 1986 on his parents' farm, 130 years old.
He is a conventional farmer, but grows hemp as organic (doesn't spray it and puts animal manure before sowing).

2. System ecology:

Hemp doesn't need spraying or conventional fertilizers (use of animal manure).
It competes weeds and is pest and diseases resistant (the crop is 20-30 cm tall after 2 weeks).
Hemp improves the soil quality to support the next crop = a good break crop (evidence is the yield of the next crop).

3. Biodiversity:

Rotation is underdeveloped as he is a conventional farmer.

4. Technology:

New machinery is not efficient as he has a small crop. The buyer lends him a processor. He wants to develop his own machinery.

5. Crop management:

He imports the seeds from France (variety Felina 34) and uses 20 kg seeds/ha.
He sows in middle April, harvests in the beginning of September and leaves the straw in the field approx. 4 weeks for retting.
Cultivation process is just like the one for corn, but no need for maintenance.
He doesn't irrigate.
He doesn't care too much about the rotation, but all the crops following hemp had better yields (wheat, barley, potatoes). Hemp doesn't seem to have problems following any other crop except for rape or plants from the same family.
Yields depend on the time of harvesting; usually – 8-12 t/ha.

6. Human aspects and R & D:

Benefits:

- Hemp has great potential (fibre used for wind mills, oil spill clean-up, insulation, horse bedding, fuel pills).
- Hemp's ease of cultivation.

Problems:

- Late harvest and field retting because it delays the next crop.
- Expensive seeds.
- Not enough land for cultivating hemp.

Expectations:

- Increasing the production (needs to work on contracts).
- Seeing himself as a leader for the other farmers in hemp growing.
- Wish to develop his own processing mill and cultivating machinery.

Knowledge about hemp from English magazines, internet and other social activities (forum in Berlin).
There are no other hemp growers in the area, but a couple in Denmark (for hunting purposes); this didn't influence his choice.
His neighbours are interested in growing hemp, but they wait for his results.
He has no problems with the community, but the formalities can be difficult as it took him 3 years to get permission to grow hemp.
He enjoys his neighbours' interest.
Future development of hemp is promising; he has plans of expansion.
He is frustrated by narcotic legislation (too heavy, since the EU allowed varieties are very low in THC).
He is involved in a research project for fibre strength to be used in windmills.
He is interested in the biodegradable aspect of hemp (it's use in car manufacture).
R&D priorities should be in fibre development area and in the hemp's ability to close cycles in agro ecosystems (because is biodegradable).

7. **Economy (facts & figures):**

The stalks are separated on the farm in 3 parts:

- Fibre (sold afterwards to a contractor in Jutland)
- … (sold directly as horse bedding)
- Dust (given away and compressing in pills used for fuel)

Securing contracts is difficult because the market is small; when the only mill in Denmark will reopen for insulation processing his contract will be secure.

INPUTS	**OUTPUTS**
1 farmer & 2 seasonal workers	Horse bedding: 2 kr/kg
Seeds: 60 kr/kg	Fibre: 2,5-5 kr/kg depending on the strenght
Cutting of straws: 800 kr/ha (because needs to go twice)	Subsidies: 2200 kr/ha & additional for separating the fibre
Pressing: 20 øre/kg ???	Overall profit: breaking even

Market will grow (now straws are sold to bio energy companies at a high price, so he sells hemp as horse bedding at lower prices and in this way has a good market.

8. **Miscellaneous:**

Yields of crops following hemp are better in both quality and quantity: **"You can see this!"**

INTERVIEW ANALYSIS SVEND DAVERKOSEN

9. Description:

Svend Daverkosen, agronomist – KVL degree in organic agriculture, now working for Barritskov (Bioscope). He is an advisor for 7 years and advisor for organic farming for the last 4 years; he advices approx. 40 farmers; most of them grow cereals and seed crops (clover, lupines etc) – 100% organic farmers.

10. System ecology:

Hemp leaves the soil clean of weeds for the next crop.
If used as green manure, hemp is excellent for soil fertility (they had an experiment for incorporating hemp in the soil after letting it on the field during winter in frost).

11. Biodiversity:

Hemp is a good crop in rotation (e.g. cereals, grasses).

12. Technology:

The research centre had a trial for harvesting hemp (they used 2 combines: a normal one – used as well for other crops – and afterwards a special one for strong materials; the experiment was successful for 2 years).
Requirement for new machinery makes hemp a special crop for farmers.

13. Crop management:

Usually the farmers import the seeds from France.
A particular problem for hemp is the harvest because of the machinery.
Good crop for rotation.
Problems with harvest, due to a long-term growth season (harvest can occur in November, December) and then drying.
Pest problems: earth fleas (during one experiment they destroyed 1 ha of plants).
The research centre is growing hemp for oilseeds; seed yield is 800-1200 kg/ha.

14. Human aspects and R & D:

He knows that 1-2 years ago there were about 8-10 farmers growing hemp, but most of them gave up. They are doing this because they see a great potential in hemp as an alternative crop and they believe in hemp's value for different end products (fibre products, insulation materials especially).
Farmer's expectations: to find a new niche in the crop market for hemp for getting a good price.
His source of knowledge: other researchers involved in hemp projects. **The farmers** know about it because they are in touch with researchers and agricultural institutes; many of them are interested in new, alternative crops
The farmers are influenced in their choice by the wish to develop new products.

The main founding body and head of decision in R&D is the government, but for some projects they get half of the money necessary, the other half being supported by the institute).
The role of hemp research in the R&D system is small now and many of the projects are stopped because they didn't succeed in harvesting and processing.
The priorities in R&D in Denmark should be the development of manufacturing and processing units because without them you can not do anything with hemp. Another important thing is to develop new machinery for harvesting (special combines).

15. Economy (facts & figures):

Hemp is a profitable crop.
The market will grow in time, for both oilseeds and fibre hemp (maybe faster for fibre because it gives products more friendly to the environment – for example, replaces plastic).
It's difficult to secure contracts because there is no processing industry and just a few growers.
The research centre inputs (seeds+fuel+machinery+labour) is approx. 3500 kr/ha (little more than the ones for cereal crops); the most expensive are the seeds and the harvest. He doesn't know about prices because legislation doesn't allow selling seeds.

16. **Miscellaneous:**

Because of the problems at points 3 and 4 (late harvest and inadequate equipment) there are not many farmers growing hemp.
Regarding hemp growers: "They are crazy people with crazy ideas."

INTERVIEW ANALYSIS BODIL ENGBERG PALLESEN

17. Description:

Bodil Engberg Pallesen, 6 years in Local Farmer Union advisor (but not anymore) – 5% of the farmers were organics, 10 years at the National Centre as researcher for flax and hemp fibre

18. System ecology:

19. **Biodiversity:**

20. Technology:

21. Crop management:

The farmers get their seeds from DLF (Danish seed company importing from France).
Harvesting difficult especially when it's a rainy season and because hemp is a late crop.
Because of little experience, they get their information from other countries.

22. Human aspects and R & D:

She knows one active hemp grower and 2-3 growers for other purposes.
Farmers are growing hemp because of it has many uses and because of an expansion in new production and market and because they are interested in alternative productions.
There are not more growers because there is no processing and no market at the moment in Denmark.
The knowledge about hemp comes from other countries.
The main funding body and the head of decision in R&D is the government.
For R&D purposes her institute made contracts with 10 farmers.

23. Economy (facts & figures):

The market is very promising (bigger investors to open the processing plant and they will have new technology to make hemp competitive as it will be cheaper to process and at higher capacity).

24. **Miscellaneous:**

"The information on hemp cultivation is on the internet."
She didn't have time for the interview, but we could send the questionnaire through e-mail. The e-mail was sent in the same day, but since now we didn't get any answer.

INTERVIEW ANALYSIS JP ANDRIEUX

Farmer: JP Andrieux, Riec/Belon, 29, France, 8,25 ha including 2 ha of wood
He grows vegetables (60 species) on 1,2 Ha in direct sell on the markets, cereals: 4 ha, pastures: 1 ha, hemp: 1 ha. He also has chickens and turkeys aside.
Installed on a first farm in 79 but a new farm since 93
Since always, he does not consider farming in another way than organic
He started growing hemp in 1993.

6. SYSTEM ECOLOGY

Hemp was known as a 1) cleaning crop 2) high agronomical potential, that is why he chose this crop when he settled his farm on non-used land

7. BIODIVERSITY

Hemp is established after a pasture and before a wheat crop and vegetables follow for 2 or 3 years

TECHNOLOGY

7 mechanical operations per season
The total inputs are about 3500 FF (530 €).
Technically, the main source of knowledge is the mistakes made year after year

8. CROP MANAGEMENT

The seeds are sourced easily in la Sarthe (72), Le Mans.
The yields are very variable, from almost nothing up to 7T/ha

Problems: hemp re-growth in the plastic films for vegetables, sensitiveness of the retting period

Interest of the crop: low management, short cycle, number of technical operations, no competition with the other operations on the farm, hemp improve the draining capacities of the soil, particularly important for the wheat crop emergence; let a clean field for the cereals

Benefits form growing hemp: Purely agronomical.

Expectations: Not a lot of work and great agronomical interests.

9. HUMAN ASPECTS/SOCIAL FUNCTION

Easy: number of technical operations
Involvement in the future of its crop: they are processed in insulation by the plant he is an associate, the whole plant is smashed and sold in bags.
Ii is not difficult to secure contracts because he is his “own” contractor

The overall profit is then between 3500 and 4000 FF per ha, the equivalent to a good wheat.
There are a lot of hemp growers around the area now, his plant is processing about 200 ha a year
He had never had to face anything from the neighbourhood because he was growing hemp, it was more the other way round, people curious
More and more artisans come and ask information, more and more people are following the workshops once a month and even architects come or phone to ask about hemp constructions. He sees the future in blue for hemp and its firm.

INTERVIEW ANALYSIS LAETITIA BRUNNEVALLE

Laetitia Brunnevalle, ingenieur from INA-PG, the most famous agronomy university in France, specialized in crop selection and improvement.

10. SYSTEM ECOLOGY

Hemp is interesting on an agronomical point of view, easy and simple crop.
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11. BIODIVERSITY

To incorporate a new family of crop in the rotation can help breaking diseases
A different crop can help against the fluctuations of prices in europe

12. TECHNOLOGY

No organic seeds exist so far and it is still a marginal market.
no need for irrigation or specific machinery
Problems: to get the good machinery to be performing

13. CROP MANAGEMENT

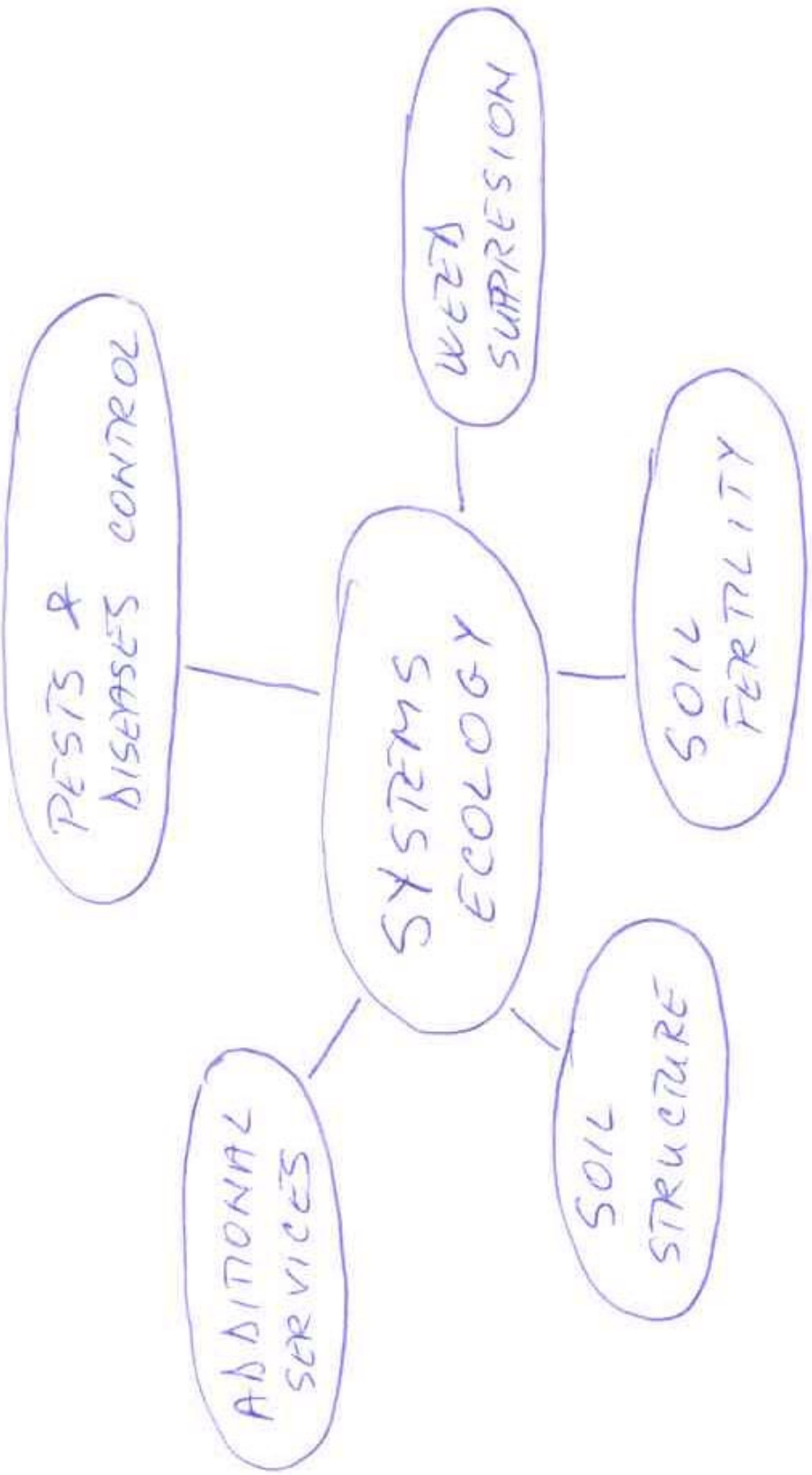
Easy except if the farmers grow rapeseed because of broomrape
Benefits: Agronomical first and around 3500 FF per ha.
The yields are usually between 5 and 8 T of straw and around 800 Kg of grains.

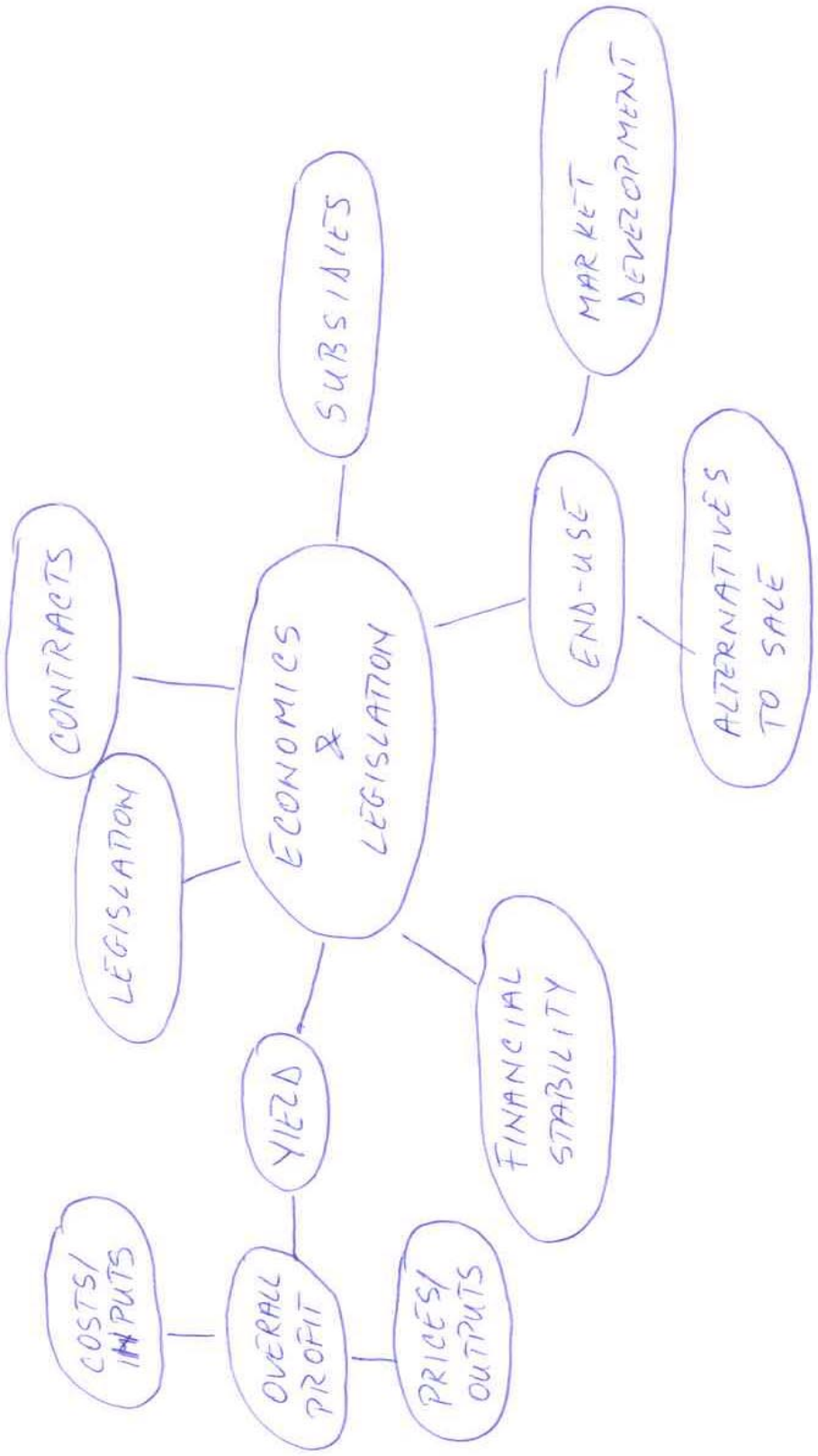
14. HUMAN ASPECTS/SOCIAL FUNCTION

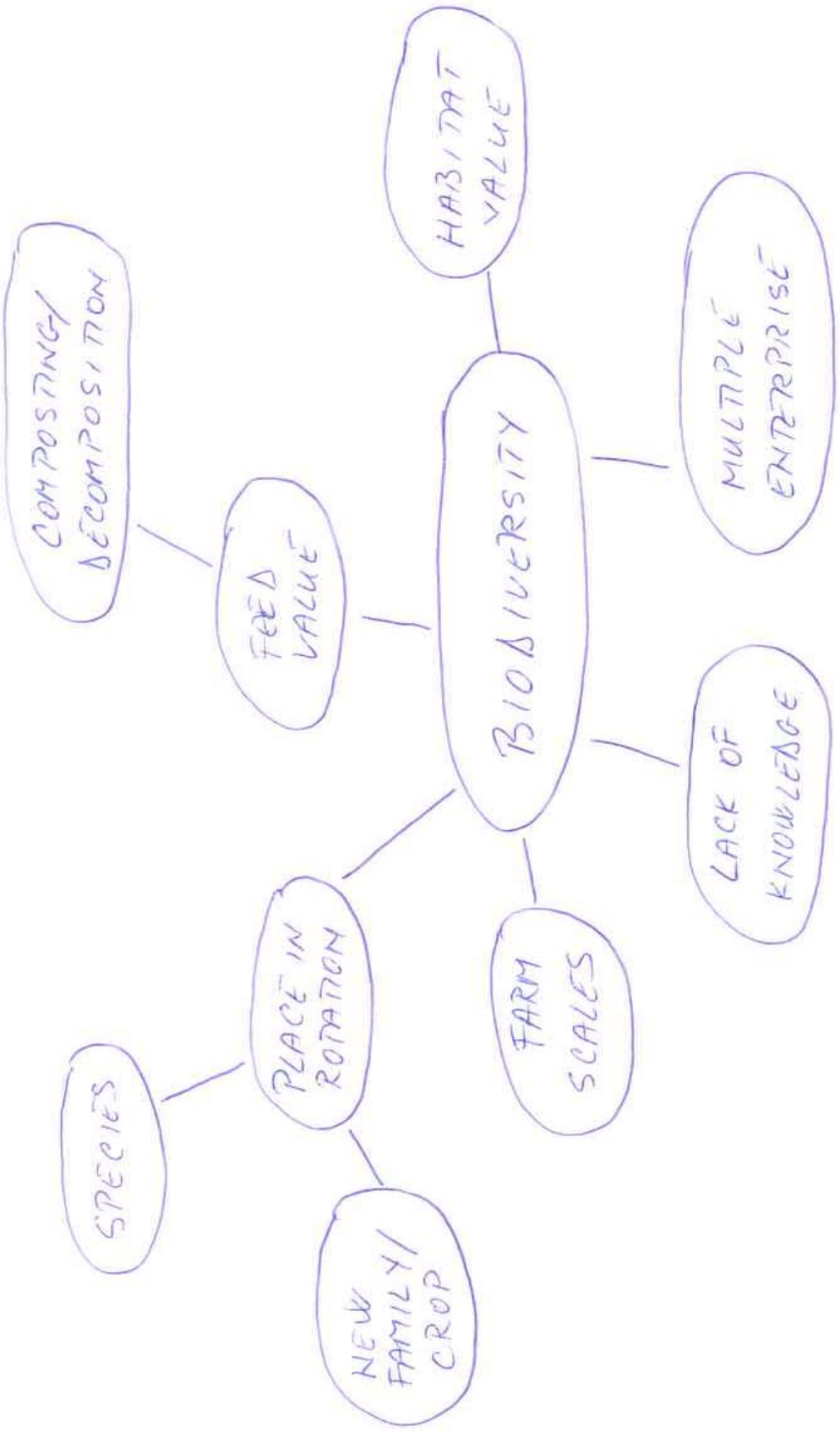
616 growers have contracts for industrial outlet which represent 7700 Ha in France
Financially, hemp was very interesting a few years ago but the subsidies are decreasing (a bit more than for wheat
The contracts are easily driven from one year to the other
New outlets like The Body Shop and Armani may help the production to increase

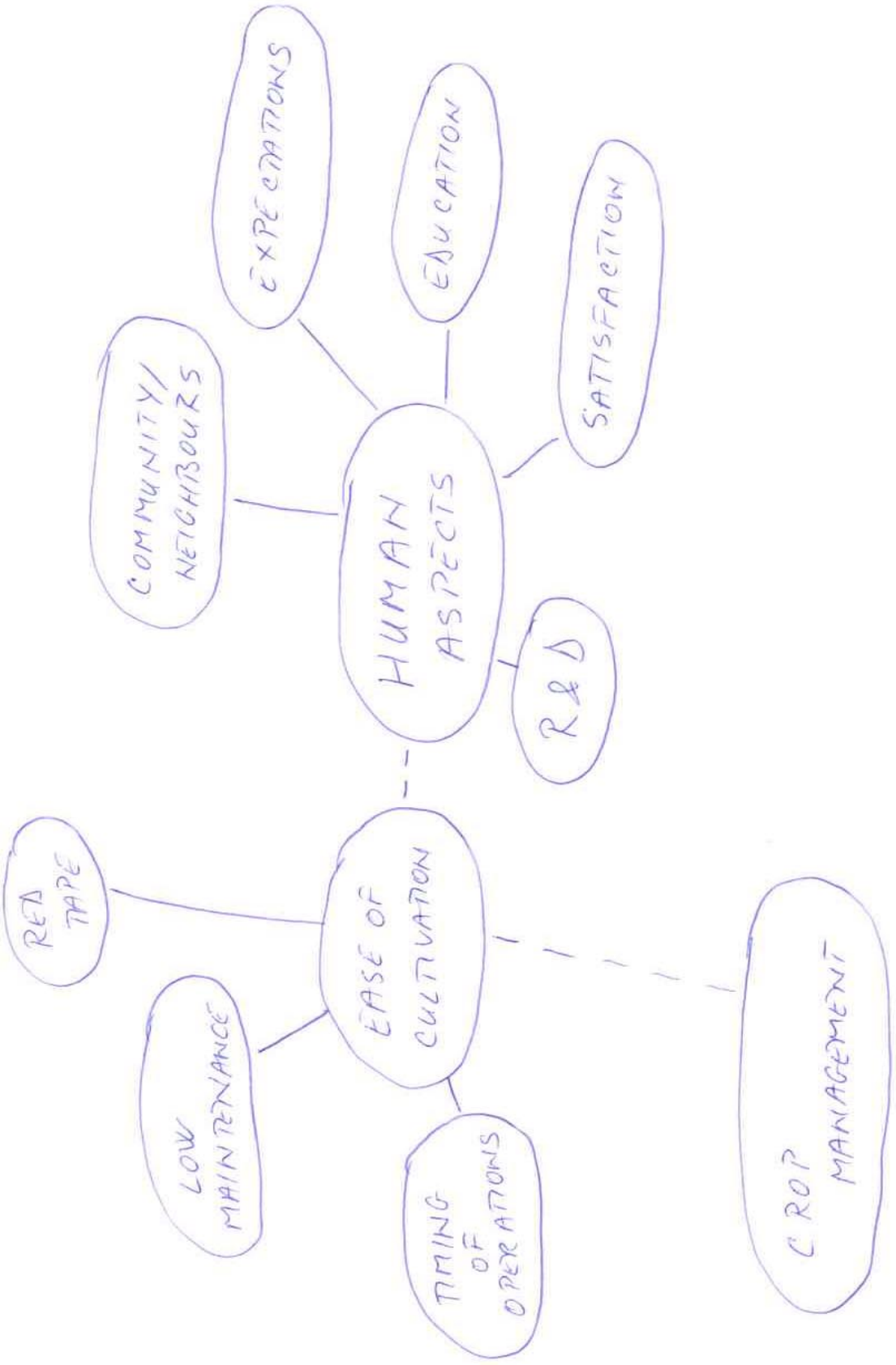
Appendix 3

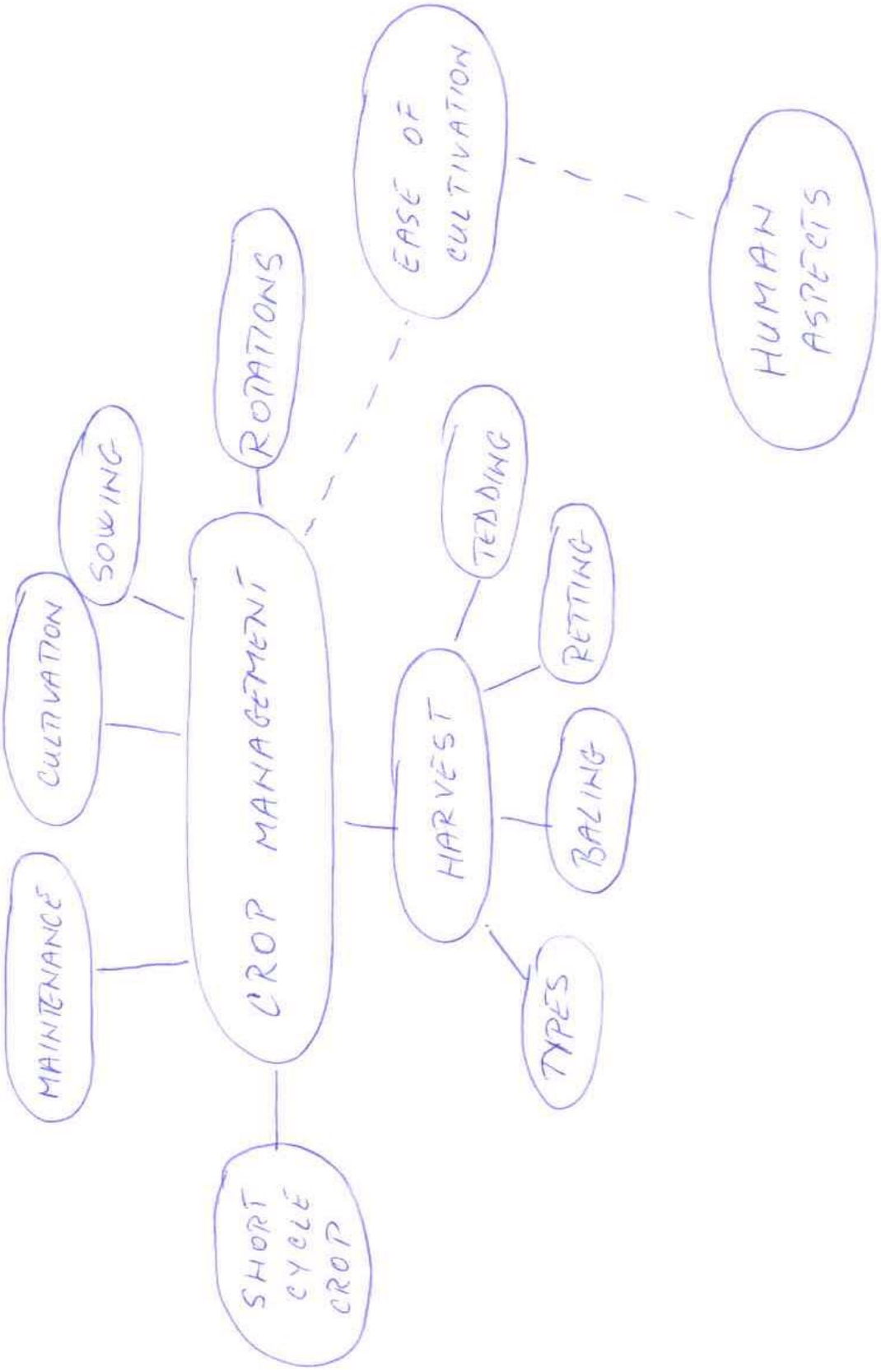
Mind maps

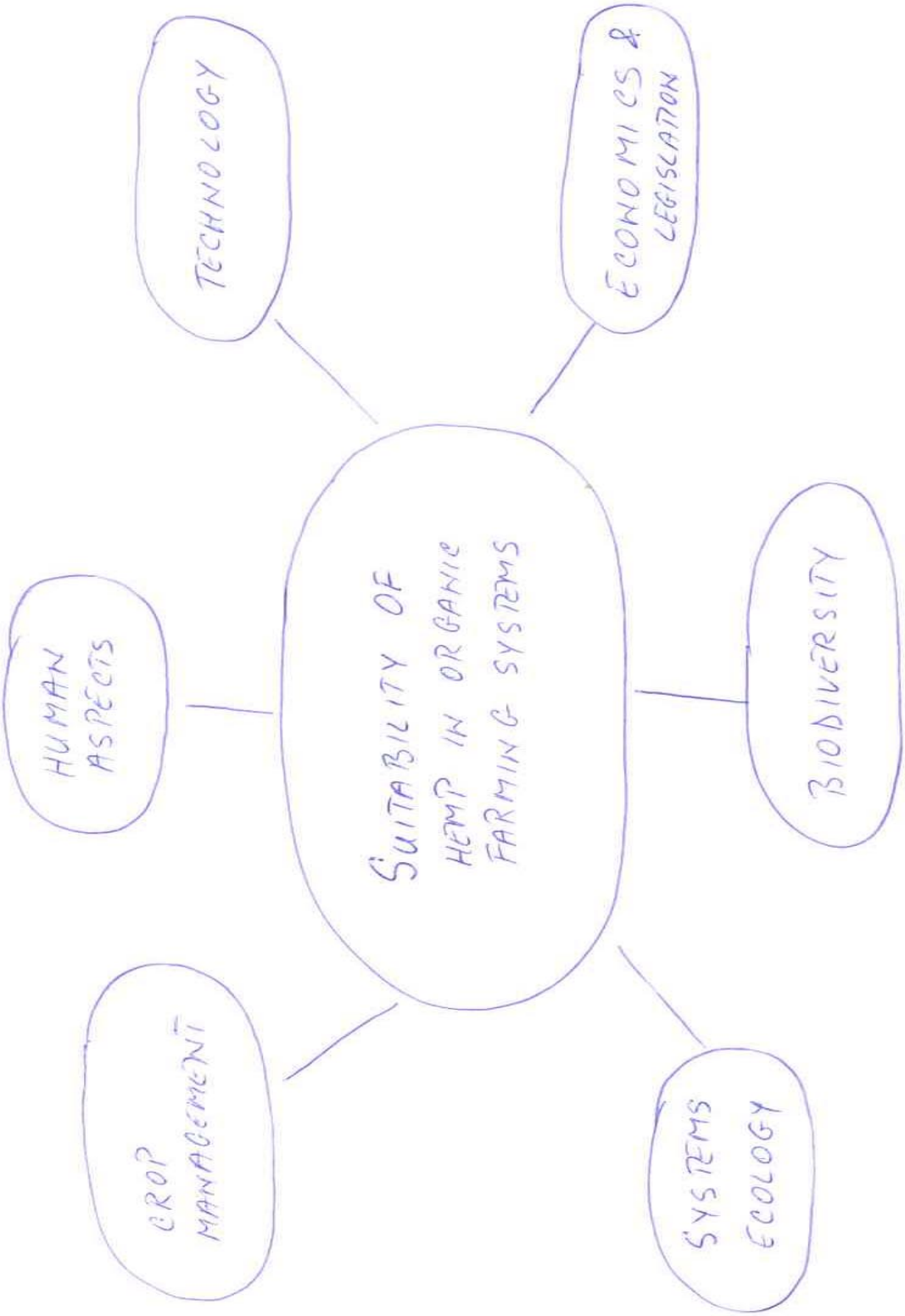

PESTS & DISEASES CONTROL
WEED SUPPRESION
SYSTEMS ECOLOGY
SOIL FERTILITY
ADDITONAL SERVICES
SOIL STRUCTURE

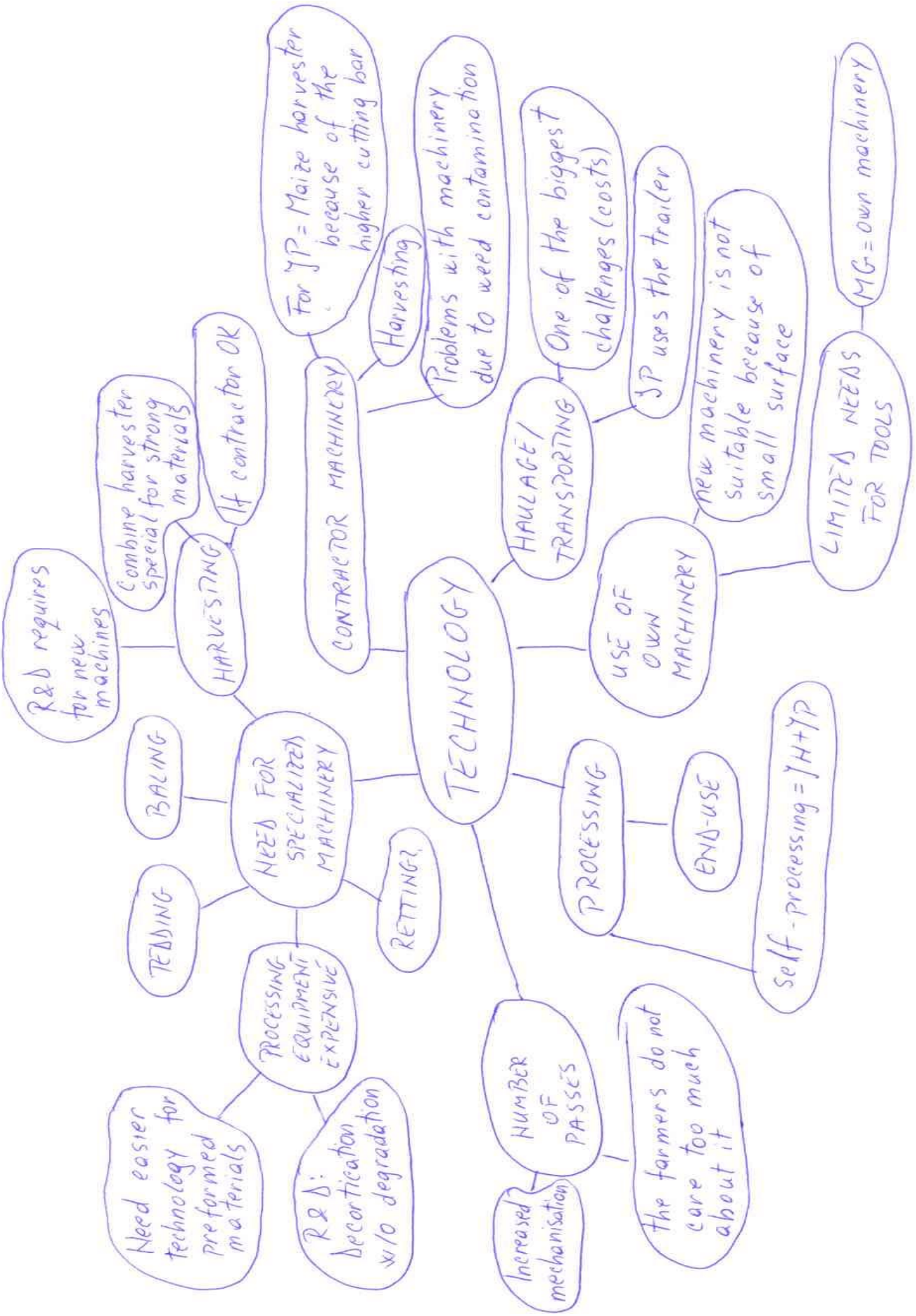

ECONOMICS & LEGISLATION
SUBSIDIES
MARKET DEVELOPMENT
END-USE
ALTERNATIVES TO SALE
CONTRACTS
LEGISLATION
YIELD
FINANCIAL STABILITY
COSTS/ INPUTS
OVERALL PROFIT
PRICES/ OUTPUTS


COMPOSTING/ DECOMPOSITION
FEED VALUE
HABITAT VALUE
BIODIVERSITY
MULTIPLE ENTERPRISE
LACK OF KNOWLEDGE
FARM SCALES
PLACE IN ROTATION
SPECIES
NEW FAMILY/ CROP


HUMAN ASPECTS
EXPECTATIONS
EDUCATION
SATISFACTION
R&D
COMMUNITY/ NEIGHBOURS
EASE OF CULTIVATION
RED TAPE
LOW MAINTENANCE
TIMING OF OPERATIONS
CROP MANAGEMENT


CROP MANAGEMENT
SHORT CYCLE CROP
MAINTENANCE
CULTIVATION
SOWING
ROTATIONS
HARVEST
TEDDING
RETTING
BALING
TYPES
EASE OF CULTIVATION
HUMAN ASPECTS


SUITABILITY OF HEMP IN ORGANIC FARMING SYSTEMS
TECHNOLOGY
ECONOMICS & LEGISLATION
HUMAN ASPECTS
BIODIVERSITY
CROP MANAGEMENT
SYSTEMS ECOLOGY


TECHNOLOGY
NEED FOR SPECIALIZED MACHINERY
HARVESTING
R&D requires for new machines
Combine harvester special for strong materials
If contractor OK
BALING
TEDDING
PROCESSING EQUIPMENT EXPENSIVE
Need easier technology for preformed materials
R&D: Decortication w/o degradation
RETTING
CONTRACTOR MACHINERY
For YP = Maize harvester because of the higher cutting bar
Harvesting
Problems with machinery due to weed contamination
HAULAGE/ TRANSPORTING
One of the biggest challenges (costs)
JP uses the trailer
USE OF OWN MACHINERY
new machinery is not suitable because of small surface
LIMITED NEEDS FOR TOOLS
MG = own machinery
PROCESSING
NUMBER OF PASSES
Increased mechanisation
The farmers do not care too much about it
END-USE
Self-processing = H+YP