IENICA

Interactive European Network for Industrial Crops and their Applications

REPORT FROM THE STATE OF

AUSTRIA

FORMING PART OF THE IENICA PROJECT

IENICA is a project funded under the FAIR Programme
by DG XII of the European Commission

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PREPARATION OF THE REPORT

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This report was made by using information from various publications such as annual reports, official national statistics and databases, webpages of organisations and industrial companies, and by interrogations of persons from institutions, organisations and private companies, as listed in the annex.

Vienna, January 1999

Executive Summary

In this national report presented from the State of Austria about the present and future role of renewal raw materials from agricultural crops for non-food purposes (with the exception of plant products for energy purposes) all aspects about oilseed crops, fibre crops, carbohydrate producing plants and crops for specialist uses are elucidated and critically analysed.

Among the **oilseed-crops** only oilseed rape, sunflower, soybean, oil-pumpkin, poppy- and linseed are crops commercially grown in Austria. On the other hand, research with more than 15 other oil-bearing species are presented by focusing production targets for industrial materials with high biodegradability. These crop products already under use in Austria are plant oil lubricants for agricultural and forestral machinery (1.2 Mio. litres/year), concrete mould release agents, printing inks and coating products (14.888 tonnes/year). Moreover, camelina and crambe are the two industrial oilseed crops with the most advanced agronomic potential for Austria, but not yet grown commercially.

In **fibre crops**, fibre flax and hemp do have some importance in the country. Because of the domestic cellulose industry-using wood as a cheap source for their products – the market for flax and hemp fibre is very limited. Some change maybe occur if the direct benefit of natural fibres to human health in clothing and for insulation/building material is more acknowledged.

Carbohydrates in form of starch products are manufactured exclusively from potato and maize sources, in form of sugar exclusively from sugar beets. The yearly production of about 220.000 tonnes potato starch and 170.000 tonnes of maize starch is nearly sufficient for Austria, whereby approx. 40% of the raw material is marketed for the non-food industry, mainly paper mills. From the sugar production of about 480.000 tonnes/year only about 14.000 tonnes are used for non-food sectors, mainly in the pharmaceutical industry.

In the promising field of **special crops, herbs- and medical plants** a lot of small activities could be discovered in a very pain-stacking investigation. Only the oil-pumpkins with about 12.000 – 15.000 hectares is a very significant crop in this field, followed by caraway seed (680 ha) and milk thistles (650 ha). Pollen from graminaceous species like rye and timothy grass for medical purposes cover up an area from about 200 hectares. All other 30 crop species for herb-tea mixtures or other purposes are grown on areas below 10 hectares and do not play an important role in this field of production.

The situation of the agricultural sector within the Austrian economy

With a 3.3 % increase in economic growth and a historic reduction of the deficit of balance of current account to 0.9 %, 1998 was a successful year for the Austrian economy. The joblessness rate was 4.5 %, thus remaining almost at the level of the previous year. Thanks to the favourable economic situation the job supply improved, also the total available manpower increased.

In the agricultural sector the production increased by volume, whereas the value of its gross yield decreased. Compared to 1997, the value of the final production of agriculture and forestry sank by 1 %, to ATS 62,7 billion (agriculture ATS 49.2 billion, forestry ATS 13.5 billion) Whereas animal keeping saw a loss mainly because of the troubles affecting the pig market, plant production recorded an increase as compared to the previous year. As a consequence of the curbed degressive compensatory payments the amount paid in direct payments sank to ATS 18.7 billion (ATS -8,1 billion). The share of agriculture and forestry in the GDP was 1.4 % in 1998. According to data from the Austrian Institute of Economic Research (Wirtschaftsforschungsinstitut, WIFO) the number of persons employed in the agricultural sector totalled 149,600. Compared to 1997 that means a decrease in employed persons by 2.4 % and the smallest decrease so observed since the mid-1980s. The agricultural quota of the working population is currently 4.2 %.
In agricultural trade, 1998 saw rising exports (+ 9 %) and imports (+ 4 %) as compared to the previous year. Agricultural products to a value of almost ATS 37 billion were exported, more than two thirds of those exports were directed to EU member countries. Imports amounted to nearly ATS 57 billion, three quarters thereof from EU countries. The agricultural trade balance was ATS _20 billion. Austrian

tourism recorded an increase of overnight stays of 1.9 % in 1998. Foreign currency receipts from tourism came to ATS 157.4 billion. The number of overnight stays increased to 111 million. In the category farm holidays overnight stays decreased in 1998, but the chances for success in future years are favourably judged.

Nutrition and food commerce have been characterised by major changes. The extraordinarily high concentration in food commerce continues to increase in all EU member states; it is therefore getting increasingly difficult for small farmers to guarantee adequate supply. The increasing ecological awareness of the customers and their higher sensitivity with respect to production methods and to the healthfulness, origin and freshness of foodstuffs however provide good opportunities for local high-quality farm products.

OILSEED CROPS

1. OPPORTUNITIES

1.1 Science and Technology

Crop species and their production methodologies

Oilseed rape, sunflower, soybean, oil-pumpkin, poppy and linseed are the main oilseed crop species which are commercially grown in Austria at present. Moreover, more than 50 other oil-bearing species are currently investigated both in agricultural production and chemical composition/utilisation research projects focusing on the establishment of novel non-food production and utilisation opportunities.

Oilseed rape

Oilseed rape is the only species grown domestically, from which oil is used at a commercial scale in a number of non-food and non-energetic industrial applications to date. The production methodology for oilseed rape on the farm-level is moderately-well established. Practically no specific agricultural production research is carried out at present, apart from testing and release of new and genetically improved cultivars. A total number of 14 winter-type rapeseed cultivars released for seed and oil production were on the national list for the 1998/99 growing season. All of these cultivars are of "canola" quality with zero erucic acid content and zero glucosinolate content (Oberforster, 1998).

Sunflower

In sunflower, 18 cultivars are on the national list at present, and two of them carry the high oleic acid character, making the oil suitable for particular industrial applications. Moreover, there are 31 cultivars of soybean, 4 cultivars of oil-pumpkin, 4 cultivars of poppy and 4 cultivars of linseed (oilseed use only) registered in the Austrian national list of agricultural crop cultivars (Oberforster, 1998). No original plant breeding work is carried out in rapeseed, sunflower and linseed in Austria, whereas in soybean, oil-pumpkin and poppy, at least some of the cultivars available have been developed domestically.

Other crop species

In a number of other oil-bearing crops, which are not yet in agricultural production, agronomic and plant breeding research is targeted towards establishing of these species as industrial crops. In camelina (false flax, gold-of-pleasure, *Camelina sativa* (L.) Crtz.), crucial agronomic parameters such as optimum sowing rate and mineral fertilisation have been elaborated for different regions of crop production in Austria (Dachler, 1993; Hackl, 1998; Liebhard, 1991) within national research projects. In a camelina breeding program at the University of Agricultural Sciences Vienna, genotypes with improved seed yield, larger seed size and increased oil content were selected (Vollmann et al., 1996); seed irradiation was used to increase genetic variation in seed quality characters, and subsequently mutant genotypes were identified with increased content of linolenic acid or reduced content of erucic acid in the seed oil (Vollmann et al., 1997). In crambe (*Crambe abyssinica* Hoechst. Ex. F.R. Fries), a few basic agronomic and breeding features have been investigated (Dachler, 1993; Liebhard, 1991; Vollmann & Ruckenbauer 1991, 1993) both in nationally funded projects and in collaboration with EU activities (Concerted Action AIR 3 CT 94-2480). In hemp, seed harvest technologies were evaluated for hemp oil production (Pernkopf, 1995; see also FIBRE CROPS section). In other research projects funded by the Austrian Ministry of Agriculture and Forestry, seed oils of 54 oilseed crop species or potential crops were investigated oleochemically. As a result, a database of oilseed crop species will be publicly available on the internet from 1999 on, which will cover not only fatty acid profile, iodine, acid and saponification values, tocopherols and tocotrienols, but also minor components of oils such as composition of free and esterified sterols, hydrocarbons, oil pigments and wax esters (Lechner et al., 1997; Lorbeer et al., 1997; Lorbeer, 1998). Furthermore, analytical methods for the quantitative determination of particular plant lipid components were developed or refined (Reiter et al., 1997).

Crop products

In the non-energetic non-food segment of oilseed crops, several crop products have been developed or refined in Austria: Vegetable oil-based lubricants for power engines, hydraulic fluids, lubricants in agricultural machinery and timber harvesting equipment (chain saw greasing), concrete mould release agents, printing ink applications, fatty acid esters for non-evaporative metal cleaning and cleaning of offset printing machines and coatings and paintings from drying oils. Moreover, plant oils are used as additives in other products such as plant protection chemicals (insecticides), plasticizers, softeners, cosmetics or different cleaning agents.

Lubricants

Research and development in the field of vegetable oil-based lubricants for power engines, hydraulic fluids and lubricants in agricultural machinery is mainly carried out at the Federal Institute of Agricultural Engineering at *Wieselburg*, Lower Austria (*BLT Wieselburg*). Technical performance of vegetable oil based lubricants was monitored in different practical applications as compared to mineral oil products, and oxidation stability and high temperature performance of plant oils in hydraulic fluid applications were investigated. Besides rapeseed oil, sunflower and camelina oils are also used as raw materials in particular studies (Prankl, 1997). As a result, a number manufacturers of tractors and other agricultural machinery made release statements for their products to be operated with vegetable oil based hydraulic fluids. Moreover, Austrian standards for biodegradable vegetable oil based hydraulic fluids were developed and published in 1997 (*Österr. Normungsinstitut Wien, ÖNORM C2027*; Prankl & Krammer, 1997).

Chain saw greasing

Rapeseed oil based lubricants for timber harvesting equipment (chain saw greasing) have been developed in Austria (Kellersperg, pers. comm.) due to the considerable environmental relevance of that kind of lubrication, in which the oil is completely released to the forest environment. An Austrian standard for vegetable oil based chain saw lubricants has been published in 1991 (*Österr. Normungsinstitut Wien, ÖNORM C2030*). Since May 1, 1992, the use of mineral oils for chain saw greasing is prohibited by federal law (*BGBl. 647/1990*), thus strongly promoting the use of biodegradable plant oils in this field. At present, an estimated 1.2 million litres of vegetable oil based chain saw oils are used annually in Austria (Wörgetter & Mang, 1998). Since 1993, chain saw oils can be labelled as "environmentally friendly" by a protected label ("*Österreichisches Umweltzeichen*", "The Austrian Eco Label") granted by the Federal Environment Agency Vienna (*Umweltbundesamt Wien*). Four manufacturers of vegetable oil based chain saw oils (*Biostar Oil GmbH Ragnitz, OMV AG Schwechat, Shell Austria AG Wien, Aral Austria GmbH Wien*) have received the Austrian Eco Label for their products to date.

Printing ink

Printing ink from vegetable oils for offset printing is a fully developed technology, which is currently being promoted in Austria (Österr. Kuratorium für Landtechnik, 1998). A patent has been received by *BLT Wieselburg* for a logo "*Gedruckt mit Pflanzenölfarben*" ("printed with vegetable oil ink") indicating the use of vegetable oil printing ink.

GEDRUCKT MIT
PFLANZENÖLFARBE

Figure: The Austrian logo "Printed with vegetable oil ink".

A few Austrian printing enterprises are using printing ink from vegetable oils occasionally. Since 1998, *Radinger Druck Scheibbs* is exclusively applying vegetable oil based printing ink, which appears to be only 1 % more expensive than conventional printing ink products; the 2 to 3 t of vegetable oil based printing ink used by *Radinger Druck* annually are currently imported from suppliers in Germany (Lebhard, pers. comm.). The Austrian printing ink initiative is legislatively supported by regulations limiting the use of organic volatile solvents (*Lösungsmittelverordnung 1995; BGBl. 872/1995*) in printing ink, wood protecting agents and various types of coatings (Eberhartinger & Krajnik, 1998).

Concrete mould release agents

Concrete mould release agents based on rapeseed oil have been developed in Austria (Kellersperg, pers. comm.). There is a very wide field of application for these oils in the concrete construction and building industry. However, the use of biodegradable vegetable oils instead of mineral oil in concrete mould release agents is not supported by environmental legislation at present.

Printing machine cleaning agents

The use of vegetable oil based esters instead of highly volatile organic solvents for cleaning offset printing machines had been promoted by an EU supported project (SUBSPRINT: Substitution of organic solvents in the printing industry). As a result of this activity, around 50 % of printing enterprises in the Linz area of Upper Austria are using vegetable oil based solvents at present (Kummerer, 1998). Recently, an extended program on cleaning of metal surfaces using vegetable oil esters has been launched within the framework of the EU LIFE program; the Austrian activities within that project are co-ordinated by *ppm forschung und beratung Linz*.

Coatings and paints

Coatings and paintings based on drying plant oils with high iodine value (i.e. linseed oil) have been used since a long time both in outdoors and indoors wood protecting and furniture coating applications in Austria. However, no new developments are known from that field of plant oil usage, and the linseed oil used in paintings has to be imported to Austria. A few of the coating and painting products have been granted the Austrian Eco Label.

Cosmetics

From hemp oil, a number of different cosmetics and body-care products have been developed in Austria by *Nektar Naturkosmetik Amstetten*, which are now available on the market (Rausch, 1994). However, the raw materials used for production are mainly imported from EU and Eastern European countries. Another series of cosmetics and body-care products ("*Hanna*") is marketed by *Kautzner Hanfkosmetik*

Kautzen; in this project, only hemp grown in the *Kautzen* region is used, and the manufacturing of the different products is done in Switzerland (Peneder, 1997).

Other applications

Vegetable oil additive applications were also investigated in aphid control experiments in potato in order to prohibit transmission of potato viruses. However, a rapeseed oil based repellent was less effective than combinations of mineral oils and insecticides in aphid control (Schiessendoppler, 1997).

Vegetable oils were investigated as biological additives in softeners and stabilisers of plastics in thermoplastic processing, because most of the conventional additives used to date are considered highly toxic (Böhm, 1998). The relevance of this project by *Gesellschaft zur Förderung der Kunststofftechnik Wien* is underlined by a new federal regulation which bans plastic toys containing phthalate softeners for children under the age of three by January 1, 1999.

Implications of novel technologies being developed and their impact

In Austria, the main implications of novel technologies based on vegetable oils are environmental implications. There is a wide consensus about the fact that many of the crop products described above have positive effects on the environment, in particular on soil and ground water due to their high degree of biodegradability.

Moreover, new scientific achievements and technologies are offering considerable new opportunities for agriculture in the non-food segment of oilseed production, in particular on set-aside land. The vegetable oil based crop products developed so far are also offering various business opportunities for small to medium scaled domestic enterprises specialising in those products. These enterprises are also supported by federal laws and regulations which clearly favour vegetable oil based technologies in certain industrial applications (Wörgetter & Mang, 1998).

1.2 Industry

Needs for and uses of industrial crops

In the non-food oilseeds field, industrial crop developments are mainly driven by agriculture, agricultural research and small scale enterprises at present (Krotschek et al. 1997). Usually, the products and applications developed are not new but substituting existing products which are based on non-renewable resources. For this reason, the "classical manufacturing industry" does not see any need for industrial crops, except in applications with severe environmental impact.

Potential uses of plant species that are not yet commercial crops

Camelina and crambe are the two industrial oilseed crop species with the most advanced agronomic potentials for Austria, which are not yet grown commercially.

Camelina oil has a similar range of industrial applications as linseed oil, e.g. environmentally friendly coatings, paintings, surface protection agents, linoleum and other types of utilisation, in which highly unsaturated drying oils are required. Furthermore, camelina oil methyl esters are used as additives to biodiesel and hydraulic fluids in recent experiments (Prankl, 1997).

Crambe oil has been claimed appropriate for a large number of different uses due to the uniquely high concentration of erucic acid. In Austria, crambe oil has not been utilised so far. The use of crambe oil as a speciality lubricant exhibiting high temperature stability appears to be the most straightforward utilisation approach;

other uses could be the anti-foaming component in washing agents or slipping agent on household plastic films.

Details of processing systems, processing capabilities and processing capacity

Most of the non-food oil products used in Austria are not processed domestically at the time. The chain saw oil manufacturing plant of *Biostar Oil GmbH Ragnitz*, is processing about 1200 tonnes of rapeseed per year (Kellersperg, pers. comm.); capacities could be easily increased on market demand.

The most advanced processing, however, can be found in the energetic segment of non-food rapeseed utilisation: There is a total number of nine biodiesel plants operated in Austria with production capacities of 25 up to 18000 tonnes of biodiesel per year.

1.3 Markets

Current areas, yields and production of industrial crops or potential industrial crops

See annex in Section 4.

Specific markets and potential markets

The well established Austrian market for chain saw oils is estimated to resemble about 1.2 million litres of oil needed per year. As a potential market, the overall need for lubricants in Austria is in the range of 90 - 100.000 tonnes per year at present (Wörgetter & Mang, 1998). Another potential market to be developed, the printing inks market is at about 21.000 tonnes per year with a domestic production of only 14.800 tonnes (Dachler, 1998).

1.4 Environmental

Environmental issues and environmental concern in particular are the main driving force towards the development and usage of non-food products from oil crops in Austria. The main advantage of vegetable oil based products in the lubricant segment is seen in the high degree of biodegradability as compared to mineral oil based products. In the fields of metal cleaning and oil additives, the advantage of vegetable oil based products is in the protection of human operators and consumers from toxic substances and health risks.

The Austrian legislation is also strongly emphasising environmental aspects with respect to the use of vegetable oil based products, e.g. by banning mineral oil based lubricants from the chain saw oil market.

2. BARRIERS TO PROGRESS

2.1 Scientific

Genetic improvement of oilseed crops in terms of modifying seed quality is a complex breeding objective, which requires highly specialised and costly approaches. For this reason and for the reason of no clear marketing perspectives, Austrian plant breeders have been active in oilseed crop improvement only in the food segment so far. Moreover, agronomic research for both food and non-food oilseed production has only been carried out at a low level.

To date, application research and product development are limited to certain fields only, most of which are closely linked to agriculture itself. Only a few research activities can be found in the "established industries".

2.2 Technical issues

The establishment of a specialised agency for co-ordinating activities within Austria has been urged for the whole non-food agricultural production and development segment. This would also include the oilseeds field.

In the field of product standardisation, existing standards for mineral oil based products very often do exclude products from renewable resources, because these standards do not cover the biological variations usually found in natural products. So, natural products often fail to match these standards, although their functional quality is acceptable (Krotschek et al., 1997). The establishment of additional technical standards for vegetable oil based products (e.g. chain saw oil standard *ÖNORM C2030*) is an example to overcome that problem.

2.3 Environmental

In areas of ground water protection, rapeseed production problems are sometimes discussed with respect to subsoil and water contamination by fertilisers and plant protecting chemicals. However, these problems are not specific to non-food production of rapeseed. Furthermore, it has been demonstrated repeatedly that advanced crop management by experienced producers can minimise the negative impact of rapeseed production on the environment.

2.4 Legislative issues

At present, there are no legal restrictions existing, which would considerably limit the production or use of oilseeds and oilseed products in the non-food segment in Austria.

2.5 Economic issues

In Austria, there are three fields of competition, which have to be overcome in the case of non-food non-energetic utilisation of plant oils: Mineral oil market, vegetable oil market at world scale, and food and energetic use of domestic oil in Austria.

The mineral oil market is a strong competitor for plant oil with respect to technical applications. This is mainly due to the lower price of mineral raw oil and to quality characters of vegetable oils (fatty acid pattern, oxidative stability etc.). For these reasons, plant oil is mainly used in applications of high environmental impact (e.g. rapeseed oil based lubricants for chain saws).

The vegetable oil market at the world scale (including the impact of the GATT agreement) is a second opponent to non-food uses of domestic oils: Agricultural production is relatively expensive in Austria (high production costs, small scale structure of farms) and different plant oils are highly interchangeable. For this reason, soybean oil from overseas production is a cheap alternative to domestic rapeseed or sunflower oil, e.g. in the printing ink application.

The food use of domestic vegetable oil as well as the well-established energetic use (biodiesel production from rapeseed oil methyl ester) are further competitive forces for non-energetic utilisation of vegetable oils in Austria. This is due to the fact that Austrian agriculture is producing only 50-80% of the total amount of oilseeds consumed and processed domestically.

Apart from these points, Agenda 2000 will definitely have an impact on oilseed production, as renewable resources are not supported explicitly. Moreover, most of the developers of new non-food applications are representing very small companies. Therefore, these enterprises are highly flexible, but they do not have market power to place their products and to compete with traditional producers/traders.

3. PRIORITISATION

In Austria, oilseed crop production is lagging behind the domestic demand of both the food and the well-established non-food utilisation. For this reason, highest priority should be given to promotion of environmentally safe oilseed production and production research. Critical issues such as crop rotation problems, yield level and seed quality should be elaborated. In the section of non-food and non-energetic utilisation of vegetable oils, development and marketing of new products should be further supported by promoting research and by legislative actions.

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FIBRE CROPS

1. OPPORTUNITIES

1.1 Science and Technology

Crop species and their production methodologies

Fibre flax and hemp are the only fibre crop species commercially grown in Austria. Apart from this, production research is being initiated in stinging nettle (*Urtica dioica* L.) at present. Moreover, plant fibres are often used in composite materials; the raw materials of these fibre composites are usually derived from agricultural waste (e.g. cereal straw), but no specific production research is carried out for that kind of utilisation to date.

Flax

Fibre flax production for textile manufacturing has been re-established on a small scale in Austria in 1982 (Dachler & Wissa, 1990). Agronomic research has focused on optimising of fertilisation towards yield and fibre quality improvement (Dachler, 1988; Hein, 1997). The effects of flax cultivation in monoculture and in different cropping sequences on various biological and chemical soil properties have also been investigated (Bachmann et al., 1996). Two new fibre flax cultivars ("Laura", "Nike") of Dutch and Polish origin, respectively, have been released for cultivation in 1995 (Oberforster, 1998), but no new breeding lines are evaluated in official trials at present.

Hemp

Hemp production was started in 1995, when Austria joined the EU and hemp production became subsidised. Initially, agronomic research in hemp focused on optimising fertilisation, plant density, row width and cultivar selection (Liebhard, pers. comm.). Moreover, harvesting technology, which is a key problem in hemp production, was evaluated for both straw and seed harvesting (Pernkopf, 1994; 1995; Mayer, 1995; Doppler, 1995). The evaluation of hemp production parameters was also analysed for organic farming conditions (Hartl, 1997; Vogl & Heß, 1995). From official variety testing, three out of 14 cultivars of hemp ("Benika", Felina 34", "Kompolti") were released in 1997 for cultivation (Hinterholzer and Mechtler, 1998).

Stinging nettle

Stinging nettle is not grown in Austria for fibre production at present. Agronomic research in stinging nettle is being initiated in 1999 with support from an EU project at *IFA Tulln* (Bürstmayr, pers. comm.). The field experiments will be focusing on selection of most adapted clones and on optimising basic agronomic parameters for Austrian organic farmer's growing conditions.

Crop products

There are two main areas of utilisation of bast fibres and woody waste from flax and hemp, textile manufacturing and other technical utilisation. The latter includes the production of isolation materials, bulky filling materials, paper manufacturing or production of composite materials. Apart from flax and hemp, composite materials with various contents of fibre have been developed using waste from a number agricultural crops.

Textile manufacturing

The processing of flax straw, spinning of long fibres and weaving of textiles is an established technology with only occasional need for research inputs. There are three companies involved in flax processing and spinning in Austria: *Steirerflachs Flachsverwertungsges. (Knittelfeld), Waldviertler Flachsverarbeitung reg. GenmbH. (Rastenfeld)* and *Lambach HITIAG Leinen AG (Golling/Erlauf)*. Most of the long fibres produced at *Steirerflachs Flachsverwertungsges.* and at *Waldviertler Flachsverarbeitung* are exported, only a small amount of the flax processed at *Waldviertler Flachsverarbeitung* is spinned, weaved, manufactured and marketed under a special clothing brand ("*Leinenstube*") in Austria (Egger, pers. comm.; Gassner, pers. comm.). At *HITIAG Leinen*, spinning of flax fibres imported from EU-countries (France, Belgium) is practised. *Steirerflachs Flachsverwertungsges., Waldviertler Flachsverarbeitung* and *HITIAG Leinen* have also successfully accomplished hemp processing and spinning, respectively, with adapted machinery on a pilot/experimental scale.

Short fibre utilisation

Short fibre from flax straw processed at *Steirerflachs Flachsverwertungsges.* and *Waldviertler Flachsverarbeitung* is utilised for production of wall isolation materials in the building industry (*Heraklith, Fürnitz*) and for isolation shields used in cars. However, the largest amount of short fibre is exported (Egger, pers. comm.).

Hemp fibre concrete

Hemp fibre applications have been developed by *Rohemp GmbH (Fürstenfeld)*: Using hemp instead of steel or synthetic fibres, a fibre-enhanced concrete with favourable durability and elasticity properties has been produced for different applications in the building industry (Mayrhuber et al., 1997).

Hemp paper

Hemp woody core, the woody waste of the hemp stem at fibre processing ("*Schäben*") has successfully been used for paper pulp and paper manufacturing at *Neusiedler AG, Kematen*. Different types of hemp paper ("*hemptec*") are now produced, which are marketed in Austria and in some EU countries at present. However, most of the hemp woody core processed has to be imported from Romania (Drexler, 1995; Mayrhuber et al., 1997; Peneder, 1997; Zoch, 1997).

Compound materials

Composite materials, which may contain plant fibre, carbohydrates, wood and other natural or synthetic components have also been developed because of their unique characteristics. "*ZELFO 1*" and "*ZELFO 2*" are two materials from renewable resources developed by *Zellform, Taiskirchen*."*ZELFO 1*" is a compound material, in which wood, straw, flax, miscanthus or waste paper are combined with different binding components (oils, waxes, chalk or gypsum) and pigments to form a new material, which can be pressed into various shapes. "*ZELFO 2*" is a compound material exclusively based on plant fibres (cellulose) such as flax, hemp, straw or waste paper without any binding components to be added. This material, which is entirely from renewable resources, has high density, hardness, water resistance and "aesthetic appearance". It could be used in a wide array of applications in the human environment, e.g. for manufacturing furniture parts, switches, computer keyboards and mice, household containers, children’s toys, office equipment or acoustics components (Mackwitz et al., 1997; Zellform, 1997).

Wood-plastics compounds

"*Fasalex*" is a method/material to extrude fibres (especially from wood, but also from other fibrous plant waste such as cereal straw) together with thermoplastic bio-polymers into profiles, thus combining wood and plastics in one material. *Fasalex* has been developed at *IFA Tulln's Department of Natural Materials and Packaging Technology*. Conventional extruders can be used to process the thermoplastic wood materials (*Fasalex* - granulates). Wall and floor profiles, window frames and many other furniture applications can be manufactured from *Fasalex*. Apart from *Fasalex*, other procedures have been developed at *IFA Tulln*, which allow injection moulding of wood or cellulose fibres from plants (Rettenbacher, 1995; Mundigler et al., 1997) into various shapes with numerous applications, e.g. children's toys, furniture, automobile interiors, sporting equipment or coat hangers (Ruckenbauer & Steyskal, 1997).

Implications of novel technologies being developed and their impact

At present, impact based on fibre crop technologies is much lower than the impact seen from oilseeds, which is due to the very small scale of both agricultural production and utilisation. Production of fibre crops is considered environmentally save, and the utilisation of agricultural waste in fibre based products is also desirable. Apart from the "direct" impact of natural textile fibres on consumers, the strongest impact of fibre crop technologies may occur in the building and construction industry in the future.

1.2 Industry

Needs for and uses of industrial crops

Similar to oilseeds, fibre crop technology would primarily replace existing products which are based on non-renewable resources. In the textile and clothing section, plant fibres from an increased domestic production would have to compete not only with synthetic fibres but also with wool and cotton. In the building industry, interest in new plant fibre materials appears to be low at the present time.

The need of hemp woody core for hemp paper production in Austria ("*hemptec*", *Neusiedler AG*) can not be satisfied by an Austrian grown crop at the moment. It is estimated that about 3000 ha of hemp would be required to supply the raw material for paper manufacturing (Zoch, 1997).

Potential uses of plant species that are not yet commercial crops

Stinging nettle has a potential for paper and textile manufacturing. The development of new fibre and textile processing technologies based on stinging nettle fibre is currently initiated at *Paptex GmbH (Dornbirn)*. The intended uses of these textiles are different household applications such as covers and cases of furniture.

Details of processing systems, processing capabilities and processing capacity

Annual flax processing capacities of *Steirerflachs Flachsverwertungsges.* and *Waldviertler Flachsverarbeitung* are 1500 tonnes and 5000 tonnes, respectively, of rotted flax straw; capacities could considerably be increased on demand. The flax fibre outputs of the two processors were 500-600 tonnes and 800 tonnes, respectively, during the previous years. Both *Steirerflachs Flachsverwertungsges.*

and *Waldviertler Flachsverarbeitung* are prepared for processing hemp straw in their production plants.

Neusiedler AG is an important player in the Austrian paper manufacturing industry with a total of 300.000 tonnes of paper produced per year. The production of "*hemptec*" hemp paper was 1500 tonnes in 1997 and an estimated 5000 tonnes in 1998 with 500 kg hemp waste required for 1 ton of paper produced.

1.3 Markets

Current areas, yields and production of industrial crops or potential industrial crops

See annex in Section 4.

Specific markets and potential markets

In the textile industry, more than 1.900 tonnes of flax fibre and 61 tonnes of hemp fiber were imported to Austria in 1997, which is only 6-7 % of the total annual import of fibres (Fachverband der Textilindustrie Österreichs, 1998). The countries of origin of these fibres were France, Belgium, Luxembourg and Hungary for flax and Germany for hemp. For flax fibre, the amount imported would resemble a domestic production area of an estimated 4000 hectares.

The building and construction industry is considered to be the largest potential market for plant fibre in the future, although plant fibre is only used marginally in this section with no market estimates available (Mayrhuber et al., 1997). An annual total of 3.5 million m^3 of isolation and bulk filling materials is used in Austria at present, with mineral and stone wool (1.6 - 1.8 million m^3) and polystyrole and polyurethane (1 million m^3) being the most important shares (Mayrhuber et al., 1997).

1.4 Environmental

At present, the environmental impact of fibre crop growing and plant fibre utilisation is low because of the low scale of production. In general, fibre crop production is considered environmentally friendly as compared to cereal or rapeseed production, which is mainly due to the low nitrogen requirement of flax and hemp.

The main benefit of products made of plant fibres is seen in their biodegradability as compared to synthetic fibres. Use of crop waste products in composite materials could reduce the waste utilisation problem in many crop products. Moreover, direct benefit of natural fibres to human health is obvious in particular textile (clothing) and isolation/building material (asbestos) applications, where natural fibres are (re-)gaining market shares.

2. BARRIERS TO PROGRESS

2.1 Scientific

Although there is a need in research on fibre crop production, the level of scientific activity in these crops is low. More agronomic research would be required particularly for hemp and stinging nettle production. In the field of processing and utilisation, a couple of products have been developed so far. If mass production could be initiated, new problems and research need would probably emerge in particular fields.

2.2 Technical issues

Harvesting and field retting of hemp is still a difficult task due to the bulky material, which has to be managed on the field. Specialised harvesting machines, which are under development at *Rohemp GmbH Fürstenfeld* (Mayrhuber et al., 1997), can only be employed efficiently, if there is a minimum number of hemp growers within a particular region. Both in hemp and flax, transport and storage of the low density and bulky products harvested is also considered a specific problem of fibre crops. This prompts for regional processing units, which are available now at two sites (*Knittelfeld, Rastenfeld*) in two different regions (*Obersteiermark, Waldviertel*) of flax processing. The problem of storing bulky fibre raw materials has been a reason to replace vegetable fibres by wood chips in certain applications, because wood has higher density, and supply of the raw material is continuous throughout the year.

Seasonal variations in crop production, harvesting problems and processing considerably influence yield and quality of fibre, which might fail to meet industry standards for particular applications. For this reason, fibres from non-renewable resources (e.g. glass fibre) or from wood are sometimes preferred by industry.

2.3 Environmental

No environmental barriers to the progress of fibre crop growing and product utilisation can be foreseen at present.

2.4 Legislative issues

According to federal regulations on prohibition of drug abuse in Austria (*Suchtgiftgesetz 1951*), growing of hemp plants for drug production is forbidden. In the case of fibre production from hemp, cultivars may only be used with a content of THC (tetrahydrocannabinol) below the limit of 0.3 % based on dry matter (Hinterholzer & Mechtler, 1998).

2.5 Economic issues

High production and handling costs of fibrous raw materials are a major economic drawback for fibre production from flax and hemp. For this reason, plant fibres are replaced by cellulose fibres from wood, whenever possible.

In hemp paper production, only hemp woody core is used for preparation of paper pulp, because hemp fibre (which could be used as well) is considered to be too expensive as a raw material, whereas the woody core is a cheap waste material (Drexler, 1995).

Apart from cotton and synthetic fibres, new developments in cellulose fibre industry such as "*Lyocell*" at *Lenzing Lyocell GmbH & Co. KG, Heiligenkreuz*, will be strong competitors to flax and hemp fibres in the textile sector both for clothmaking and technical textiles. In *Lyocell*, wood is used as a raw material, and spinning of cellulose fibres is accomplished using N-methylmorpholine-N-oxide (NMMO) as a solvent. The production of *Lyocell* at *Heiligenkreuz* is at 12.000 tonnes of fibre per year and is scheduled to be increased to 35.000 tonnes by the year 2000 (Marini, 1997).

3. PRIORITISATION

In Austria, utilisation of fibres from crop plants such as flax and hemp is going on in small niche markets at present, e.g. manufacturing of traditional clothing. For hemp, there is no industry interested in fibre processing, and the cultivation of hemp in recent years was mainly intended for hemp oil production. Moreover, cellulose from wood is a very cheap raw material in Austria, which is more and more used in the textile branch, thus competing with traditional fibres for textile manufacturing. For this reason, promotion of fibre crop production and utilisation is of low priority in Austria and does not appear to be reasonable economically, except for a few traditional niches.

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STARCH

1. OPPORTUNITIES

1.1 Science and technology

Crop species and their methodologies

Starch is made from potatoes and maize, respectively. In the national list (*Österreichische Sortenliste*) there are 5 potato cultivars described for their exclusive use to produce starch, 22 other cultivars can be used for starch production and as food. In regard to maize no cultivars are specified for starch production (Bundesamt und Forschungszentrum für Landwirtschaft, 1998). Both the production of potatoes and maize are highly mechanised.

Crop products

Starch is the most important idustrial carbohydrate, used in more than 500 products, e.g. as adhesive and binder agents in the paper and corrugated board industry, as binder agent in the building chemistry. Starch is also used in the textile, fermentation and biochemical industry.

Together with plant fibres and food additives the product *Biopac / Cambio* is produced (*Biopac* is the trademark in Austria and Scandinavia, in other countries it is called *Cambio*). *Biopac* is used as secondary packagings for technical and pharmaceutical articles and for dried foodstuff with a water content < 16%. Other uses of *Biopac* are non-returnable plates, boxes, knifes and forks for snack bars. *Biopac* is fully biodegradable and has no negative environmental impact. Starch is also used for the production of bio-degradable foils and dust bags, and several products for transport packaging, so called loose-fill.

Implications of novel technologies being developed and their impact

Research dealing with starch is carried out by the *Zuckerforschung Tulln Ges.m.b.H.* (a subsidiary of the *AGRANA Beteiligungs-Aktiengesellschaft*) considering plant production, chemistry, technology, microbiology and biotechnology. In the last years research in starch technology resulted in the development of a new product for the textile industry which can be regained by ultrafiltration. A project on a starch product for the paper industry resulting in a higher quality of the paper surface is still under progress. Several projects are also carried out for the use of starch in the building trade. Special binding agents for plaster products were developed and the development of special products for the tunnelling in order to minimize the formation of dust and the rebound of stone material was started (AGRANA, 1997).

1.2 Industry

Details of processing systems, processing capabilities and processing capacity

In Austria starch is produced only by one company, the *AGRANA Beteiligungs-Aktiengesellschaft*. The processing of starch from potatoes is done in the plant in *Gmünd*, Lower-Austria, with a capacity of more than 230,000 tonnes per year. Starch from maize is produced in *Aschach*, Upper-Austria. The capacity of this plant, where also the sugaring of starch is done, is about 200,000 tonnes per year (AGRANA, 1997).

1.3 Markets

Current areas, yields and production of industrial crops or potential industrial crops

Potato starch

In 1996 *AGRANA* processed 231,000 tonnes of potatos with an average starch content of 17.9% to reach the Austrian quota of 49,100 tonnes (AGRANA, 1997). In 1997 starch potatoes were cultivated on an acreage of 7,600 hectares with an average yield of 31.7 t ha^{-1}. In total 218,086 tonnes were processed which resulted in 99.7% of the Austrian quota. The starch content of the 1997 harvest was 19.06% (AGRANA, 1998).

Maize starch

Since the production of maize starch is not regulated by the EU there are good perspectives to raise the production. Hence, the capacity of the *AGRANA* plant in Aschach was more than doubled in 1996 by an investestment of 400 million ATS in brand new technology. The additional requirement of 130,000 tonnes per year will result in the additional cultivation of about 13,000 ha maize in the next years (AGRANA, 1997). Already in 1997 the plant worked up 148,564 tonnes of maize and it is estimated that the amount increased to about 170,000 tonnes in 1998 (AGRANA, 1998).

Specific markets and potential markets

The Austrian starch market is because of an important paper- and fermentation-industry bigger than the production. In 1995 about 268,000 tonnes of starch were used by Austrian industry, a great part of that were used by non-food industries.

Non-food or technical starch represents about 40% of the total *AGRANA* turnover. The Austrian demand for technical starch is about 68,000 tonnes per year. The total amount of starch required by the Austrian paper industry as adhesive and binder agents was about 80,000 tonnes in 1996/97, but because of the shortage of Austrian starch in this year only 25,000 tonnes were supplied by *AGRANA* (AGRANA, 1997). In 1997/98 the sale to the paper industry increased substantially. Prices were at EU level (AGRANA, 1998).

The corrugated board industry was supplied with 1,440 tonnes in 1995/96 and 2,960 tonnes in 1996/97. About 4,440 tonnes were exported in 1996/97, so that the total sale to the corrugated board industry was 7,400 tonnes (AGRANA, 1997). In 1997/98 the sale to the Austrian corrugated board industry decreased, however, because of higher exports the total sale to this branch of industry increased by more than 40%. The price, however, was 10% lower than the year before (AGRANA, 1998).

The textile industry was supplied with 4,100 tonnes in 1995/96 and 4,400 tonnes in 1996/97 (AGRANA, 1997). After years of decrease and stagnation the sale to the Austrian textile industry increased in 1997/98. Including the export the sale to the textile industry increased by 14% compared to 1996/97. Because of better and/or specialised products also the prices increased by about 7% (AGRANA, 1998).

Other important industries which use starch in their production cyclus are the building trade and the cosmetical and pharmaceutical industry. The increasing demand from the building trade is not only due to the good economic situation of this industry, but mainly to the substitution of other building material. In the fermentation- and biochemical industry about 150,000 tonnes per year are used for the production of dextrose and in further steps of citrus acid, xanthanes and antibiotics (AGRANA, 1997).

Starch is also used by the packaging industry. Some techniques for the production of digestable packaging are already successfully established Some projects are still under progress and it is generally expected that the market for starch in the packaging industry and for the production of synthetic material will increase within the next years (Mundigler, 1995).

The percentage of the export market of the total *AGRANA* turnover was 32% in 1995 and 39% in 1996. The most important export market is Germany with 15%. Further important export markets are Hungary (4%), Italy (3%), Switzerland (2%) and the Czech Republic (2%) (AGRANA, 1997).

The price level for starch is not stable. Especially the unstable yields of starch potatoes have a strong influence on the price. The crises of the Austrian and German corrugated board industry seems to be over and consequently the market for starch in this branch is stabilized. However, there is an continously decline in the need of starch from the textile industry. The plus of *AGRANA*'s starch sale to the textile industry in the last years is mainly the result of new special products and partly of exports (AGRANA, 1997; 1998).

1.4 Environmental

The environmental impact of an increased production of starch from potato and/or maize is high, since for both crops the amount of used pesticides and fertilizers is high. Pollution of water with nitrate and pesticides is possible and in some regions of

Austria already a serious problem. Also the problem of soil erosion and soil compaction is relevant.

2. BARRIERS TO PROGRESS

2.1 Scientific

The packaging industry still has some enormous problems with the too low water durability of starch-based biodegradable products. Hence, these products can only be used in cases where the biodegradability stands in the first line. Mechanical characteristics are comparable to polyethylene or polypropylene, however, they depend on temperature and humidity. Great changes in mechanical characteristics can appear when the relative humidity is above 80%. A great disadvantage of starch-based packagings is the high permeability for steam. Therefore, the packaging of food provides only a short time of protection from desiccation. An advantage of starch-based bio-synthetis is the fact that they are not electrostatic (Mundigler, 1995).

2.2 Environmental

The *Zuckerforschung Tulln* tried to carry out field trials and technical experiments with potatoes free of amylose developed by genetic manipulation. However, due to Austrian peoples‘ concern in regard to GMO’s this project will not be discussed anymore for the next years. Therefore, Austria's environmental groups prevented both an possible increase in the acreage of starch potatoes as well as an more ecological and economical starch-gaining process.

2.3 Economic issues

The AGENDA 2000 proposal designates lower prices of about 20% for starch potatoes. Although the equilization payment should increase it can be supposed that a lower price for the raw material will result in an negative impulse in regard to the production of starch potatoes. Most of Austrian starch potatoes are grown in the *Waldviertel* county, a region which is characterized by small-scaled farmers and a high percentage of rural exodus. The production of potatoes is one of the main pillars of agriculture in this region. It must be supposed that if this production will get under pressure more farms will be abandoned and more farmers from this region will be pushed on the labour market of the greater cities, especially Vienna.

Competitiveness of starch-based products for packaging with petroleum derived products is only possible if starch products have better quality characteristics. At the moment the products are too expensive compared with conventional products. Depending on the product there must be a price reduction of 30 to 75%. It can be supposed that a price reduction between 10 and 30% could be reached if the production could be at least doubled or even tenfolded (Mundigler, 1995).

3. PRIORITISATION

Most of scientific research on starch is done and therefore financed by the *AGRANA* group itself. However, research on starch-based packagings is carried out by only a few private industries and official institutions. It is necessary that projects get a strong financial support, since Austrian consumers‘ would prefer to buy products with biodegradable packaging so far as the price of the product will not be much higher. If in the future synthetic material would be substituted by starch-based packagings produced from national cultivated potatoes and/or maize this would result in a plus of

700 to 1,100 hectares (Mundigler, 1995). It is a must that projects on starch-based packagings are carried out in co-operation between scientific institutions and the packaging industry in order to guarantee an optimal transfer of know-how and a realistic estimation of technical and economical possibilities.

SUGAR

1. OPPORTUNITIES

1.1 Science and technology

Crops species and production methodologies

In the national list (*Österreichische Sortenliste*) there are 30 sugar beet cultivars described for their cultivation in Austria (Bundesamt und Forschungszentrum für Landwirtschaft, 1998). The production of sugar beets is to the greatest part highly mechanised and done in contracts between the industry, the *AGRANA Beteiligungs-Aktiengesellschaft*, and the farmers. In 1996 sugar beets were cultivated by 11,800 farmers on an acreage of 51,800 hectares (AGRANA, 1997).

Crop products

The main sugar products of plant origin processed in Austria are saccharose and glucose. Saccharose is processed from sugar beets. Glucose is processed either from saccharose or from maize and/or starch.

Non-food saccharose is used for multiple functions in the polymer chemistry, for the production of tensides, detergents, cosmetics, pharmaceuticals, additives for the flushing in the drilling for oil, membranes and fluid crystalls. Saccharose is also used for the production of citric acid which is used as preservative or flavouring in the food and pharmaceutical industry. Sugar is used in relatively huge amounts by the biotechnology industry as food for micro-organisms.

Packagings are processed through fermentation of sugar to lactic acid and following polymerisation to polylactids (PLA's) or through polymerisation to polyhydroxyalkanoats (PHA's) using bacteria.

Implications of novel technologies

The *Zuckerforschung Tulln* developed a new method for stabilizing the sugar extraction and applied for an international patent. This new technology should make the sugar-gaining process more efficient (AGRANA, 1997).

The *Technische Universität Graz* and the *Verpackungszentrum Graz* have a project on the fermentative production of PHA's in bacteria (Mundigler, 1995), which should result in a more efficient and economic processing of bio-synthetics for the production of bio-degradable packagings.

1.2 Industry

Details of processing systems, processing capabilities and processing capacity

Sugar processing from sugar beets is carried in the three *AGRANA* plants in *Tulln*, *Leopoldsdorf* and *Hohenau*, respectively. Glucose processed from starch is carried out in the *AGRANA* plant in *Aschach*.

1.3 Markets

Current areas, yields and production of industrial crops or potential industrial crops

In 1997/98 the three sugar plants of the *AGRANA* in Tulln, Leopoldsdorf and Hohenau processed 3.030,000 tonnes of sugar beets (1996/97: 3.080,000 t) which resulted in the production of 484,000 tonnes of sugar (1996/97: 492,000 t; 1995/96: 442,000 t). Average sugar content of the 1997 harvest was 17.63% (1996: 17.47%; 1995: 16.8%) (AGRANA, 1997; 1998).

Specific markets and potential markets

Only a small part of the produced sugar goes to the non-food industries. Austrian quota of sugar production within the European Union is 390,410 tonnes per year (2.7% of the total EU sugar production quota).

The sale to the non-food industry was more than doubled in 1996/97 (5,600 t) compared to 1995/96 (2,400 t) (AGRANA, 1997). The plus of 8,700 tonnes of the total inland sale in 1997/98 is nearly completely due to the increase in the non-food sector (pharmaceutical and chemistry industries) (AGRANA, 1998). This means that the non-food sector used more than 14,000 tonnes of sugar in 1997/98.

The major part of non-food sugar is used by the fermentation and biochemical industry. The biochemical company *Biochemie Kundl* uses about 48,000 tonnes of glucose molasses, 750 tonnes of saccharose and 2,000 tonnes of lactose permeate per year (Bundesministerium für Land- und Forstwirtschaft, 1998).

The production costs of so-called bio-synthetics (PLA's and PHA's) are at the moment rather high so that packaging products made from them are very rare. However, bio-synthetics have good processing quality and therefore it can be supposed that there is a potential market for them in the future (Mundigler, 1995).

1.4 Environmental

The production of sugar beets often results in soil compaction if weather conditions at harvest are very wet. However, new machines with special tires which are becoming more and more familiar improved this situation in the last years.

Since the production of sugar beet and its process is organized by contracts directly between the growers and the industry there exists an extremely good transfer of know-how between industry's research and the farmers. Tests of soil fertility and nutrients are regularly carried out by the soil analyses lab and fertilization recommendations are given to the farmers according to the analyses results. Therefore, fertilization of sugar beets is extremely efficient and the loss of nutrients, especially of nitrate into the ground water, can be neglected. However, a certain flow of nitrate washed out from mineralizing sugar beet leaves into the ground water can happen if harvest is too late so that no following crop is sown before winter which can use this nitrogen source of the plant residues.

2. BARRIERS TO PROGRESS

2.1. Scientific

Since sugar is mainly used by the food industry there exists no well developed research for non-food uses. Only in the last years research was intensified in regard to fermentation and packagings, respectively. However, the production of the so-called bio-synthetics like PLA's or PHA's is too expensive at the moment so that these new biodegradable materials are not already widely commercialised.

2.2 Legislative issues

There are no political barriers for the use of sugar and/or starch in the non-food industry, because the user of sugar and/or starch gets a production return in order to compensate the price difference between the European and the world market. The farmers, however, get the same price for their crop as if it would be used in the food industry. This cheapening through the EU is valid for both products made from starch and from sugar so that they do not compete. Nevertheless, as raw material for the fermentation industry sugar competes with starch.

2.3 Economic issues

Over-production of sugar is much more higher than the demand from the non-food industry. Therefore, an extension in the sugar beet acreage in Austria is not realistic.

3. PRIORITISATION

Austrian companies need political (financial) impulses for the production of bio-synthetics. Financial support must be application orientated so that the products can be optimized in their characteristics for their special use. Information campaigns must inform the consumers about the new biodegradable packagings and must raise their acceptance. The invention of a CO_2-tax can result in an equal price level of bio-synthetics and conventional synthetics. Legislation must be changed so that the bio-synthetics are regarded as raw materials for compost and therefore can be collected within the national recycling system. Last but not least the demand for compost by farmers, gardeners, etc. must be raised.

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CROPS WITH SPECIALIST USES

HERBS AND MEDICINAL PLANTS

1. Opportunities

The Austrian market in regard to plant species used for pharmaceuticals and related uses is not transparent enough to make a detailed description, since extremely concealment exists in the pharmaceutical industry and producers of medicinal plants. Most of the great pharmaceutical firms are only branches of international companies and are not willing to provide any information. Only in the production of homeopathic medicaments Austrian companies cover a relative high share of the market. However, information is generally only provided on products and not on plant drugs, production, market etc. Information is something clearer regarding herb-teas and projects carried out by public authorities like universities, federal research centers and/or farmers‘ co-operatives.

1.1. Science and technology

Crop species and their production methodologies & Crop products

Crop species for the production of herb-teas are either cultivated on small acreages or collected from the wild. For the composition of herb-tea mixtures leaves (*folium*), herb (*herba*), flowers (*flos*), roots (*radix*), fruits (*fructus*) and/or seeds (*semen*) of the diverse species listed in table 1 are used (Pelzmann & Schmied, 1998).

Table 1: Crop species and their products used for herb-tea mixtures and their relative amount in the mixtures according to the *Codex Alimentarius Austriae* (ÖLB).

Latin name	ÖLB	common name
leaves / herb:		
Fragaria hortensis, F. vesca	-99%	strawberry
Melissa officinalis	-20%[2]	common balm
Mentha x piperita	-30%	peppermint
Mentha rotundifolia	-99%	apple mint
Mentha spicata var. *crispa*	-99%	spearmint
Ribes nigrum	-20%[2]	black currant
Rosmarinus officinalis	-20%[2]	rosemary
Rubus fructicosus	-99%	blackberry
Rubus idaeus	-99%	raspberry
Salvia officinalis	-20%[2]	sage
Thymus vulgaris	-20%[2]	thyme
flowers:		
Bellis perennis	-5%[1]	daisy
Calendula officinalis	-5%[1]	marigold
Centaurea cyanus	-5%[1]	cornflower
Chamomilla recutita	-30%	chamomile
Carthamus tinctorius	-5%[1]	safflower
Delphinum consolida	-5%[1]	larkspur
Helianthus annuus	-5%[1]	sunflower
Juglans regia	-5%[1]	walnut
Lavandula	-20%[2]	lavender
angustifolia	-5%[1]	common mallow
Malva silvestris ssp. *mauritiana*	-5%[1]	bee balm
Monarda didyma	-5%[1]	peony
Paeonia officinalis	-5%[1]	rose
Rosa sp.	-20%[2]	elder
Sambucus nigra	-20%[2]	linden
Tilia cordata, T. platyphyllos	-5%[1]	white clover
Trifolium repens	-5%[1]	violet
Viola odorata	-5%[1]	pansy
Viola tricolor		
fruits / seeds:		
Carum carvi	-20%[2]	caraway
Foeniculum vulgare var. *dulce*	-99%	fennel
Hippophae rhamnoides	-99%	sallow thorn
Rosa sp.	-99%	rose-hip
roots:		
Cichorium intybus	-20%[2]	chicory

[1] total sum of flower drugs may not exceed 5%

[2] total sum of flavour drugs may not exceed 20%

Most plant species mentioned in table 1 are cultivated only on an acreage of < 10 ha. Fennel and safflower (< 100 ha), and caraway (< 1000 ha) are cultivated on higher acreages, which is due to their use in the food industry. Fennel and caraway are used as spices, safflower seeds are used to press a delicious salad oil. Not specially cultivated and/or mainly wild-harvested are: strawberry, walnut, blackberry, raspberry, daisy, sunflower, white clover, linden flowers, sallow thorn and rose-hip. Herbs exclusively used for pharmaceutical teas are yarrow (*Achillea millefolium*), marsh-mallow (*Althaea officinalis*), wormwood (*Artemisia absinthium*), ribwort plantain (*Plantago lanceolata*) and nettle (*Urtica dioica*) (Franz et al., 1998; Pelzmann & Schmied, 1998).

Table 2: Estimated acreage (ha) of diverse species from 1995 – 1998 (free cells mean that no data were available) (Agrarmarkt Austria, 1997; Franz et al., 1998; Keider, pers. comm.)

species	1995	1996	1997	1998
oil pumpkin	10 000		13895	
caraway	900		687	
milk thistle	270		386[1]	652,46[1]
fennel	54			
safflower	12		13,3[1]	
chamomile	13,94[1]	7.82[1]	9,04[1]	3,43[1]
common balm	7			
peppermint	7			
common mallow	3			
bee balm	3			
yellow gentian	2			
St. John's wort	2			58,43[1]
yarrow	2			
nettle	1			
cornflower	1			
thyme	< 1			
marigold	< 1			
pansy	< 1			

[1] **on set-aside land only; total acreage must supposed to be higher**

Medicinal plants are cultivated all over Austria, however, there are five main regions, in which most of Austrian production is performed. In the *Mühlviertel* county, province of Upper-Austria, ribwort plantain, marjoram, common balm, and peppermint are the most important crops, about 65% of the total herb acreage in this region is organic grown. In the *Innviertel* county (Upper-Austria) mainly caraway, linseed, fennel, aniseed and safflower are cultivated. In the *Waldviertel* county (Lower-Austria) the cultivation of caraway, milk thistle, chamomile and the production of pollen from rye, timothy grass and maize are prevailing. Linseed and safflower are cultivated in the *Weinviertel* county (Lower-Austria). In south-eastern Styria cornflower, bee balm and wild plant seeds are cultivated (Franz et al., 1998; Franz & Mathé, 1998). In general, species which are suitable for their cultivation in the more dry and arid eastern part of Austria are fennel, lavender, thyme, marjoram and milk thistle, whereas ribwort plantain, arnica and valerian are grown in the more humid areas. Caraway, the diverse species of mints, arnica, valerian, angelica and yellow gentian can even be grown in subalpine regions. Only modest soil fertility is required for the cultivation of chamomile, caraway, mallow, yarrow and pansy. Humus rich soils are necessary for common balm, the mint species, valerian, caraway, marjoram and yellow gentian. Cornflower and ribwort plaintain should be cultivated only on soils deficient in lime, whereas fennel, lavender, marigold, sage, marjoram and thyme tolerate also higher percentages of lime. In regard to temperature caraway has a very high frost tolerance, chamomile, cornflower, lavender, common mallow, valerian, angelica, yellow gentian, marigold, larkspur and pansy have a high frost tolerance. Fennel, cone-flower and safflower are only of moderate frost tolerance, whereas common balm and marjoram are susceptible to frost damage (Dachler & Pelzmann, 1989).

Crop rotation with other agricultural crops is necessary in regard to soil fertility and phytopathological aspects. If there is no possibility for a rotation with conventional crops then at least a rotation of root-, herb-, leaves-, seeds-, and flower-drugs is carried out. Crops of the same botanical family are not be cultivated one after the other. Mixed cultivation of diverse drugs is recommended. Soil tillage is carried out in the way that weeds are reduced and water supply of the soil is remained. Weed control is usually done by mechanical measures. No fungicides or insecticides are used to control diseases and pests. Chemical fertilizer is applied carefully in only moderate amount. In organic farming no chemical fertilizers are allowed to be used. Organic fertilization is done mostly with compost (Dachler & Pelzmann, 1989; Franz & Mathé, 1998).

The influence of the cultivar is very important for the success of cultivating herbs. High yield and high quality are the most important features for a cultivar. Also disease resistance is important for some crops, e.g. rust resistance of peppermint (cv. *Multimentha*), or downy-mildew resistance of bee-balm (cv. *Squaw*).

Harvest is usually carried out at midday at dry and sunny weather. Flowers are manually harvested when fully developed. Leaves and herb are harvested at the beginning of flowering. Seeds are harvested by combine harvesters. Additionally some regional organisations and/or co-operatives also provide special machines for cultivation and harvest (Dachler & Pelzmann, 1989).

In the following part the most important pharmaceutical crops in Austria are briefly described.

Common chamomile (*Chamomilla recutita*)

The cultivation of chamomile has a long tradition in Austria and it is therefore one of the most important pharmaceutical crop. The flowers of chamomile are used in traditional folk medicine, in homeopathy and in common medicine. Chamomile products are used against multifold inflammations, e.g. of the skin, mucous membrane, gums, respiratory tracts, anal and genital region. Tea made from chamomile is also used against menstruation complaints (Holzner, 1985).

The most important contents of chamomile flowers are essential oils, diverse bisaboloids: bisabolole, bisabololoxide A, bisabololoxide B and bisabololonoxide-types. Some other contents of medical importance are flavanoids, especially apigenine, and spiroether (Novak, pers. comm; http://www.hpfldb.de/).

Much research on chamomile is done by the group of Prof. C. Franz, *Institut für Angewandte Botanik* of the *Veterinärmedizinische Universität Wien*. One of the greatest success of this research group was the breeding of a tetraploid variety which contains higher amounts of the valuable essential oils and especially pure bisabolole which is the most active compound of all bisaboloids (Novak, pers. comm.).

Data of the acreage of chamomile production are officially only available for set-aside land (see table 2) (Agrarmarkt Austria, 1997). It can not be estimated if the decrease of the acreage on set-aside land reflects the trend in the total production. Problems with the harvest technology could have been a reason for a little decrease. Austria's most important producer of chamomile *Waldland* was not willing to provide any data on their production. However, it can be supposed that only the acreage of chamomile for seed production, especially for the Spanish chamomile cultivation, is between 2 and 3 hectares. While the organically grown chamomile of the *Bergkräuter* co-operative is used for herb-teas, the production of *Waldland* is used for pharmaceuticals. It is supposed that mainly German companies process this part of Austrian chamomile.

Milk thistle (*Silybum marianum*)

Milk thistle is a spring-sown crop of great importance in the production of pharmaceutical crops in Austria. On set-aside land there were 386 ha and 653 ha cultivated in 1997 and 1998, respectively. It can be assumed that the total acreage is a few hectares larger. According to M. Auer (pers. comm.), breeder of milk thistle, there are about 700 ha of milk thistle cultivated at the moment in Austria. Milk thistle is harvested by a conventional combine harvester. After harvest the seeds are dried at 8% water content.

The seeds (*Fructus Silybi mariae*) are used for the production of medicaments against liver diseases. The active agents are the silymarins which belong to the flavanoids. Extraction of these flavolignans is done with methanol. Determination of silymarin content is carried out with HPLC (Auer, pers. comm; http://www.hpfldb.de/).

The cultivation of milk thistle has no negative environmental impact, but, because of it's high high nutrient uptake and large amount of plant residues remaining on the field, there is a positive impact on the following crop. Yield level of milk thistle varies between 800 – 1200 kg ha^{-1}.

Yellow gentian (*Gentiana lutea*)

Yellow Gentian is an economical interesting medicinal plant for alpine farmers. The cultivation in alpine regions presents an alternative income for alpine farmers, especially since the cultivation is done without agrochemicals, which results in higher prices for the product. About one ton of yellow gentian roots is collected from the wild. Since yellow gentian is protected in natural habitats there are attempts to establish the cultivation of yellow gentian as field crop in alpine regions. Experience on the cultivation without agrochemicals was gained in a four years‘ project carried out by the *Bundesanstalt für alpenländische Landwirtschaft* (BAL) in *Gumpenstein*.

The main problem is the germination of seeds which must be stratified at 2°C in order to obtain a satisfying germination rate. Young plantlets are cultivated in little pots in the greenhouse. Afterwards the plants are transferred to the field. Weed control is done only mechanically by hand and/or using a little rotary hoe. Since weed control in yellow gentian is expensive, fields with a low weed pressure should be used.

The harvested products of yellow gentian are the seeds and the roots (*Radix Gentianae*). Harvest of the seeds can be started in the 3^{rd} year. In the project of the *BAL Gumpenstein* the yields of seeds were as follows: 3^{rd} year: 175 kg ha^{-1}; 4^{th} year: 262 kg ha^{-1}; 5^{th} year: 496 kg ha^{-1}, however a loss of about 30% through cleaning must be considered. Harvest of the roots is usually done after 4 or 5 years. Yield is around 30 t fresh roots ha^{-1}. In the meantime 10 – 15 ha of yellow gentian are commercially cultivated in Austria, mainly in the provinces of Vorarlberg and Tyrol.

Yellow gentian contains the most bitter plant glycosids so far known, xanthons, some alkaloids and diverse sugars. Products containing yellow gentian are tonic medicines which activate the function of the liver, gall-bladder and the heart, and stimulate the stomach and gut activity. Yellow gentian acts blood-forming and hypertensive. Yellow gentian is also an important component of homeopathic medicaments against colds and influenza (Chytil & Krautzer, 1989).

Besides yellow gentian there are also attempts to reactivate the historically important collection and commercialisation of *Valeriana celtica* (spike valerian) (Franz et al., 1998). Another alternative pharmaceutical crop for alpine regions could be *Arnica montana* (arnica) which is traditionally wild collected. Arnica contains flavanoids, carotinoids and essential oils (sesquiterpens) which act antibiotic, hypotensive, inflammation inhibitory and nervine. Arnica is used for the production of diverse salves and tinctures and/or homoeopathic medicaments. Over-harvesting in the last years resulted in significant lower incidence in the wild. Therefore the cultivation of arnica is of high interest.

Cultivation methods of *Arnica montana* were developed by the *BAL Gumpenstein*, however, since the price for arnica flowers is relatively low only some 100 m^2 are cultivated at the moment. The market potential can not be exactly prognosticated but it can be supposed that there will be no increase within the next few years because Austrian drug companies are not very interested in the production of higher-price inland arnica. The only potential market is the European Union, especially Germany, if high pharmaceutical quality can be produced. Low-price arnica mainly derives from intensive wild-collections in the successor states of former Yugoslavia. This product is much cheaper than Austrian derived arnica. Cheap arnica with low quality is also on the market from a Latin American arnica species (Hein & Krautzer, 1993; Franz et al., 1998).

Elder (*Sambucus nigra*)

While elder flowers are used for herb-teas and herb-tea mixtures the berries are used for the production of medicaments because of there high content of flavanoids (anthocyans). Elder berries are for example used together with yellow gentian for the production of homeopathic lung, bronchi and sinus medicaments. Anthocyans of elder berries have anti-carcinogenic and anti-oxydative effects and are becoming of increasing importance in pharmaceutical industries. Besides anthocyan and other bioflavanoids the elder berries contain also high amounts of amino acids, minerals, vitamines, enzymes, trace elements etc.

About 1200 ha of elder are cultivated at the moment, however, more than 95% of the berries are used in the food-industry. At the moment about 2500 t a^{-1} are produced for west European pharmaceutical industries by *the Streirische*

Beerenobstgenossenschaft regGenmbH in *Lieboch*, which process about 99% of the Austrian produced elder berries. Most of the elder orchards are in the province of Styria, followed by Lower-Austria and Burgenland. Some few hectares are cultivated in Carinthia. At the moment all the orchards are planted with the variety *Haschberg*, an Austrian selection which so far exhibits the highest content of anthocyans (Kaufmann, pers. comm.).

A part of the berries is exported to South Tyrol (Italy) where they are processed by the *IPRONA AG* in *Lana/Etsch* for the Austrian company *The Wellness Co. Heilmittelvertriebsges.m.b.H.*

Gramineae for pollen production

Some graminaceous species are cultivated for the production of pollen which is used in the pharmaceutical industry. The cultivation is done by farmers in the *Waldviertel* county for the company *Graminex*. The acreage of rye (*Secale cereale*) varies between 200 and 300 ha (1992: 204 ha; 1993: 193 ha; 1994: 302 ha; 1995: 270 ha; 1996: 192 ha; 1997: 336 ha; 1998: 299 ha). Timothy grass (*Phleum pratense*) was grown on 26 ha (1996), 21 ha (1997), and 19 ha (1998), respectively. For the 1999 harvest there are already 47 ha of timothy grass under contract. Maize (*Zea mays*) pollen is harvested from about 40 ha (Eigner, pers. comm.). Since timothy grass for pollen production is an industrial crop, more than 80% of the total acreage are grown on set-aside land. Pollen of timothy grass is exported to Sweden where a prostata medicament is produced (Agrarmarkt Austria, 1997).

Oilpumpkin (*Cucurbita pepo*)

The Styrian oil pumpkin (*Cucurbito pepo* L convar. *citrullina* var. *styriaca*), a 'seed-coat-free' (malakosperm) pumpkin variety, is an important traditional and now specialised industrial crop, supported by the Austrian Government as an alternative crop. Pumpkin seed oil is a traditional salad oil in the southern parts of Austria. It is dark green and has a high content of free fatty acids. The Styrian oil pumpkin has also a long tradition in medical use and the production of pharmaceutical products. *Semen Cucurbitae* contains a very high content of vitamine E, especially γ-tocopherol, citrullin, carotinoids and glutathione. Products made from oil pumpkin seeds are in use against prostate adenoma and other infections and problems of the urinary tract. Moreover, oil pumpkin seeds have a relatively high content of selenium, which has anti-carcinogenic activity. The toxic cucurbitacins (triterpene-alkaloids) do not exist in the Styrian oil pumpkin (Reiterer & Reiterer, 1994).

Although the cultivation of oil pumpkin was boostened in former times because of it's pharmaceutical importance, today it's impact on the pharmaceutical industry is only of minor importance. Export of oil pumpkin seeds as raw material for pharmaceutical use and the production of snacks increased steadily between 1987 (372 tonnes) and 1992 (about 680 tonnes) (Franz et al., 1998). Styrian pumpkin seeds are mainly used by Austrian and German pharmaceutical companies for the production of medicaments. Since *Cucurbita pepo* has the ability to take up and store chemical residues in the seed it must be grown without the use of herbicides, fungicides, etc. in order to make it acceptable to the pharmaceutical industry.Breeding of oil pumpkin is done by the *Saatzucht Gleisdorf*. Breeding aims are high seed yield, well-formed seeds with dark colour and high oil content, uniform and earlier maturity, better mildew and leaf spot resistance. So far four cultivars are registered in the national list (Bundesamt und Forschungszentrum für Landwirtschaft, 1998).

Harvest of the oilpumpkins is done either by hand or by special harvesters which crash the pumpkins und wash the kernels. After harvest the kernels are dried.

St. John’s wort (*Hypericum perforatum*)

St. John’s wort is one of the most fashionable pharmaceutical plant at the moment although it is a 'miracle herb' with long tradition in folk medicine. However, the increasing demand for phytogenic pharmaceuticals, its excellent results in the treatment of mild depression, anxiety and nervous unrest and no serious side effects resulted in an unbelievable increase of the acreage of St. John's wort. While in 1995 only about 2 ha were cultivated the acreage increased to about 60 ha in 1998 (see table 2) (Agrarmarkt Austria, 1997). The red pigment hypericin found in the herb has been shown to interfere with an enzyme in the brain, that would normally make a person feel down or depressed. Hence, St. John's wort is an excellent anti-depressant drug. Several products are made from the herb. The herb can also be used as tea against nervous restlessness and somnipathy. In folk medicine herb of St. John's wort is also used against womens' griefs, headache, anemia, etc. Oil of St. John's word is used against dandruff and eczema (http:www.med-online.de/natap/hy-perfo.htm). Valuable compounds besides hypericin are essential oils, flavonoids, tannins and resin. In some studies hypericin and pseudohypericin have also shown antiretroviral activity (Meruelo et al., 1988; http://hepatitis-c.de/johannis.htm).

St. John's wort is produced in the Waldviertel county by *Waldland* which was not willing to provide any information on production and utilization.

Wild plant species

Some wild plant species are used in small amounts for the production of teas and homeophatic medicaments. These species are either wild-collected or grown on small acreage or in greenhouses. Examples of used wild plant species are *Achillea millefolium, Alchemilla vulgaris, Atropa belladonna, Capsella bursa-pastoris* (shepherd's purse), *Crataegus monogyna* (hawthorn), *Cyclamen purpurascens, Echinacea angustifolia, E. pallida, E.*

purpurea, *Geranium robertianum*, *Lamium album*, *Pulsatilla vulgaris*, *Potentilla anserina* (silverweed), *Verbena officinalis* (vervain), and *Viscum album*. Austria's greatest producer of homeopathic medicaments *Dr. Peithner KG* buys fresh and/or dried wild plant species from Austrian production mainly from the *Landwirtschaftliches Versuchszentrum Steiermark, Außenstelle Wies* and from *Waldland*. However, the total amounts are rather low, e.g. 100 kg of fresh *Echinacea angustifolia* flowers are sufficient for the production of homeopathic medicaments sold in a period of two years (Stanislaw, pers. comm.).

BIOCIDES

Red squill (*Urginea maritima*)

Red squill has been used for the control of rodents for several hundred years but was more or less forgotten in the past 40 years. However, there is now a recognised need for environmentally harmless rodenticides especially because of the increasing mice-populations on set-aside land. The major toxic compound of the bulb, scillirosid, is relatively fast acting, causing convulsions and death to rats and mice. The active glycosid is emetic to humans, cats and dogs, affording a safety factor uncommon to high-toxicity rodenticides.

Red squill is a large, onion-like plant that grows wild in the coastal lands around the Mediterranean Sea. Today the demand for red squill in the chemical and pharmaceutical industry (sinistrin and fructans of red squill are used in medical kidney test-kits) is high and a cultivation is necessary instead of just gathering the wild species.

The project *FAIR3-CT96-1436*, "Improvement of efficiency and reduction of application rates of preferable naturally grown biocides by complexation with gamma-cyclodextrin“ deals with methods of extracting and stabilising plant and other extracts which can have a role in plant protection, medicine or as food ingredients. In particular this project will investigate the use of cyclodextrins as carriers for pesticides. According to coordinator of this FAIR project, Dr. Teuber-Weckersdorf (pers. comm.) of the company *F. Joh. Kwizda GesmbH*, there exists no actual production of red squill or white ox-eye (for the production of pyrethrum) in Austria, since climatic conditions are not favourable. The raw material is imported from North Africa, mainly Algeria, and Southern Italy.

1.2. Industry

Details of processing systems, processing capabilities and processing capacity

Immediately after harvest herbs and medicinal plants are dried. It is important in that process not to injure the drugs. Drying installations are usually used jointly by the farmers. The used temperature depends on the plant species and their used contents. Usually drying is done at about 40°C, for some species, however, temperature can be raised up to 60°C without significant losses in essential oils etc. The final water content varies between 8 and 12%. Herb-teas are produced by the farmers themselves, farmers‘ co-operatives, marketing associations or herb-tea factories, respectively. Generally, regional organisations (co-operatives, marketing associations) have sales assured by contracts with traders and/or the industry. Herb-tea factories are in general willing to buy local products.

Plants for the production of pharmaceuticals are mainly produced for export, since almost no phytopharmaceutical industry exists in Austria. Milk thistle seeds and elder berries are exported to Italy, timothy grass pollen is exported to Sweden, chamomile flowers are exported to Germany. The place where the herb of St. John’s wort and oilpumpking seeds are processed could not have been identified. It is supposed that St. John’s wort is produced for a German pharmaceutical company.

Pharmaceuticals made from oilpumpkin seeds are on the market from Austrian, German and French companies. Most yellow gentian is distilled or used in combination with other herbs to produce bitters. Some yellow gentian is used in the homeopathic medicament production.

1.3. Markets

Specific and potential markets

The cultivation of herbs requires a long-term strategy. Though there has been a remarkable increase of some minor crops with specialist use, especially from organic production, the future development is dependant on various facts. In regard to the marketing it is of immense importance to stimulate the consumers‘ desire for "bio“-products, derived from organic farming. In that way also higher prices for these products can be achieved. Since the acreage of Austrian farmers which are engaged in the cultivation of minor crops for specialist use is small it is necessary that the farmer knows quite well the possibility for the need and marketing possibilities of the crops.

Herb-teas are an important alternative income for farmers with a small acreage and for organic farmers. Herbs for tea mixtures are usually grown on small scale. Herb-teas are directly commercialised by the farmers or farmers‘ co-operatives at so-called Bauernmärkte (farmers‘ street markets), co-operative markets and health food shops, respectively.

More difficult is the production of medicinal plants for the pharmaceutical industry since the price for plant drug is regulated by the world market. Because of higher costs for labour, Austrian-produced medicinal plants are

more expensive for the industry than products from Eastern European countries, Asia or Latin America, respectively. Although for some products the quality of Austrian plant drugs is higher, most pharmaceutical plants buy cheaper products. Support from the government for the production of medicinal plants e.g. on set-aside land could possibly stabilize the acreage.

1.4. Environmental

At the time of July 1998 out of 225,847 agricultural farms, the number of so called Bio-farms is 19,996 (8.85%) which cultivate an area of 345,375 ha (10.09%). The extent of medicinal and aromatic plant production is, however, not known in detail. The most important co-operative of bio-farmers which cultivate medicinal plants only organically is the *Bergkräuter-Genossenschaft* in the *Mühlviertel* region of Upper-Austria. Other organizations, e.g. *Saatbau Linz*, *Waldland* or *Schilcherland* comprise official organic as well as conventional producers. However, according to Austrian legislation the application of pesticides is prohibited in the growing of medicinal and aromatic crops. Therefore, production can be considered as *quasi* organic (Franz & Mathé, 1998).

Because of the non-use of pesticides, the only moderate use of fertilizers and intensive crop rotation in the cultivation of medicinal plants there are no predictable negative impacts on the environment.

2. BARRIERS TO PROGRESS

2.1. Scientific

Research in the field of medicinal plants often results in a intensification of difficulties for the producers. On the one hand methods of controlling become more refined and improved, on the other hand no breeding for higher quality is

done for most medicinal plants. Often breeding work and/or field trials to evaluate cultivation methods are only carried out in the scope of financed projects. If the financial support is denied or stopped no research can be carried out. Hence, official institutions are rather no source of valuable information for the farmers.

2.2. Technical issues

In a few cases the cultivation of medicinal plants is too labour-intensive and there seems to be no possibility for mechanization. Plants with extremely small seeds can not directly be sown on the field by machines. Sowing must be done by hand in greenhouses and young plants are then transferred to the field.

For some medicinal plants harvest is an even greater problem since no harvest machines are available. Harvest of a few medicinal plants is still be done by hand. Sometimes special harvest machines exist, however, these machines do not provide the same high quality as hand harvested material and/or they are too expensive for the small-scaled Austrian farmers.

According to the manager of a co-operative the absence of registrated pesticides, especially herbicides are one of the main reasons that herbs and/or medicinal plants are only grown on small acreage, since much time and labour has to be spent for manual weed control.

2.3. Legislative issues

Herbs used for herb-tea mixtures have to fulfill Austrian foodstuff legislation (ÖLB, *Codex Alimentarius Austriacus*). Tea packages have to be labeled according to the foodstuff labeling regulation LMKV 1993, BGBL 205/93. Only if

these regulations are fulfilled farmers are allowed to sale their products directly from the farm or on street markets. Hence, most herb-tea mixtures are sold by farmers' co-operatives, marketing associations etc. in order to minimize the costs for quality controls according to ÖLB and labelling.

Herbs for exclusively pharmaceutical use, e.g. marsh mallow, ribwort plantain, nettle, milk thistle, wormwood etc. may only be sold in pharmacies and drugstores. These products have also to fulfill the regulations of the Austrian pharmacopoea (ÖAB, Österr. Arzneibuch) and the Pharmacopoea Europaea. Quality controls according to these regulations have do be carried out for each charge. Controls for the small charges delivered by Austrian producers, however, are very costly, time consuming and labour-intensive, resulting in a high price for the product.

According to the manager of a co-operative one of the main political barriers are the absence of awards from the state although herbs and medicinal plants are market exonerating. Moreover, there are no political attempts to render it more difficult for the industry to import cheap raw material from low wage countries.

2.4. Economic issues

For Austrian farmers which grow medicinal plants and herbs it is very hard to compete with the world market, and especially with the products from South Eastern European low-wage countries. The low prices of the international market have a strong negative influence on the inland market. Decreasing prices are mainly the result of the high export ware from countries of the former Eastern bloc. Although from time to time the prices recover liberalization of the international market (GATT-Uruguay-agreement) causes a very unstable situation for the local market and the Austrian producers.

The non-existence of herbicides for weed control in herbs and medicinal plants and the frequent absence of mechanization of sowing and/or harvesting rises the costs for production and consequently of the final product. For example *Mentha piperita* thrives very well in Austria and achieves a satisfying quality, but the production costs compared with the prices on the world market are enormously high (world market price: 30.-ATS, Austrian production cost: 65.-ATS), and therefore profitability is not given (Franz et al., 1998).

3. PRIORITISATION

For some herbs and medicinal plants Austrian soil and weather conditions are not favourable in regard to quality and contents of valuable compounds. The unstable climatic conditions and the cultivation of the crops on often only sites of poor soil fertility result in an non-uniform and often low-quality product. From year to year the crops are grown with varying success and yield, an intolerable situation for the farmers to depend on these crops. Consequently, the average acreage cultivated with herbs and medicinal plants is small. Moreover, the mechanization of the production of herbs and medicinal plants still needs that great breakthrough so that Austrian producers can compete with producers from low wage countries. An efficient production seems to be very much dependent on information and know-how. Therefore, research on all aspects of the cultivation of medicinal plants must be intensified and the transfer of know-how to the farmers must be improved. There is a relevant need for research to clear such basic questions as e.g. the relationship between growing practices vs. crop quality and nutrition, as well as the relationship of crop rotations to fertility and pest management. However, in order to reach this goal also the producers must break their silence and share their know-how among themselves.

Despite of above mentioned problems the number of producers of medicinal plants and herbs is steadily growing, and also the consumption of produced herbs and medicinal plants is of increasing importance underpinned by the consumers movement towards natural products. The high sensibility of Austrian people in regard to biotechnology and genetic manipulated products lead to a revival of natural products, even in mainstream medical and pharmaceutical professions. In general, the rise of the 'green' and environmental movements made patients and consumers much more interested in natural products. The time has come for the introduction of new health care products derived from plants.

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4. ANNEXES

Yield (in t/ha) of field crops grown in Austria between 1970 and 1997

Crop species	1970	1975	1980	1985	1990	1995	1996	1997
Maize	4.92	5.86	6.70	8.31	8.18	8.50	8.62	9.78
Oats	2.68	3.41	3.43	4.17	3.94	3.96	3.67	4.27
Spring barley	3.14	4.12	4.04	4.52	4.90	4.38	4.23	4.47
Spring rye	2.22	3.41	3.10	3.61	4.51	4.09	3.05	3.58
Spring wheat	2.70	3.27	3.78	4.10	4.25	3.88	3.85	4.09
Triticale						3.93	4.35	4.83
Winter barley	3.23	3.95	4.12	4.67	5.81	5.12	4.06	5.61
Winter rye	2.73	4.01	3.48	3.85	4.51	4.09	3.05	3.58
Winter wheat	2.96	4.33	4.52	4.95	5.12	5.13	5.06	5.26
Beets	50.70	51.63	52.00	60.22	44.35	48.99	51.10	50.89
Potato	24.60	23.92	24.04	27.63	24.99	26.79	29.20	28.83
Sugar beet	44.42	46.07	51.00	56.32	50.13	55.88	58.99	58.41
Faba bean	3.28				3.15	2.47	2.00	2.26
Field pea	2.34				3.58	3.25	3.01	3.19
Vegetable pea	2.26		9.29	8.53	8.44	8.25	8.49	8.05
Oil-Pumpkin	44.75	43.51	42.29	46.65	40.46	46.50	0.67	0.59
Oilseed rape	2.00	2.26	2.12	2.73	2.49	3.01	1.86	2.36
Poppy	1.15	0.94	0.99	0.96	1.01	0.93	1.00	0.98
Soybean					1.90	2.28	2.01	2.20
Spring rapeseed, turnip	1.82				2.38	2.34	1.91	1.84
Sunflower	2.00	2.30	2.38	2.08	2.32	2.15	2.30	2.20
Hop				1.63		1.39	1.32	1.54
Sorghum, millets, buckwheat	2.60		1.19	1.07	0.90	1.11	0.90	0.88
Tabacco				1.73		1.79	1.71	2.29
Asparagus	4.00					4.88	4.98	4.50
Broccoli						14.18	15.74	18.74
Brussels sprouts	13.17					12.86	12.61	12.38
Bummerlsalat (*Lactuca sativa*)						29.04	32.20	30.22
Cabbage (other)	23.70					47.60	44.80	41.54
Cabbage (sauerkraut, red cabbage)	41.29	42.49	50.48	48.49	50.13	48.90	48.54	57.08
Carrot	31.46	28.06	31.18	34.39	35.66	31.82	34.76	42.83
Celery						39.75	39.66	43.70
Chinese cabbage	28.78	29.89	38.41	39.10	50.78	58.61	42.58	46.08
Cucumbers (other)	20.61	14.38	22.42	23.48	28.58	29.18	28.95	37.29
Cucumbers (salad use)	25.14	19.72	27.44	36.42	43.66	41.83	32.60	41.09
Endive Salad (*Cichorium endivia*)						27.56	30.19	27.83
Feuerbohne (*Phaseolus cuccineus*)						2.80	2.00	1.50
Fisole (*Phaseolus vulgaris*)	11.99	10.46	14.30	14.59	15.96	15.93	15.73	14.40
Garlic						4.19	6.59	7.27
Horse raddish	9.70					11.99	11.00	12.00
Hot Pepper						18.91	17.50	14.44
Kohlrabi	23.21					20.84	24.72	23.80
Leek						35.75	37.21	39.98
Lettuce	22.77	21.46	27.05	30.48	30.36	28.42	33.02	35.81
Lollo Rossa (*Lact. sat. var. crispa*)						14.81	170.4	195.6
Onions	25.25	22.32	29.66	38.79	36.58	37.94	40.78	46.82
Parsley (root)	18.65					30.81	28.93	37.26
Pepper	19.80	13.39	18.12	18.75	19.72	29.77	26.11	29.67
Raddish (Bierrettich)						39.30	35.67	39.14
Raddish (Radieschen)						20.05	21.08	20.62
Radiccio (*Cichorium intybus*)						14.33	14.75	16.63
Red beet	21.48	22.33	23.63	30.62	30.91	30.13	33.38	49.33

Yield (in t/ha) of field crops grown in Austria between 1970 and 1997, *continued*

Crop species	**1970**	**1975**	**1980**	**1985**	**1990**	**1995**	**1996**	**1997**
Spinach	8.95	9.17	8.83	10.83	11.59	11.55	13.46	22.42
Strawberry					12.13	11.02	8.79	10.37
Sweet maize						14.00	16.39	9.53
Tomato	52.35	54.19	60.48	63.34	72.18	112.01	105.47	104.94
Zucchini						25.69	30.00	30.20
Alfalfa	8.75	7.90	8.80	9.30	8.31	8.55	8.02	8.91
Clover-Grass-Forage	7.92	7.02	8.39	9.00	8.51	8.29	7.97	8.34
Clovers, other	6.37	5.45	6.65	6.96				
Forage Maize	51.51	49.41	50.37	55.73	40.04	43.87	45.90	46.65
Red Clover	8.19	7.33	8.32	9.00	8.35	8.17	8.09	8.24

Source: ÖSTAT (Österreichisches Statistisches Zentralamt), Ergebnisse der landwirtschaftlichen Statistik

Area (in ha) of field crops grown in Austria between 1970 and 1997

Crop species	**1970**	**1975**	**1980**	**1985**	**1990**	**1995**	**1996**	**1997**
Maize	123927	159800	192947	207785	198073	19133	201342	188311
Oats	101567	94747	91989	75247	61956	40778	41609	46083
Spring barley	136498	290877	323441	252875	196076	123788	168366	179607
Spring rye	2518	3666	4009	2711	93041	76826	51222	57807
Spring wheat	16338	18252	21729	23581	23079	9491	10862	12318
Triticale						19279	17571	21896
Winter barley	275229	33630	50471	81204	96348	105311	91282	81034
Winter rye	133980	166010	105225	85420	93041	76826	51222	57807
Winter wheat	258891	271074	247024	296256	255147	246419	236740	247514
Beets	41844	18320	11620	6163	3845	1737	1203	1166
Potato	109924	73312	52569	37719	31760	27036	26335	23476
Sugar beet	43827	56070	50753	42745	49758	51643	53082	51569
Faba bean	705				13131	6886	4574	2783
Field pea	336				40619	19133	30782	50913
Vegetable pea	610		1104	1395	1695	1496	1355	1232
Oil-Pumpkin	2182	3106	5585	4317	5729	8957	12533	13955
Oilseed rape	3786	1951	3941	6324	38971	87300	64192	53772
Poppy	167	218	246	218	706	2567	1131	887
Soybean					9271	13669	13315	15217
Spring rapeseed, turnip	174				1873	1939	712	1125
Sunflower	645	227	291	222	22211	26915	18983	19954
Hop	100	118	131	152		242	241	248
Sorghum, millets, buckwheat	989	1125	905	1251	647	1863	892	704
Tabacco	278	236	258	261		147	141	99
Asparagus	40					154	164	178
Broccoli						61	69	86
Brussels sprouts	38					51	52	47
Bummerlsalat (*Lactuca sativa*)						426	458	496
Cabbage (other)	125					150	137	167
Cabbage (sauerkraut, red cabbage)	1897	1827	681	1057	1079	1108	1093	1103
Carrot	647	702	713	591	648	979	986	1104
Celery						253	283	272
Chinese cabbage	546	1720	3202	853	937	765	715	653
Cucumbers (other)	1196	595	1185	740	515	407	332	321
Cucumbers (salad use)	867	747	550	128	196	155	158	133
Endive Salad (*Cichorium endivia*)						123	114	126
Feuerbohne (*Phaseolus cuccineus*)						91	71	80
Fisole (*Phaseolus vulgaris*)	831	736	883	830	1048	718	709	515
Garlic						27	27	30
Horse raddish	149					221	222	220
Hot Pepper						22	22	20
Kohlrabi	101					161	166	168
Leek						126	139	148
Lettuce	601	706	1187	853	894	876	909	893
Lollo Rossa (*Lact. sat. var. crispa*)						48	52	54
Onions	864	1304	1220	1398	1566	1590	1719	1975
Parsley (root)	96					101	94	133
Pepper	1013	995	672	114	192	152	225	194
Raddish (Bierrettich)						136	136	134
Raddish (Radieschen)						306	347	467
Radiccio (*Cichorium intybus*)						27	30	27
Red beet	216	218	291	153	228	183	203	211

Area (in ha) of field crops grown in Austria between 1970 and 1997, *continued*

Crop species	**1970**	**1975**	**1980**	**1985**	**1990**	**1995**	**1996**	**1997**
Spinach	270	266	248	369	418	562	522	478
Strawberry	473	672	956	1140	1122	1248	1248	1499
Sweet maize						142	163	316
Tomato	448	335	511	319	250	226	180	174
Zucchini						58	68	80
Alfalfa	36526	20875	14851	10992	7539	10455	9173	8966
Clover-Grass-Forage	39944	25160	25954	23435	27828	41932	47458	52163
Clovers, other	7077	2342	1542	1799	54225	66096	69992	73391
Forage Maize	46530	93499	106262	122398	107134	90682	85359	84464
Red Clover	60596	42691	31500	21773	18858	13709	13361	12262

Source: ÖSTAT (Österreichisches Statistisches Zentralamt), Ergebnisse der landwirtschaftlichen Statistik

List of current industrial crops and their areas and yields

1. Area of cultivation and yield of oilseed rape, fibre flax and hemp

		1970	1975	1980	1985	1990	1995	1996	1997	1998
Oilseed rape total:	ha	3786	1951	3941	6324	38971	87300	64192	53772	51916
	kg/ha	20.0	22.6	21.1	27.3	24.9	30.1	18.6	23.6	-
Area on set-aside land:	ha	-	-	-	-	-	13592	7471	3053	-
Fibre flax	ha	-	-	-	-	-	1608	1013	754	-
	kg/ha	-	-	-	-	-	-	-	-	-
Hemp	ha	-	-	-	-	-	160	674	1082	-
	kg/ha	-	-	-	-	-	-	-	-	-

Sources: ÖSTAT (Österreichisches Statistisches Zentralamt), AMA (Agrarmarkt Austria), Grüner Bericht (Bundesministerium für Land- und Forstwirtschaft).

Comments:
Oilseed rape total: No differentiation or estimation is available for the areas of food use, biodiesel use and non-energetic use of oilseed rape.
Oilseed rape on set-aside land: Used for biodiesel production only.

2. Area of cultivation and yield of carbohydrate crops ans specialist uses crops

See the tables and references included in the text.

4.3 List of key contacts in industrial crops interest groups and people contacted

Company/Institute	Street	Post Code	Town	Contact Persons	O[1]	Main Activities
All aspects						
Bundesamt und Forschungszentrum für Landwirtschaft, Institut für Pflanzenbau	Spargelfeldstr. 191	1226	Wien	J. Hinterholzer, M. Oberforster	F	cultivar registration
Bundesanstalt für Landtechnik	Rottenhauser Str. 1	3250	Wieselburg	K. Payer	F	NF-2000 representative
Bundesanstalt für Landtechnik, Abt. Landtechnische Forschung	Rottenhauser Str. 1	3250	Wieselburg	M. Wörgetter	F	non-food research coordinator
Bundesministerium für Land- und Forstwirtschaft	Stubenring 1	1012	Wien	E. Fuhrmann	F	agricultural research organisation
Niederösterreichische Landeslandwirtschaftskammer	Löwelstr. 16	1010	Wien	W. Keider	F	extension service
SUSTAIN, c/o Institut für Verfahrenstechnik	Inffeldgasse 25	8010	Graz		O	co-ordination of non-food projects; public relation (workshops etc.)
Universität für Bodenkultur, Institut für Pflanzenbau und Pflanzenzüchtung	Gregor Mendel Str. 33	1180	Wien	P. Ruckenbauer	A	plant breeding, agronomy
Oilseed crops						
Biostar Oil GmbH & Co KG	Edelsee 9	8413	Ragnitz	Mr. Kellersperg	I	lubricants, chain oil, separation oil
Bundesamt und Forschungszentrum für Landwirtschaft, Institut für Agrarökologie	Spargelfeldstr. 191	1220	Wien	M. Dachler	F	field trials with oilseeds, fibre and medicinal crops
Bundesanstalt für Landtechnik, Ref. Landtechnische Forschung I	Rottenhauser Str. 1	3250	Wieselburg	J. Rathbauer	F	oil and fibre technical research
Bundesanstalt für Landtechnik, Ref. Landtechnische Forschung II	Rottenhauserstr. 1	3250	Wieselburg	H. Prankl	F	plant oil based lubricants research
Ges. z. Förderung d. Kunststofftechnik	Wexstr. 19-23	1200	Wien	N. Böhm	O	plant oil based softeners
Nektar Naturkosmetik	Weberstr. 6	3300	Greinsfurth	P. Rausch	I	hemp oil based cosmetics
Öhlmühle Bruck GmbH	Industriegelände West 3	2460	Bruck	S. Pinterits	I	rapeseed and sunflower processing
PPM Forschung und Beratung	Kaplanhofstr. 1	4020	Linz	Mrs. Kummerer	I	printing industry consultant
Radinger GmbH & Co KG	Hauptstr. 12	3270	Scheibbs	Mr. Lebhard	I	printing industry
Universität Wien, Institut für Organische Chemie	Währinger Str. 38	1090	Wien	E. Lorbeer	A	plant oils analytical research

Company/Institute	Street	Post Code	Town	Contact Persons	O[1]	Main Activities
Fibre crops						
Bundesamt und Forschungszentrum für Landwirtschaft, Institut für Agrarökologie	Spargelfeldstr. 191	1220	Wien	M. Dachler	F	field trials with oilseeds, fibre and medicinal crops
Bundesanstalt für Landtechnik, Ref. Landtechnische Forschung I	Rottenhauser Str. 1	3250	Wieselburg	J. Rathbauer	F	oil and fibre technical research
Fachverband der Textilindustrie Österreichs	Rudolfsplatz 12	1010	Wien	F. P. Schinzel	O	textile industry association
Interuniversitäres Forschungsinstitut für Agrarbiotechnologie (IFA) Tulln, Abt. Naturstoff- und Verpackungstechnologie	Konrad Lorenz-Str. 20	3430	Tulln	N. Mundigler	A	compound materials
Lambacher HITIAG Leinen AG	Fabrikstr. 3	3381	Golling		I	textile industry
Neusiedler AG	3. Str. 1	3331	Kematen	G. Drexler	I	hemp paper
Österr. Heraklith GmbH	Industriestr. 18	9586	Fürnitz		I	short fibre
Paptex GmbH	Schillerstr. 4	6850	Dornbirn		I	textile manufacturer
Rohemp Hanfhandels GmbH	Wallstr. 36	8280	Fürstenfeld	K. Ströml	I	hemp processing
Steirerflachs Flachsverwertungsges.	Alte Wagnerstr. 2	8720	Spielberg	Mr. Egger	I	flax processing
Universität für Bodenkultur Wien, Institut für Agrarökonomik	Peter Jordan-Str. 82	1180	Wien	H. Haimböck	A	agricultural economics, markets
Waldviertler Flachs-Verarbeitung GenmbH	Rastenfeld 169	3532	Rastenfeld	Mr. Gassner	I	flax processing
Zellform GesmbH	Taiskirchen 3	4753	Taiskirchen		I	compound materials
Carbohydrates						
AGRANA Beteiligungs-AG	F.W. Raiffeisen Pl. 1	1020	Wien		I	production of starch and sugar
F. Haas Waffelmaschinen Industrie AG	Ebreichsdorfer Str. 16-18	2512	Tribuswinkel	Abt. BIOPAC	I	production of starch-derived packagings
Verpackungszentrum Graz	Anton Mell Weg 14	8053	Graz	S. Meininger	I	production of biodegradable packagings
Zuckerforschung Tulln Ges.m.b.H.	Reitherstr. 21-23	3430	Tulln		I	research on starch and sugar technology

Company/Institute	Street	Post Code	Town	Contact Persons	O[1]	Main Activities
Crops with specialist use						
Bergkräuter-Genossenschaft	Thierberg 32	4192	Hirschbach	E. Grödl	I	organic production of medicinal plants in subalpine regions
Bundesamt und Forschungszentrum für Landwirtschaft, Institut für Agrarökologie	Spargelfeldstr. 191	1220	Wien	M. Dachler	F	field trials with oilseeds, fibre and medicinal crops
Bundesanstalt für alpenländische Landwirtschaft Gumpenstein	Altirdning 11	8952	Irdning	B. Krautzer	F	research on yellow gentian, arnica, alpine grasses
Dipl. Ing. Margarita Auer	Amerlingstr. 3/8	1060	Wien		I	breeding of milk thistle
Dr. Peithner KG	Richard Strauß Str. 13	1230	Wien	A. Stanislaw	I	production of homeopathic medicaments from wild plant species
F. Joh. Kwizda GesmbH, Werk Leobendorf	Laaer Bundesstr., Kwizda Allee	2100	Korneuburg	R. Teuber-Weckersdorf	I	developing of biological rodenticides (FAIR3-CT96-1436)
Fa. Graminex	Meiereihof 2	3910	Stift Zwettl	A. Eigner	I	production of Gramineae pollen
Karl Franzens Universität, Institut für Pharmakognosie	Universitätsplatz 4/I	8010	Graz	T. Kartnig	A	phytochemical and chemotaxonomical investigations of medicinal plants
Landwirtschaftliches Versuchszentrum Steiermark, Außenstelle Wies	Gaißeregg 5	8551	Wies	H. Pelzmann	F	maintenance of medicinal, aromatic and dye plant species; field trials seed production of wild plant species
Saatbau Linz, Kräuter und Gewürze	Unterer Markt 23	4292	Kefermarkt	J. Eckmayr	I	production of herbs and medicinal plants
Steirische Beerenobstgenossenschaft	Hans Thalhammer Str. 28	8501	Lieboch	Mr. Kaufmann	I	processing of elder berries
Universität für Bodenkultur Wien, Institut für Botanik	Feistmantelstr. 4	1180	Wien	W. Holzner	A	domestication and semi-cultivation of spike valerian
Universität Wien, Institut für Pharmakognosie, Pharmazie-Zentrum	Althanstraße 14	1090	Wien	B. Kopp	A	plant tissue culture of yarrow, red cone-flower, red squill etc.
Veterinärmedizinische Universität, Institut für Angewandte Botanik	Veterinärplatz 1	1210	Wien	C. Franz, J. Novak, R. Chizzola	A	breeding research on yarrow, yellow gentian, marjoram, sage, oregan butterbur, marigold, chamomile
Waldland Betriebs- u. Handels Ges.m.b.H.	Oberwatenreith 10	3533	Friedersbach	G. Zinner	I	production of herbs and medicinal plants
Zeno-Projekte	Pötzleinsdorfer Str. 10	1180	Wien	G. Dobos	I	breeding of grain-amaranth, quinoa, winter poppy

[1] Codes for Type of Organisation

F = Federal institutions and organisations
I = Industrial companies
A = Academic research groups and organisations
O = Other interest groups