Crops2Industry Crops2Industry

"Non-food Crops-to-Industry Schemes in EU27"

WP 1

Task 1.4 Other specialty crops

NATIONAL INSTITUTE FOR CHEMICAL PHARMACEUTICAL R&D
BUCHAREST, ROMANIA

SUMMARY

1.Screening on wild and cultivated medicinal plants in EU 27

Medicinal plants play a central role, not only as traditional medicines used in many cultures but also as trade commodities that meet the demand of often distant markets.

Some wild species are being over-exploited it is recommended that wild species be brought into cultivation systems. Cultivation can also have conservation impacts. Medicinal plant production through cultivation, for example, can reduce the extent to which wild populations are harvested, but it also may lead to environmental degradation and loss of genetic diversity.

Economical feasibility is the main rationale for a decision to bring a species in cultivation but it is also a substantial limitation as long as sufficient volumes of material can still be obtained at a lower price from wild-harvest. Cultivated material will be competing with material harvested from the wild that is supplied onto the market by commercial gatherers who have incurred no input costs for cultivation. Low prices, whether for local use or for the international pharmaceutical trade, ensure that few species can be marketed at a high enough price to make cultivation profitable.

In Europe as a whole, only 130–140 MAP species are cultivated and the number of MAP species currently in formal cultivation for commercial production does not exceed a few hundred worldwide – less than 1% of the total number of medicinal plants used (Shippmann et al, 2006).

The situation of wild and cultivated medicinal and aromatic plants across Europe is the following:

AUSTRIA

Geography of Austria is diverse in nature, comprising all major types of topographical features. Austria is mainly a mountainous country with a central location on the map of Europe. With a total land area of 83,859 kilometer square, it is surrounded by countries on all sides.

Climate is quite significant an issue as far as the Geography of Austria is concerned. The climatic condition in Austria is basically moderate, with Mediterranean winds blowing constantly to make the weather temperate in nature. This maritime climate suffers no precipitation, hence devoid of humidity.

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.

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.

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 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.

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.).

Milk thistle (*Silybum marianum*)

Milk thistle is a spring-sown crop of great importance in the production of pharmaceutical crops in Austria.

The active agents are the silymarins which belong to the flavanoids.

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.

The harvested products of yellow gentian are the seeds and the roots (*Radix Gentianae)*. Harvest of the seeds can be started in the 3rd year. The yields of seeds were as follows: 3rd year: 175 kg ha^{-1}; 4th year: 262 kg ha^{-1}; 5th 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.

Besides yellow gentian there are also attempts to reactivate the historically important collection and commercialisation of *Valeriana celtica* (spike valerian). 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). Over-harvesting in the last years resulted in significant lower incidence in the wild. Therefore the cultivation of arnica is of high interest.

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.

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).

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.).

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.

Semen Cucurbitae contains a very high content of vitamine E, especially γ-tocopherol, citrullin, carotinoids and glutathione.

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.

Harvest of the oilpumpkins is done either by hand or by special harvesters which crash the pumpkins and 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.

Valuable compounds besides hypericin are essential oils, flavonoids, tannins and resin.

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 A*chillea 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.*

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. It is supposed that St. John's wort is produced for a German pharmaceutical company.

Overview about areas and market forecasts of herbs and medicinal plants in Austria, 2002

Production branches	Species	Area in hectares	Market forecasts
Tea plant	Pippermint Common balm Common mallow Stinging nettle Sage St. John's wort	**Total: 320**	++ ++ ++ + + -
Flowers	Marigold Cornflower Common mallow	**Total: 5**	- -

Spices (plants)	Parsley Thyme Marjoram Fennel	**Total: 104**	+++ ++ ++ ++
Spices (seeds)	Mustard Caraway Fennel Aniseed	**Total:950**	+ +++ ++ ++
Total		**1379**	
Market forecast: + stable, ++ raising, +++ high demands - falling market			

Medicinal plants, aromatic and culinary plants were cultivated on 3796 ha in 2006, respectivelly on 3822 ha in 2007 (S. Statistics Austria. Crops on arable land).

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.

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.

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.

Over 80% of the different species of medicinal plants cultivates in Austria are selections of wild plants, but are mainly distributed as cultivars. Most of these selections are very old and their origin can no longer be certified. Advanced cultivars are rather rare.

Other specialty crops

The cultivation and processing are carried out by:

- seed companies
- agricultural cooperatives working as seed companies
- agricultural associations of farmers

Only the productions and packaging of medicinal and aromatic plants is done in Austria. For the processing/extraction itself, semi-processed products are exported to Switzerland or Germany.

Summary:

- Medicinal plants are cultivated all over Austria, however, there are five main regions in which most of Austrian production is performed:

- Mühlviertel county (Upper-Austria): ribwort plantain, marjoram, common balm, and peppermint - about 65% of the total herb acreage in this region is organic grown.
- Innviertel county (Upper-Austria): caraway, linseed, fennel, aniseed, safflower.
- Waldviertel county (Lower-Austria): caraway, milk thistle, chamomile, timothy grass pollen.
- Weinviertel county (Lower-Austria): linseed and safflower.
- South- eastern Styria: cornflower, bee balm and wild plant seeds.

- The most important pharmaceutical crops in Austria are: Common chamomile (*Chamomilla recutita*), milk thistle (*Silybum marianum*) (yield: 800 – 1200 kg ha^{-1}), yellow gentian (*Gentiana lutea*) (about 1 ton roots collected from the wild, 10-15 ha commercially cultivated yield 30 t fresh roots/ha), arnica (*Arnica montana), elder (Sambucus nigra)* (1200 ha cultivated, production 2500 t/year), oilpumpkin (*Cucurbita pepo*), St. John's wort (*Hypericum perforatum*).
- Wild – collected plant species: A*chillea 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.*
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Information resources:

- www. ienica.net
- W. Kainz 2002. Medicinal and aromatic plants in Austria, European Cooperative Programme for Crop Genetic Resources networks ECPGR. Report of a Working Group on Medicinal and Aromatic Plants.

BELGIUM

The Kingdom of Belgium encompasses a total land area of 32,547 sq. km.

Belgium can be divided into three regions - the coastal plain, the central plateau, and the Ardennes highlands. The coastal plain extends inland 16 to 48 km on the northwest. The central plateau is a slightly elevated area, made up of a number of wide, fertile valleys with a rich, alluvial soil. The Ardennes highlands consist of densely wooded plateau averaging 1,500 ft in elevation, extending across southeastern Belgium and into northeastern France. The area is generally rocky and poorly suited for agriculture.

The climate of Belgium is mixed in nature, with areas near the sea experiencing humid and mild climate, while the inland sees a marked increase in temperature. Ardennes highlands has hot summers and cold winters. The months of April and November are considered to be rainy months even as heavy rains remain confined almost exclusively to the highlands. Fog and drizzle are also a common feature during this time. (www.mapsofworld.com).

A great diversity of species have medicinal and aromatic properties. Few of them are currently grown in Belgium. Several producers were located in the western part of the country (Tournai, Ath and Lessines regions), the production ceased more than twenty years ago excepted some angelica for aromatic use. North of Antwerp, close to the Dutch border, some farmers have occasionally grown species like *Carum carvi* or *Cuminum cyminum* (cumin).

Table 1. Surfaces in medicinal plants in Belgium

Crop species	Surfaces (ha)		
	in 1996	in 1997	in1998
Angelica archangelica	14.7	14.8	16
Silybum marianum (syn. *Carduus marianus*)	Non available	n.a.	124.5

For several years cuts of ornamental *Taxus baccata* have been gathered at private's owners by a company specialised in taxol and derivatives extraction. In 1998 a company has proposed contracts to farmers for growing *Silybum marianum.*

The are cultivated with medicinal and aromatic plants /1997: 583 ha.

Summary:

- There are no recent public available data as concerns medicinal and aromatic plants in Belgium.
- Few of MAPs are currently grown in Belgium: *Carum carvi, Cuminum cyminum* (occasiinally grown), *Angelica archangelica (*<20 ha), *Silybum* marianum (~125 ha/1998).

Information resources:

- www.ienica.net

BULGARIA

Bulgaria is situated in the Balkan peninsula, South East Europe, occupies the area of 110912 Km^2 with elevations ranging from 0 to 2925 m and has corresponding subalpine, Mediterranean and continental climates. The relief of the country is quite diverse ranging from plains to low hills and high mountains. The climate is moderate continental to modified continental, but in southern regions reflecting rather a strong Mediterranean influence. Normally, winter last about 3 months, spring and autumn are rainy and the summer is hot.

Despite intensive urbanization, a large part of population is engaged in agricultural activities. About 17% of Bulgarian people are occupied with farming,

The Bulgarian flora is remarkable for its diversity, 3500 plant species and 600 of them are known as medicinal plants.

According to the Bulgarian Government, Bulgaria is the biggest exporter of herbs in Europe and is ranked fifth or sixth in the world.

Production totals 17000 tons, with exports accounting for between 10000 and 15000 tons in recent years. The export of herbs includes 150 different plants.

Wild-growing medicinal plants are a major renewable resource of Bulgaria. Bulgarian medicinal plants have a broad diversity of species and a rich composition of active ingredients. They represent a traditional export product and are well placed on the international markets. There are about 770 species of medicinal plants constituting 20% of the Bulgarian flora. Of these, 200 are currently in use and over 250 herbal drugs are derived from them and presently used in the prophylaxis, medicine, cosmetics, and the food industry.

The families *Asteraceae, Lamiaceae, Rosaceae, Fabaceae, Apiaceae* are represented by the greatest number of species.

Of all identified medicinal plants, 50% are perennial herbaceous plants, 20% are annual plants, 25% are shrubs and trees, and the smallest contribution of 5% goes to biannual herbaceous plants.

Reproduction of medicinal plant is carried out with seeds, spores, or in a vegetative way, which

prevails in the case of perennial plants.

In some regions of Bulgaria with clear floristic endemism and in active ecological *hotspot areas* many endemic and rare species are distributed, which morphologically are very close to some of the widest-used medicinal plants. This is illustrated best by the species of genus *Alchemilla*, such as *A. achtarowii, A. asteroantha, A. jumrukczalica* as well as by other species, such as *Viola balcanica, Betonica bulgarica*, etc. Colecting herbs in the regions of their distribution may expose them to a serious risk of extinction.

The great biodiversity of medicinal plants and the resource characteristics of many of them have established Bulgaria as a depot of promising conserved medicinal plants and, along with this, offer a good chance for sustainable use of these resources.

Most medicinal herbs are collected in the mountainous and semi-mountainous regions of the country. This is determined by the allocation of resources, as well as by such socio-economic factors as employment and income of the population.

On the basis of their distribution in Bulgaria, the wild medicinal plants are divided into five groups by their conservation status, resources of natural habitats and prospects for collection. Groups I and II include the species of conservation concern, groups III and IV include the species with very good and good utilization resources, while group V comprises species with distinct distribution, but no economic importance.

Protection and utilization of medicinal plants is of great importance not only for the Bulgarian flora but also for the world flora. Once of the best ways to combine these two controversial activities is cultivation of species. Cultivation allows for high-quality biological products from medicinal plants to be exported on the international market in line with international standards.

In the case of critically endangered plant species by excessive exploitation, the only method to stop their decline and to ensure their long-term survival is certainly cultivation.

Cultivation of medicinal plants is traditional in Bulgaria, but it contributes up to 50(60)% of the total annual harvest of medicinal plants in the country. In the last five or six years the interest in cultivation has considerably increased. Today, about 30-40 medicinal and aromatic plants are cultivated in Bulgaria. The most important of them are: *Mentha piperita, Coriandrum sativum, Silybum marianum, Tilia* spp., *Aesculus hypocastanum, Hypericum perforatum, Valeriana officinalis, Althaea officinalis, Foeniculum vulgaris, Glaucium flavum, Chamomilla recutita, and Melissa officinalis.*

According to the data of Ministry of Agriculture and Forestry, an area of 43 243 ha is under medicinal and aromatic cultures (*Rosa damascena, Lavandula vera, Mentha piperita, Valeriana officinalis, Coriandrum sativum, Foeniculum vulgare, Silybum marianum, Hypericum perforatum, Glaucium flavum, Rosa rugosa*). However, these data are not quite precise, owing to the obtaining

system of information gathering. The real values, as well as the as the diversity of cultivated species must be higher, because the area of personal farms have not been included. Data on cultivation in different regions of the country of such species as *Atropa bella-dona, Althaea officinalis, Majorana hortensis, Origanum vulgare* subsp. *hirtum, Salvia officinalis, Plantago spp., Taraxacum officinalis,* etc. have also not been taken into account.

Presently, there have been increasing efforts to regenerate by cultivation some wild gathered endangered and valuable species. The last three years have witnessed good practical results from cultivation of such protected species in Bulgaria as *Sideritis scardica* (a Balkan endemic) and *Rhodiola rosea*. The most important results were obtained in the Institute of Botany with the Bulgarian Academy of Sciences, at the two experimental centres for researching the possibilities for cultivation of new medicinal plant species.

Introduction of organic agriculture for cultivation of medicinal plants shall bring about ecologically sound production and is expected to meet the standards for quality of organic herbs by adopting in full the ISO 9000 for medicinal plants and species.

Some examples of adaptability of wild MAP_s to cultivation:

Very good: *Inula helenium, Iris aphylla, Gypsophila trichotoma, Gypsophila tekirae, Althaea officinalis, Rubia tinctorum, Origanum vulgare subsp. hirtum.*

Good: *Gypsophila paniculata, Clinopodium vulgare, Mentha longifolia, Symphytum officinale, Paeonia tenuifolia, Cistus salvifolius.*

Low*: Adonis vernalis, Rhododendron ponticum, Vaccinium arctostaphyllos, Cistus incanus.*

The medicinal plants used in Bulgarian phytoterapy are the followings:

Apiaceae: *Anethum graveolens* L. (fruits), *Carum carvi* L. (fruits), *Coriandrum sativum* L. (fruits), *Foeniculum vulgaris* Mill. (fruits), *Heracleum sibiricum* L. (aerial parts), *Levisticum officinale* L. (roots), *Pastinaca sativa* L. (seed and roots), *Petroselinum hortense* L. (leaves, seeds, roots).

Apocynaceae: *Vinca minor* L. (leaves)

Araceae: *Acorus calamus* L. (roots, rhizomes), *Arum maculatum* L. (tuber),

Aristolochiaceae: *Asarum europaeum* L. (rhizomes)

Asteraceae: *Artemisia absinthium* L. (leaves, flowers), *Artemisia vulgaris* L. (leaves, flowers), *Carlina acanthifolia* All. (roots), *Centaurea cyanus* L. (flowery tops), *Cnicus benedictus* L. (aerial parts), *Filaginella uliginosa* (L.) Opiz (aerial parts), *Helichrysum arenarium* (L.) Moench (flowers), *Hieracium pilosella* L. (aerial parts), *Inula helenium* L. (rhizomes), *Matricaria chamomilla recutita* (L.) Raush. (flowers), *Silybum marianum* (L.) Gaertn. (seeds), *Solidago virgaaurea* L. (aerial plants), *Tussilago farfara* L. (leaves).

Berberidaceae: *Berberis vulgaris* L. (bark, roots, fruits)

Betulaceae: *Alnus glutinosa* (L.) Gaerth (bark), *Corylus colurna* L. (leaves, bark).

Boraginaceae: *Pulmonaria officinalis* L. (aerial parts).

Brassicaceae: Armoracia rusticana P. Gaetner. (rhizomes).

Caryophyllaceae: *Herniaria glabra* L. (aerial parts).

Equisetaceae: *Equisetum arvense* L. (aerial parts)

Fabaceae: *Gleditsia triacanthos* L. (leaves), *Glycyrrhiza glabra* L. (roots), *Ononis spinosa* L. (roots).

Gentianaceae: *Gentiana lutea* L. (aerial parts).

Menyanthaceae: Menyanthes trifoliata L. (leaves).

Geraniaceae: *Geranium macrorrhizum* L. (rhizomes), *Geranium sanguineum* L. (roots).

Hippocastanaceae: *Aesculus hippocastanum* L. (flowers, fruits).

Lamiaceae: *Marrubium vulgare* L. (aerial parts), *Mentha pulegium* L. (leaves), *Origanum vulgare* L. (aerial parts), *Rosmarinus officinalis* L. (leaves), *Satureja hortensis* L. (aerial parts), *Sideritis scardica* Griseb. (aerial parts), *Teucrium chamaedrys* L. (aerial parts), *Thymus sp. diversa* L. (aerial parts).

Liliaceae: *Allium ursunum* L. (aerial parts), *Veratrum lobelianum* Bernh. (rhizomes).

Linaceae: *Linum usitatissimum* L. (seeds).

Malvaceae: *Althaea officinalis* L. (roots), Malva sylvestris L. (leaves).

Oleaceae: *Fraxinus ornus* L. (bark)

Papaveraceae: *Chelidonium majus* L. (aerial parts), *Fumaria officinalis* L. (aerial parts), *Glaucium flavum* L. (aerial parts).

Polygonaceae: *Rheum palmatum* L. (roots).

Primulaceae: *Primula officinalis* L. (rhizomes).

Ranunculaceae: *Helleborus odorus* Waldst. et Kit (roots).

Rhamnaceae: *Frangula alnus* L. (bark), *Rhamnus catharticas* L. (fruits).

Rosaceae: *Agrimonia eupatoria* L. (aerial parts), C*rataegus monogyna* Jacg. (leaves, flowers, fruits), Geum urbanum L. (roots), Potentilla erecta L. (roots), *Rosa damascena* L. (flowers), *Rubus* sp. (leaves, fruits).

Scrophulariaceae: *Linaria vulgaris* Mill. (aerial parts), *Verbascum thapsiform*e Schrad. (leaves), *Veronica officinalis* L. (aerial parts).

Solanaceae: *Atropa belladonna* L. (leaves, flowers, roots).

Violaceae: *Viola tricolor* L. (aerial parts).

The annual harvest of medicinal plants in Bulgaria amounts to about 15000-17000 tons, 80% of which is exported. During the last 15 years Bulgaria has attempted to increase its harvests from wild

collection of medicinal aromatic plants.

The good biological resources and quality of medicinal herbs have put forth Bulgaria as the biggest exporter of herbs in Europe (Lange 1998,2002) for that period. The exports are destined to about 50 countries, with prevailing amounts in the Bulgarian annual exports for Germany (65%), and to lesser for Spain (10%), Italy (5%), France (5%), and others countries (15%).

Some 200 medicinal herbs from over 140 medicinal plant species are exported every year. Only a limited number of species constitutes the huge amount of exported herbs and many of them are cultivated. Mainly about 25 species are of primary interest to the international markets, which accounts for 76.9% of the exported quantities.

The average quantity of herbs declared for export in the period 2001–2005 was 16 427 631 kg. The collected medicinal herbs can be divided into the following elements: radices & rhisomata 25, folia 56, herbae 91, flos 31, fructus 30, semen 4, cortex 8, diversae 7.

An analysis of the above-mentioned data shows several groups of herbs, according to the average volume of quotas declared in the export licences (Data of the Ministry of Environment and Water).

• Over 100 000 kg

This group includes 32 herb types derived from 23 plant species, accounting for over 80 % of the quota declared for export. The natural resources of the species are very good or they are traditionally cultivated. Among them are: *Tilia* sp., *Urtica dioica, Hypericum perforatum, Crataegus monogyna, Mentha piperita, Melissa officinalis, Lavandula vera, Chamomilla recutita, Valeriana officinalis, Rosa spp. div., Prunus spinosa, Rubus idaeus, R. caesius, Juniperus sibirica, Vaccinium uliginosum*, etc. In this group, cultivated herbs constitute half of the total amount. The berries claim a significant share in the exports (40 %).

• From 50 000 to 100 000 kg

This group includes 19 herb types derived from 18 cultivated or widely spread plant species with good resources (*Urtica dioica, Taraxacum officinale, Euphrasia* spp., *Althaea officinalis, Ononis spinosa, and Vaccinium vitis-idaea*). Some of them occur as weeds in the arable lands (*Tribulus terrestris, Agropyrum repens*). The cultivated herbs amount to about one-third of the total quantity for the group.

• From 10 000 to 50 000 kg

This group has a significant diversity of plant species, from which 47 herb types are derived. The number of cultivated medicinal plants is 12. About one-fourth of the total drug quantity in the group is derived from them.

• From 5 000 to 10 000 kg

Other specialty crops

This group includes 31 herb types. About one-fourth of the total drug quantity in the group is derived from cultivated medicinal plants, including *Althaea officinalis* and *Salvia officinalis.*

• From 1 000 to 5 000 kg

This group includes 44 herb types. About one-fifth of the total quantity is derived from cultivated medicinal plants, including *Aesculus hyppocastanum, Althaea officinalis* and *Salvia officinalis*. Here also belong some species subject to a special regime of protection and use.

• Under 1 000 kg

This group manifests a significant diversity of plant species and herbs (92). They are offered as an assortment and constitute only an insignificant part of the exports (0.15 %). Herbs from species subject to a special regime of protection and use, such as *Galium odoratum, Carlina acanthifolia, Betonica officinalis, Primula officinalis, Paeonia peregrina, Sedum acre, Alchemilla vulgaris* complex, etc., derived from their natural populations, belong here. About one- fifth of the total herbs quantity in the group is cultivated.

Table 1. Export quantities (kg) for medicinal plant species from Bulgaria, officially declared by licences during the period 2001–2005 (Source: Ministry of Environment and Water).

Type of herb	Wild collected (1); cultivated (2)	Average/2001-2008
Cortex Betulae	1,2	802
Cortex Diversae	1,2	3000
Cortex Frangulae	1	122
Cortex Fraxini	1	6674
Cortex Platanidis	1	3900
Cortex Quercus	1	19092
Cortex Salicis albae	1	49788
Cortex Tiliae spp.	1,2	1000
Flos Achilleae clypeolatae	1	103
Flos Achilleae millefolii	1	36130
Flos Althaeae	2	180
Flos Calendulae	2	6250
Flos Centaureae cyani	1	10937
Flos Chamomillae	1,2	278850
Flos Consolidae	1	2274
Flos Crataegi ox.	1	9520
Flos Crataegi ox.cum follis	1	422400
Flos Farfarae	1	26

Flos Filipendulae	1	3895
Flos Helianthi annui	2	43043
Flos Hippocastani	2	25
Flos Hyperici perforatae	1,2	1825
Flos Lavandulae	2	118435
Flos Malvae	1	2016
Flos Onopordi	1	20
Flos Paeoniae sine calycibus	1	1243
Flos Rhoeados	1	56
Flos Primulae cum calycibus	1	2772
Flos Robiniae	2	9470
Flos Rosae damascenae	2	246
Flos Sambuci ebuli	1	368
Flos Sambuci nigri	1	60828
Flos Syringae	1,2	3
Flos Tanaceti	1	5816
Flos Tiliae	1,2	1246223
Flos Trifolii pratensis	1,2	1611
Flos Valerianae	2	15
Flos Verbasci	1	454
Flos Violae odoratae	1	6
Folia Hippocastani	2	1659
Folium Allii ursini	2	10126
Folium Althaeae	2	6656
Folium Artemisiae vulgaris	1	230
Folium Bardanae	1	397
Folium Basilici	2	5440
Folium Belladonnae	2	1777
Folium Betulae	1,2	72760
Folium Bidentis	1	58
Folium Buxi		9107
Folium Coryli	1	27683
Folium Cotini	1	2400
Folium Crataegi	1	11795
Folium Cytisi laburni	2	4

Folium Stramonii	1	336
Folium Farfarae	1	13370
Folium Caricae	1,2	100
Folium Filicis- maris	1	177
Folium Fragariae moschatae	2	67749
Folium Fragariae vescae	1	420
Folium Fraxini	1,2	3990
Folium Hederae	1	46599
Folium Helianthi annui	2	100
Folium Juglandis	1,2	12680
Folium Majoranae	2	160
Folium Malvae	1	9181
Folium Melissae	1,2	330629
Folium Menthae piperitae	2	944481
Folium Mori albae	2	996
Folium Myrtilli	1	5246
Folium Nasturtii	1	600
Folium Origani heracleotici	2	14678
Folium Petasiti	1	1660
Folium Pini sylvestris	1	2390
Folium Plantaginis majoris	1	19013
Folium Plantaginis lanceolatae	1	20481
Folium Populi	1,2	208
Folium Populi tremulae	1	1040
Folium Pulmonariae	1	6297
Folium Qvercus		20
Folium Rubi fruticosi	1,2	213718
Folium Rubi idaei	1	85662
Folium Rumicis	1	14
Folium Salicis albae	1	3729
Folium Salviae	2	6272
Folium Sambuci nigri	1	268
Folium Saturejae hortensis	2	76763
Folium Symphyti	1	9210
Folium Syringae	1,2	69

Folium Taraxaci	1	9761
Folium Thymi serpylli	1,2	1712
Folium Tiliae	1,2	1668645
Folium Urticae	1	930595
Folium Verbasci	1	16965
Folium Visci	2	3805
Folium Vitis-idaeae	2	3350
Fructus Hyppocastani	2	413769
Fructus Coriandri	2	739291
Fructus Corni	1	4000
Fructus Crataegi	1	286446
Fructus Crataegi pentagynae	1	50
Fructus Crataegi-frozen	1	60704
Fructus Foeniculi	2	167946
Fructus Fragariae vescae-frozen	1	5886
Fructus Juglandis - cortex	1,2	9300
Fructus Juniperi	1,2	230719
Fructus Mali	1,2	94226
Fructus Mali sylvestris	1	7518
Fructus Myrtilli	1	253919
Fructus Paliuri	1	1653
Fructus Phaseoli sine semina	2	10912
Fructus Alkekengi	1	768
Fructus Pruni spinosae	1	62227
Fructus Pruni spinosae-frozen	1	725615
Fructus Quercus	1	5040
Fructus Rhamni cathartici	1	56
Fructus Rosae	1,2	25231
Fructus Rosae cum semini	1,2	1088795
Fructus Rosae-frozen	1,2	268688
Fructus Rosae-semini	1,2	676836
Fructus Rubi fruticosi	1,2	646544
Fructus Rubi idaei	1,2	479668
Fructus Sambuci ebuli	1	411383
Fructus Sambuci ebuli-frozen	1	6540

Fructus Sambuci nigri	1	32106
Fructus Sambuci nigri-frozen	1	1046
Fructus Sorbi	1	5310
Fructus Vaccinii vitis idaeae	1	80540
Gemmae Pini sylvestris	1	1516
Herba Absinthii	1	39728
Herba Agrimoniae	1	13088
Herba Alchemillae	1,2	234
Herba Allii ursini	1	13532
Herba Allii ursini -frozen	1	20836
Herba Aristolochiae	1	289
Herba Artemisiae	1	127345
Herba Artemisiae vulgaris	1	1721
Herba Asperulae	1	567
Herba Basilici	2	11275
Herba Betonicae	1	3295
Herba Bidentis	1	840
Herba Bursae pastoris	1	4752
Herba Centaurii	1	17317
Herba Chamomillae	2	880
Herba Chelidonii	1	18398
Herba Cichorii	1	147
Herba Clematidis vitalbae	1	212
Herba Consolidae	1	1400
Herba Epilobii parvifolii	1	13796
Herba Equiseti	1	194670
Herba Eringii	1	364
Herba Euphrasiae	1	62213
Herba Filicis -maris	1	5122
Herba Filipendulae ulmariae	1	6826
Herba Fumariae	1	31712
Herba Galegae	1	13346
Herba Galii aparinis	1	10172
Herba Galii veri	1	4506
Herba Gei urbani	1	336

Herba Geranii macrorhizi	1	1599
Herba Glauci flavi	2	854
Herba Glechomae	1	1503
Herba Helichrysi arenarii	1	20
Herba Herniariae hirsutae	1	9567
Herba Hieracii pilosellae	1	27439
Herba Hyperici	1,2	218339
Herba Hyssopi	2	523
Herba Lactucae	1	400
Herba Lavandulae	2	720
Herba Leonuri cardiacae	1	4312
Herba Leucoji aestivi	1,2	662
Herba Lithospermi officinalae	1	740
Herba Majoranae	2	149
Herba Malvae	1	781
Herba Marrubii	1	10713
Herba Meliloti	1	51762
Herba Meliloti	1	3418
Herba Melissae	1,2	118840
Herba Melissae stipites	1,2	11400
Herba Menrhae piperitae stipites	2	360904
Herba Menthae aquaticae	1	214
Herba Menthae piperitae	1,2	291071
Herba Millefolii	1	26848
Herba Myrtillii	1	5443
Herba Nasturtii	1	16319
Herba Ononidis	1	55
Herba Origani heracleotici	2	46943
Herba Origani	1	41098
Herba Petasitides	1	4
Herba Polygoni hydropiperis	1	9
Herba Polygonii avicularis	1	4651
Herba Pulmonariae	1	1000
Herba Rutae	2	224
Herba Salviae	2	8302

Herba Saponariae	1	394
Herba Saturejae hortensis	2	90552
Herba Sedi acris	1	65
Herba Silybi	2	1200
Herba Solidaginis virgae aureae	1	8831
Herba Stellariae mediae	1	14552
Herba Synphyti	1	318
Herba Tanaceti	1	3226
Herba Taraxaci	1	100872
Herba Teucrii chamaedrys	1	758
Herba Teucrii pollii	1	42
Herba Thymi serpylli	1,2	51632
Herba Tribuli terrestris	1	90083
Herba Trifolii	1,2	400
Herba Urticae	1	53111
Herba Verbasci	1	70
Herba Verbenae	1	27105
Herba Veronicae	1	44115
Herba Vincae minoris	2	4653
Herba Violae tricoloris	2	11062
Herba Visci	1	7494
Herba Armoraciae	2	53
Herva Gentianae asclepiadeae	1	6
Lichen Parmeliae	1	3663
Lichen Quercus	1	5103
Radix Althaeae	2	80262
Radix Althaeae cortex	2	8153
Radix Angelicae	1	10807
Radix Bardanae	1	45909
Radix Belladonnae	2	93
Radix Betonicae	1	196
Radix Bryoniae	1	382
Radix Carlinae	1	306
Radix Chelidonii	1	4152
Radix Cichorii	1	1164

Other specialty crops

Radix Echinacei	2	180
Radix Eryngii	1	4
Radix Filipendulae	1	1
Radix Fragariae moschatae	2	720
Radix Fragariae	1	39
Radix Gei urbani	1	27
Radix Glycyrrhizae	1,2	3540
Radix Hellebori	1	20
Radix Inulae	1	2794
Radix Levistici	2	80778
Radix Ononidis	1	80815
Radix Paeoniae	1	86
Radix Primulae	1	72
Radix Rubiae tinctorum	1,2	5
Radix Sambuci ebuli	1	606
Radix Symphyti	1	19242
Radix Taraxaci	1	20648
Radix Urticae	1	432780
Rhizoma Bistortae	1	90
Rhizoma Calami	1	1
Rhizoma Cynodonis dactylonis	1	67600
Rhizoma Filicis maris	1	9174
Rhizoma Geranii macrrorhizi	1,2	20
Rhizoma Iridis	2	54
Rhizoma Petasitidis	1	7380
Rhizoma Rumicis alpini	1	840
Rhizoma Valerianae	2	245864
Rhizoma Veratri albi	1	232
Semen Colchici	1	186
Semen Lini	2	53
Semen Silybi	2	493030
Stigmata Maydis	2	30574
Stipites Pruni avii	2	22000
Strobili Lupuli	2	11679
TOTAL		16427631

Other specialty crops

Table 2. Export quantities for the 25 most exported medicinal plant species from Bulgaria, officially declared by licences (Source: Ministry of Environment and Water).

Type of herb	Wild collected (1); cultivated (2)	Years/Volume (Kg)
		Average/2001-2005
Flos Tiliae	1,2	1246223
Fructus Rosae cum semini	1,2	1088795
Folium Menthae	2	944481
Folium Urticae	1	930595
Fructus Coriandri	2	739291
Fructus Pruni spinosae-frozen	1	725615
Fructus Rosae-semini	1,2	676836
Fructus Rubi fruticosi	1,2	646544
Semina Silybi	2	493030
Fructus Rubi idaei	1,2	479668
Radix Urticae	1	432780
Flos Crategi ox.cum foliis	1	422400
Fructus Aesculi hyppocastani	2	413769
Fructus Sambuci ebuli	1	411383
Herba Menrhae piperitae stipitis	2	360904
Folium Melissae	1,2	330629
Herba Menthae piperitae	2	291071
Fructus Crataegi	1	286446
Flos Chamomillae	1,2	278850
Fructus Rosae-frozen	2	268688
Fructus Myrtilli	1	253919
Rhizomata Valerianae	2	245864
Fructus Juniperi	1	230719
Herba Hyperici	1,2	218339
Folium Rubi fruticosi	1,2	21718
Total of top 25 species		12630565 76,9%
Total declared export		16427631

As regards essential oil crops, the most important crops are the followings: *Rosa kazanlika* (1500 ha/2002, 1.84 t/ha), *Lavandula vera* (2900 ha/2002, 1.73 t/ha), *Coriandrum sativum* (26900 ha/2002, 0.94 t/ha), *Mentha piperita* (140 ha/2002, 1.99 t/ha).

From 1998 to 2001, 350 ha of new fields of *Rosa kazanlika* were created; in 2002-480 ha and in 2003-300 ha. The average yield of flowers is 1.5-2 tones/ha for old fields, respectively 4-7 tones/ha for the new fields.

Bulgarian legislation concerning medicinal and aromatic plants.

The major act regulating the conservation and use of the medicinal plant resources is the **Medicinal Plants Act** (State Gazette, no. 29/2000) and the **Regulations** for its implementation. Some of the medicinal plant species unlisted in the Medicinal Plants Act are subject to the **Forestry Act** (SG, no. 125/1997). The issues relating to the Government policy on the plant varieties and the production of sowing and seedling material are subject to the **Sowing and Seedling Materials Act** (SG, no. 20/2003).

In addition to the above-mentioned acts, the following laws also deal with the medicinal plants: the framework **Environmental Protection Act** (SG, no. 91/2002), the special **Biodiversity Act** (SG, no. 77/2002) and the **Protected Areas Ac**t (SG, no. 133/1998).

The Medicinal Plants Act regulates all activities related to the conservation and use of medicinal plants, and the obligations for conservation of biological diversity and medicinal plants resources on the part of the physical and juridical persons and of the institutions. The main purpose of this Act is to ensure conditions for sustainable use of the medicinal plants on the territory of Bulgaria.

The legislation provides for two categories of conservation-significant species: protected species and species under a special regime of conservation and use.

The medicinal plants with critically limited natural resources are declared protected under the Bulgarian national legislation. They are prohibited for picking up, gathering, cutting, rooting up, and storing into herbaria, and destruction and/or intended damage to their habitats is also forbidden. Collection of their seeds, bulbs, roots, and other reproductive parts is also banned, as well as attempts at owning these plants, taking them abroad, trading them off, offering them for sale, and/or exchanging these species or parts thereof, whether fresh or dried.

Other wild-growing species with a conservation status are put under a special regime of conservation and use case of a downward trends in biodiversity or in the resources. The regime includes: banning the collection of any type of herbs on the territory of the entire country or in specified regions; annual quotas determined for the different regions and localities; application of regenerating measures for the populations and habitats.

Gathering of herbs for trade and/or processing is allowed after obtaining a permit and paying the due charges thereto.

The collected funds are used for maintenance, regeneration, assessment of the resources, creation of an information system, and education programs related to medicinal plants.

Gathering of herbs in the protected areas is subject to special requirements. It is absolutely prohibited to gather herbs in the reserves and managed reserves, as well as in spots of high biodiversity, which can be affected by that process. Gathering of herbs on the territories of the national parks is restricted. The national parks management plans determine the places, where the herbs can be collected and the quantities allowed for picking.

Some general conditions relating to the traditional processing of herbs are laid down in the regulations, as well as scientifically supported requirements and elements of the good practices in the domain of herbs collecting and processing:

1. Regulation no. 2/2004 on the rules and requirements for collecting of herbs and genetic material from medicinal plants (SG, no. 14/2004).

2. Regulation no. 5/2004 on the requirements for the herbs-processing stations and/or herbs stores (SG, no. 85/2004).

Medicinal plants that do not meet the specifications of the listed plants in the Appendix to the Medicinal Plants Act are subject to the **Forestry Act.**

Some other plant species, such as *Leucojum aestivum,* are subject to a regime of protection and regulated use pursuant to the **Biodiversity Act.**

The Sowing and Seedling Material Act regulates the assessment and tests, approval and enlistment of the varieties in the official varieties list of the Republic of Bulgaria. This Act also provides for the production control, distribution, trade, and storage of sowing and seedling material; it deals with quality control and control and authentication of sowing and seedling material. The Act includes two regulations, which relate to the medicinal plants:

• *Regulation no. 24/2004 on the Production and Trade in Sowing and Seedling Material from Medicinal and Aromatic Plants (SG, no. 24/2004).*

***In-situ* and *ex-situ* conservation of the genetic fund of medicinal plants**

The genetic fund of medicinal plants is protected in the natural habitats (*in-situ*), under a network of protected areas in Bulgaria totalling 550 000 ha. Species diversity is well presented in the national and nature parks, reserves and protected sites. They include the most representative ecosystems and plant communities. About 50 areas are declared protected so as to safeguard the medicinal plant habitats (*Leucojum aestivum, Paeonia peregrina, Glycyrrhiza glabra, Sideritis syriaca*, etc.).

Ex-situ conservation of medicinal plans is carried out in specialized live collections at some scientific institutes: the Institute of Botany of the Bulgarian Academy of Sciences, the Institute of Roses and Essential-Oil Cultures in Kazanluk, and the Institute of Plant Genetic Resources in Sadovo, where the material from medicinal plants is stored in the National Genetic Seed Bank.

List of medicinal conservation-significant plant species subject to national legislation in Bulgaria:

Protected medicinal plants: *Acanthus spinosus, Acorus calamus, Adianthum capillus- veneris, Aesculus hippocastanum, Alchemilla achtarowii, Alchemilla asteroantha, Alchemilla jumrukczalica, Alchemilla mollis, Anemone sylvestris, Anacamptis pyramidalis, Angelica archangelica, Aquilegia nigricans, Artemisia lerchiana, Aristolochia rotunda, Caluna vulgaris, Campanula lanata, Chamaecytisus ratisbonensis, Cicuta virosa, Cyclamen coum, Dianthus pontederae* subsp. *kladovanus, Diphasiastrum alpinum, Drosera rotundifolia, Ephedra distachya, Eryngium maritimum, Euphorbia peplis, Galanthus elwesii, Galanthus nivalis, Gentiana lutea, Gentiana punctata, Glycyrrhiza glabra, Haberlea rhodopensis, Himantoglossum caprinum, Hippophae rhamnoides, Hottonia palustris, Hypericum androsaeum, Ilex aquifolium, Juniperus sabina, Ligularia glauca, Limonium vulgare, Menyanthes trifoliata, Nymhpaea alba, Nuphar lutea, Opopanax chironium* subsp. *bulgaricum, Orchis militaris, Orchis papilionacea, Orchis provincialis, Orchis spitzelii, Osmunda regalis, Pedicularis palustris, Prangos ferulacea, Potentilla palustris, Pyrola rotundifolia, Quercus coccifera, Rheum rhaponticum, Rhodiola rosea, Ruta graveolens, Salix pentandra, Sideritis syriaca, Taxus baccata, Verbascum pseudonobile,*

Medicinal plant species under special regime of protection and use:

Gathering for trade use is prohibited: *Adonis vernalis, Althaea officinalis, Angelica pancicii, Arctostaphyllos uva-ursi, Artemisia alba, Artemisia santonicum, Asarum europaeum, Asplenium trichomanes, Cetraria islandica, Cnicus benedictus, Convallaria majalis, Cystoseira barbata, Glaucium flavum, Helichrysum arenarium, Huperzia inundata*

Hyssopus officinalis subsp. *aristatus, Inula helenium, Juniperus oxicedrus, Lycopodium clavatum, Orchis sp. Diversa, Origanum vulgare* subsp. *hirtum, Phyllitis scolopendrium, Ruscus aculeatus, Salvia tomentosa, Sideritis scardica, Valeriana officinalis.*

Regulated by annual quotas: *Alchemilla vulgaris complex, Atropa belladonna, Berberis vulgaris, Betonica officinalis, Carlina acanthifolia, Frangula alnus, Galium odoratum, Paeonia peregrina, Primula veris, Sedum acre.*

A further sustainable development of the herbs branch in Bulgaria, maintenance of the current positions on the international market and meeting its contemporary requirements outline the following trends:

- A growing demand in herbs
- Higher quality requirements
- Higher market competition
- Need in resource assessment

- Monitoring of the resources
- Certification of harvesting regions
- Production of biological/ecological herbs
- Application of the good harvesting, agriculture and manufacture practices

Summary:

- Bulgaria is the biggest exporter of herbs in Europe and is ranked fifth or sixth in the word. Production totals 17000 tons, with exports accounting for between 10000 and 15000 tonnes in recent years. The export of herbs includes 150 different plants.

- The exports are destined to about 50 countries, with prevailing amounts in the Bulgarian annual exports for Germany (65%), and to lesser for Spain (10%), Italy (5%), France (5%), and other countries (15%).

- Wild-growing medicinal plants are a major renewable resource of Bulgaria. There are about 770 species of medicinal plants constituting 20% of the Bulgarian flora. Of these, 200 are currently in use. The families *Asteraceae, Lamiaceae, Rosaceae, Fabaceae, Apiaceae* are represented by the greatest number of species.

- Of the wild plant species, the larges quantities exported are of *Mentha* sp., *Mellisa officinalis, Lavandula vera, Hypericum perforatum, Matricaria chamomilla, Lamium album, Rosa canina, Tilia s*p.

- Cultivation of medicinal plants is traditional in Bulgaria. In contributes up to 50-60% of the total annual harvest of medicinal plants in the country.

- About 30-40 medicinal and aromatic plants are cultivated on an area of about 43 200 ha. The most important of them are: *Rosa damascena*, *Mentha piperita, Coriandrum sativum, Silybum marianum, Tilia* spp*., Aesculus hypocastanum, Hypericum perforatum, Valeriana officinalis, Althaea officinalis, Foeniculum vulgaris, Glaucium flavum, Chamomilla recutita, and Melissa officinalis.*

- As regards essential oil crops, the most important crops are the followings: *Rosa kazanlika* (1500 ha/2002, 1.84 t/ha), *Lavandula vera (*2900 ha/2002, 1.73 t/ha), *Coriandrum sativum* (26900 ha/2002, 0.94 t/ha)*, Mentha piperita* (140 ha/2002, 1.99 t/ha).

- The Medicinal Plants Act regulates all activities related to the conservation and use of medicinal plants, and the obligations for conservation of biological diversity and medicinal plants resources on the part of the physical and juridical persons and of the institutions. The main purpose of this Act is to ensure conditions for sustainable use of the medicinal plants on the territory of Bulgaria.

Information resources:

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legislation, conservation and trade. Phytologia Balcanica 13(3), 415-427.

- K. Varbanova, 2002. Medicinal and aromatic plant diversity in Bulgaria – Protection, collection, study, use and conservation. European Cooperative Programme for Crop Genetic Resources network ECPGR. Reports of a working group on medicinal and aromatic plants.
- www.ienica.net

CZECH REPUBLIC

The Czech Republic covers an area of 78,864 km^2 in the centre of Europe.

The western and central part of the Czech Republic belongs to the Bohemiam Highlands, the east to the west Carpathians. There are two biogeographic zones with most of the country covered by the continental zone, and a small part in the south east by the Pannonian zone.

Agricultural lands cover 54% of the country and forests 33%; the flora is relatively diverse due to environmental conditions. The best-preserved and most valuable natural areas preserved by a dense network of protected areas which cover 16.6% of the state territory.

The plants with the highest acreage in the Czech Republic include caraway (*Carum carvi* L.), milk thistle (*Silybum marianum* L.) and ergot (*Claviceps purpurea* TUNL., inoculated in rye). For pharmaceutical use poppy head, a by-product of poppy seed production, is used. Two varieties with mid-morphine content (Gerlach and Opal, 0.43%) and one variety with a high content of morphine (Lazur, 0.8%) are grown in the Czech Republic. Total production of herbs and medicinal plants is shown below.

Table 1. Total production of medicinal plants/1996-2002

Year	Harvest. area (ha)	Medicinal plants Production (t)
1996	5306	3636
1997	6127	3570
1998	6362	5282
1999	950	578
2000	2201	2118
2001	1500	974
2002	2841	2086

There are two main sources of plants in the Czech Republic - cultivation and collection. Chamomile, peppermint, lemon balm, thyme, long plantain, burdock, marshmallow, valerian and garden angelica are cultivated in the largest amounts and rosehip, lime flower, common St. John's

Wort, ribbon tree, stinging nettle, fragrant agrimonies, colt's tail, raspberry, black elderberry and blackberry are the collected in the largest amounts.

Table 2. Processing and usage of medicinal and aromatic plants (tonnes)

	1997	1998	1999	2000	2001	2002
Pharmaceutical	93.0	156.0	325.0	1118.0	930.0	900.0

In 2006 medicinal, aromatic plants and spices have been cultivated in the CR only on 5858 ha which is a decrease more then by 50% in the comparison with 2004 when Czech Statistical Office recorded the largest interest in medicinal, aromatic plants and spices cultivation. But the reason for such large difference can also lies in differing access to statistical reports on areas relating to the registration of land for the purposes of direct payments acquisition (SAPS) from 2004. In 2006 has been according to Czech Statistical Office survey harvested 4727 t of medicinal, aromatic plants and spices. As a result of climatic conditions 2006 is the year with the highest average crop yield (0.81 t/ha) for last five years.

The most important commodities cultivated on large-scale remain, despite of production fluctuations in the period of 2004-2006, caraway, milk thistle (*Sylibum*), ergot and poppy heads utilisation.

Summary:

- There are two main sources of medicinal and aromatic plants in the Czech Republic: cultivation and collection.
- Cutivated area/2006: 5858 ha.
- The plants with the highest acreage include caraway (*Carum carvi* L.), milk thistle (*Silybum marianum* L.), ergot (*Claviceps purpurea* TUNL., inoculated in rye) and poppy (*Papaver somniferum*).
- The plants collected from the wild in the largest amounts includes rosehip, lime flower, common St. John's Wort, ribbon tree, stinging nettle, fragrant agrimonies, colt's tail, raspberry, black elderberry and blackberry.

Information resources:

- www.ienica.net
- IPA database
- Medicinal, aromatic and spice plants. Situation and prospect report 2007. Ministry of Agriculture of Czech Republic.

Other specialty crops

CYPRUS

Cyprus is the third largest island in the Mediterranean with an area of 9251 km2 and includes four distinct topographical areas. The climate is intense Mediterranean with wet, changeable winters from November to March, and hot, dry summers from May to September, separated by short spring and autumn seasons. The vegetation consists mainly of coniferous forest, the maquis, the garigue and batha. A total of 1907 taxa have been recorded as native or naturalized and 376 taxa as cultivated. A number of aromatic, medicinal and other useful plants are being exploited in Cyprus, e.g. O*riganum dubium, Salvia fruticosa, Sideritis perfoliata, Matricaria recutita, Urtica urens, Plantago coronopus* subsp. *commutata*, *Mentha spicata* subsp. *spicata*, *Rosmarinus officinalis*, etc. Among the wild shrubs which are partly used for their aromatic fruits are: lentisk, *Pistacia* lentiscus L. ("schinia", "schinnos") and *Pistacia terebinthus* L. (terebinth, "trimithkia"). The aromatic fruit of *Pistacia atlantica* Desf. ("tremithos"), the mastic-producing tree, which is used for making pies, was used in the past for oil production. *Laurus nobilis* L. (laurel) is gathered or grown for its aromatic leaves and fruit. The leaves are used as aromatics and the oil from its fruit in cosmetics. An interesting plant of economic importance is *Rhus coriaria* L. (sumach, "roudhi", "soumatji"), an erect or spreading shrub of about 2 m in height, which grows on stony mountainsides and in vineyards above 600- 1800 m. The leaves of *Rhus coriaria*, an industrial plant rich in tannin, are collected every year and exported. *Crataegus azarolus* L. (azarole, "mosphilia"), a small round-headed tree, is grown on rocky mountainsides, by road sides or by field margins, where it is often planted. It is found from sea level to 1200 m altitude. Its fruit is gathered and eaten fresh or used to make home-made jams. It is used also in industry. The carob tree, *Ceratonia siliqua* L., the "charoupia" or "teratsia" of the Cypriots, which is grown in the wild, is also cultivated for its ripe fruit. It grows on dry hillsides in the garigue and in coastal and sub-maritime maquis from sea level to 700 m. It is widely cultivated in lowland areas.

The agro climatic conditions in Cyprus are ideal for the cultivation of aromatic crops.

Many aromatic plants are collected from the wild. The extensive exploitation of many aromatic plants has decreased plant population size to such an extent, that some of them are almost extinct. In addition, experts consider wild collection detrimental to the ecosystem, accelerating soil erosion and reducing biodiversity. The growing market for herbs puts an additional strain on resources.

Initiatives related to the cultivation of aromatic and medicinal plants in Cyprus began in 1991.

Aromatic plants grow well in all parts of the island, but the quality and quantity of production of plants is higher in semi-mountainous areas.

The Department of Agriculture has established, the necessary infrastructure which consists of: plantations of aromatic and herbal plants, seeds, nurseries, experimental plantations, modern drying installation, distillation installations, installations for ethereal oils analysis, etc. The Section of Aromatic

Other specialty crops

Plants of the Department of Agriculture has been working on the cultivation of aromatic and medicinal plants since 1992, starting with the cultivation of *Origanum*, *Mentha* and *Salvia*.

The main aromatic plants that are promoted by the Department of Agriculture are: Oregano, Sage, Mint, Basil, Tarragon and Lavender and to a lesser extent Marjoran, Bay *Dictamus*, Rosemary, *Melissa*, Thyme and *Siderlitis*. There is a great demand for such products in the countries of the E.U. and other countries because of their excellent quality, which is attributed to the favourable climatic conditions of Cyprus.

The cultivated plants in Cyprus: *Ocimum basilicum, Borago officinalis, Geranium or, Pelargonium roseum, Glycyrriza glabra, Laurus nobilis, Rosmarinus officinalis, Origanum dictamus, Thymus vulgaris, Calendula officinalis, Foeniculum vulgare, Origanum majorana, Mentha piperita, Capparis spinosa, Lavandula sp., Hyssopus officinalis, Sideritis* sp*., Rosa damascena, Salvia* sp*., Origanum dubium, Anethum graveoleus, Melissa officinalis, Myrtus communis, Artemisia absinthium, Crithmum maritimum, Pistacia lentiscus, Artemisia dracunculus, Mentha viritis, Plantago coronopus, Gentranthus rubber, Agrimonia eupatoria, Hypericum perforatum, Angelica archangelica, Artemisia pontica, Valeriana officinalis, Humulus lupulus, Verbena officinalis, Saponaria officinalis, Verbascum thapsus, Leonurus cardiaca, Gentaurea scabiosa, Vanilla plantyfolia, Gestrum noxtumum, Pimpinella Anisum, Lippia cidriodora, Sambucus nigra, Matricaria chamomilla, Crocus sativus, Urtica dioica, Eucalyptus* sp*., Sanguisorba minor, Allium shoenoprasum, Allium sativum, Petroselinum sativum, Psidium guijava.*

Carob trees have been cultivated in Cyprus for many years. It is estimated that 4,000 hectares in the free areas are planted with 200,000 carob trees, while another 100,000 are spread around.

Carob Production 1995-2000 (tonnes)

	1995	1996	1997	1998	1999	2000
Production	6300	8800	5100	4850	5400	7300

Of the 7,300 tonnes produced in 2000, 328 tonnes were exported; 200 tonnes were retained for inputs, and 6,772 tonnes were sales to industry and other sectors.

Ex situ collections are conserved in the National Genebank (Della 1997). National legislation protects the forest, rare endemic plants, national forest parks or nature reserves, as well as very old trees. A framework law has been ratified for the protection of nature. Although aromatic plants have always been grown in Cyprus, their cultivation has increased in recent years due to their use in international cuisine and to their association with better health. It is fortuitous that the agroclimatic conditions in Cyprus are very suitable for a wide range of aromatic crops. Aromatic and medicinal plants are grown at the Athalassa (near Nicosia) Government Nursery (Department of Agriculture) for evaluation and utilization. A number of the above species are already grown on a commercial scale.

Research work at the Agricultural Research Institute includes studies of plant population density, cutting height, selection of different genotypes of oregano, experiments with pre- and post-emergence herbicides in a number of aromatic plant species, and irrigation experiments to study the effect of irrigation on the yield and quality of oregano and sage.

Summary:

- The agroclimatic conditions are ideal for the cultivation of aromatic crops.
- The cultivation of aromatic and medicinal plants began in 1992 starting with Origanum, Mentha and Salvia.
- The main aromatic plants promoted by the Department of Agriculture are: Oregano, Sage, Mint, Basil, Tarragon, Lavender, Marjoran, Bay, *Dictamus*, Rosemary, *Melissa*, Thyme and *Siderlitis*.
- Other 50 medicinal plants are cultivated in Cyprus.
- Carob tree occupies a special place. It is estimated the 4000 hectares in the free areas are planted with 200000 carob trees, while another 100000 are spread around Carob production/2000: 7300 tonnes.
- An interesting plant of economic importance is Rhus *coriaria* L. whose leaves rich in tannin are collected every year and exported.
- "Ex situ" collections are conserved in the National Genebank. National legislation protects the forest, rare endemic plants, national forest parks or nature reserves.

Information resources:

- www.ienica.net
- D. Droushiotis , A. Della 2002. Genetic resources of medicinal and aromatic plants in Cyprus with emphasis on the selection, evaluation and management of *Origanum dubium.* European Cooperative Programme for Crop Genetic Resources network ECPGR. Reports of a working group on medicinal and aromatic plants.
- G. Georgiou, A. Gavrilides 1997. The cultivation of aromatic and medicinal plants in Cyprus. Proceedings of the International Experts Meeting.

ESTONIA

Estonia is an eastern European country which is surrounded by Gulf of Finland and Baltic Sea. It is flat and low country and covers the area of 45,226 square kilometers.

The climate of Estonia is of maritime nature. The winters are moderate and the summers are characterized by cool weather. The terrain of Estonia is generally characterized by swampy plain.

The country of Estonia has a forest cover of about 108 million hectares. Cultivable lands in

Estonia total to about 926,000 hectares.

The flora and vegetation of Estonia are both very interesting for their biological diversity. Despite its small surface area, Estonia has two different biogeographical subdivisions. Geologically, eastern Estonia can be characterized by its sandstone bedrock and western Estonia by its limestone bedrock. Therefore different soil types occur in these areas. The indigenous flora of Estonia includes approximately 1500 vascular plants.

Estonia has long traditions in using medicinal and aromatic plants. Some of the drugs are gathered in the wild. These include mainly common, widely spread species. Along with the restoration of land ownership within the last decade, a number of farmers have started growing indigenous MAP species. On the average, about ten species are grown but there are also farms where 30 or more species are grown. Statistical data about MAPs gathered in the wild and grown on-farm are lacking since no reporting or monitoring system has been established yet.

Fennel, Hypericum, Melissa, Peppermint, Petroselina, Rosa, Taraxacum, Thymus and Valerian are grown in small areas (approximately 6 ha in total) for herbal health products. No industrial applications exist at the moment.

Kubja Herb Farm is one of the biggest and oldest producers and packagers of herbs in Estonia.

The farm itself produces approximately twenty different species of plants: Calendula, Chamomile, Digitalis, Fennel, Gentiana, Hypericum, Hyssop, Lavender, Leonurus cardiaca, Marjoram, Melissa, Nettle, Nepeta, Oregano, Peppermint, Petroselina, Rosa, Salvia, Taraxacum, Thymus and Valerian. These plants are grown on approximately 3.5ha in total. These herbs are marketed as the health product mixed in the different tea mixtures.

OÜ Elujõud operates in the field of growing, packaging and sales of herbs. The main production is carried out in a 5.8 hectare area in Central Estonia.

Over 20 herbs and the same number of tea mixtures are produced. The herbs are grown on several hectares without mineral fertilisers and chemical control products. The natural plant species are picked only from selected and clean areas. Thymus, Salvia, Rosa, Artemisia, Alchemilla, Solidago, Hypericum, Marjoram, Melissa, Nettle, Plantago, Parsley, Echinaceae and Yarrow are grown on approximately 2ha in total. These herbs are marketed as the health product mixed in the different tea mixtures.

Regarding medicinal plants, thorough research was done in Estonia in the 1980s on the resources and sustainable use of two forest plants: *Arctostaphylos uva-ursi* (L.) Spreng. and *Vaccinium vitis-idaea* L. A possible annual use was calculated on the yearly gain in growth of the biomass that guaranteed a continuous renewal of resources. Based on the findings, distribution maps

of the resources were drawn up.

Legislation

The *Law of Natural Objects under Protection* (passed in 1994, supplemented in 1998) establishes the terms for the protection of both plant communities and plant species. Almost 10% of the country's area is subject to various levels of protection. The strict regime of protection applies to over 1% of the whole area, and is planned to cover up to 5% of the mainland by 2010. The above-mentioned law has established the following categories of protection:

• Conservation areas

- national parks, meant for the protection of typical landscapes and the biological diversity of ecosystems (Lahemaa – northern Estonian plant communities; Karula – southern Estonian plant communities; Soomaa – the communities of mires and bogs; Vilsandi – littoral communities);

- wildlife conservation areas, meant for the protection of rare species and species in danger of extinction;

- landscape conservation areas (parks, arboreta, botanical gardens), usually small;

- programmed areas, in which monitoring, research work and educational activities are carried out in accordance with the programme;

• Protected natural individual objects (e.g. single trees, rocks and stones, waterfalls, caves, etc.);

• Species, fossils and minerals under protection.

Endangered plant species are divided into three categories according to the protection regime:

1. The first category includes 22 protected species of high scientific value (relicts, species with a narrow area of distribution and those on the margin of an area), very rare plants (1-5 sites) and clearly endangered species (Kukk 1999).

2. The second category (145 species) consists of rare and endangered species and species of scientific value, for which the threat is not as acute as for the species in the first category. They include endemic species, relicts from earlier climatic periods or species situated on the margin of their distribution area. The following species used as medicinal plants belong to this category: *Taxus baccata* L., *Jovibarba globifera* (L.) J. Parnell (syn. *J. sobolifera* (Sims) Opiz), *Prunus spinosa* L., *Rubus arcticus* L., *Hedera helix* L., *Helichrysum arenarium* (L.) Moench and *Orchis* spp.

3. The third category of protected species covers 41 quite common species that are endangered for various reasons. These include many decorative, medicinal and edible plants. The following medicinal species are listed: *Huperzia selago* (L.) Bernh. ex Schrank. et Mart., *Lycopodium clavatum* L., *Daphne mezereum* L., *Myrica gale* L., *Allium ursinum* L., *Colchicum autumnale* L. and *Orchis* spp.

In situ and ex situ conservation of medicinal and aromatic plants

Given the rather large coverage of protected areas in Estonia, the habitats of numerous medicinal plants enjoy a fairly good level of protection. In case of necessity it is possible, besides protecting the species under observation, to protect the habitat also by setting up small conservation areas, thus making the protection of plant communities considerably more effective.

Regarding ex situ conservation, the collection of medicinal and aromatic plants (MAPs) in the experimental garden of the Pharmacy Institute at the University of Tartu has a leading role. An adequate MAP seed bank is still lacking. The botanical gardens of Tartu and Tallinn have organized to a certain degree the ex situ conservation of medicinal plants, and a collection of useful plants. In the Nigula Wildlife Conservation area, ex situ conservation has been arranged for 760 indigenous forms of *Oxycoccus palustris* Pers. as well as for natural forms of *Vaccinium* vitis-*idaea* L. and *Rubus arcticus* L. at the University of Agriculture.

In Estonia, the following measures are taken for in situ and ex situ conservation:

- Further development and unification of laws;
- Land use restrictions in the areas under protection;
- Arranging support systems and paying compensation in the areas under protection;
- Claims for damages in case of violation of the law.

Summary:

- Some of the medicinal and aromatic plants traditionally used in Estonia are gathered in the wild (mainly common, widely spread species).
- As concerns the cultivation, on the average,about ten species/farm are grown.
- Fennel, Hypericum, Melissa, Peppermint, Petroselina, Rosa, Taraxacum, Thymus and Valerian are grown in small areas (approximately 6 ha in total).
- Statistical data about MAPs gathered in the wild and grown on farm are lacking since no reporting or monitoring system has been established yet.
- The regim of protection of plants communities and plant species applies to 5% of the mainland including 14 medicinal species.
- “In situ” an “ex situ” conservation are used to avoid potential danger and existing threats to MAP species.

Information resources:

- Ulve Pihlik 2002, Medicinal and aromatic plants in Estonia. European Cooperative Programme for Crop Genetic Resources network ECPGR. Reports of a working group on medicinal and aromatic plants.
- www.ienica.net

FINLAND

The geographical features of Finland vary greatly from the other Scandinavian countries. Located in the northernmost part of the European continent, it is bordered on all sides by the Gulf of Finland, Baltic Sea and the Gulf of Bothnia.

Apart from the water bodies, most of Finland is under deep and dense forest cover. Mostly a low terrain, the country has some plains with small lakes and mountains.

Because of Finland's northern location, winter is the longest season.

Despite the severity of the environmental conditions in Finland, more than 100 medicinal and culinary herbs grow wild over the entire country during the relatively short but intensive photoassimilation period.

Medicinal plants have not been inventoried officially in Finland. More attention should be paid to the following species, because their populations are decreasing in Finland: *Acorus calamus*, *Antennaria dioica*, *Artemisia abrotanum*, *Hierochloa odorata* subsp. *odorata*, *H. odorata* subsp. *baltica*, *Pimpinella saxifraga*, *Isatis tinctoria*, *Leonorus cardiaca* subsp. *cardiaca*, L. *cardiaca* subsp. *villosa*.

Collection of wildflower medicinal plants

In Finland there are about 50 wild flower medicinal plants of commercial importance. Accurate data on the quantities of collected wildflower medicinal plants is quite difficult to obtain. Many of these plants are collected for personal consumption by thousands of families. Numerous small local herb farms produce dry tea mixtures or other products. Finally, some producers of health food products are using larger quantities for further processing/extraction.

The quantity of dry wildflower medicinal plants can be estimated at about 4000-5000 kg/year (Galambosi 1996).

The most important wild medicinal plants are stinging nettle (*Urtica dioica*) and birch leaves (*Folium betulae*) with 1000-5000 kg collected each year. The quantity of dry plant material of *Calluna vulgaris*, *Juniperus* berries and *Achillea millefolium* flowers varies from 500 to 1000 kg/year, while 100-500 kg of dried raw material of *Solidago*, *Filipendula*, *Taraxacum*, *Epilobium* and *Vaccinium myrtillus* leaves are collected each year. About 15 other species are collected (less than 100 kg/year per species).

In addition to these species, there is a special product collected by the Oulu District of the Finnish 4H Association. During the last 10 years, 500-2200 kg of fresh sundew (*Drosera rotundifolia*) was collected from peatlands and marketed mainly to Switzerland, and partly domestically.

Bearberry leaves (*Arctostaphylos uva-ursi*) are collected from the wild for further industrial

processing and the extract is used in the perfume industry abroad and in Finland.

Cultivated herbs

During the last 15 years, interest in and cultivation of herbs has increased significantly. The acreage of herbs in 1985 was 100 ha and in 2001 it reached 3600 ha. At present about 30 different herbs and medicinal plants are cultivated in Finland to various extents.

The most important herb is biannual caraway (*Carum carvi*), since its cultivation can be easily mechanized. The area grown in 1994 was 1560 ha. In 2001 it had reached 3600 ha, spread over about 350 farms.

The second important spice seed is mustard (*Sinapis alba*). At its largest, in l991, the growing area was about 400 ha, but due to price and quality problems its cultivation has now nearly ceased. Presently the area of mustard is barely 50 ha.

The third important herb is the popular leaf dill (*Anethum graveolens*). In 1999 it was cultivated on 162 ha (323 farms) outdoors and on 8.2 ha indoors. Nearly all dill is used in fresh form for direct sale or in the processed food industry. Only a few tonnes are dried in Finland.

Parsley (*Petroselinum hortense*) is the fourth important herb. It is cultivated outdoors and indoors on a total of 20-28 ha, mainly for fresh consumption.

During the last 4-5 years, the cultivation of garlic (*Allium sativum*) has increased to 24 ha. Production is widely distributed and is carried out on small-scale plots. Nearly 170 farms are engaged in garlic cultivation.

About 10 different herbs, including some medicinal plants (e.g. *Coriander*, *Angelica*, *Oreganum*, *Mentha* sp., *Echinacea purpurea*, *Urtica* and *Artemisia dracunculus*), are cultivated on an area of between 1 and 5 ha/each. These plants are produced for further processing, for the health food industry or for the growers' own products. The harvested raw materials are dried, frozen or extracted.

About 20 different herb and medicinal plant species (*Hypericum*, *Hyssopus*, *Matricaria*, *Agastache*, *Calendula*, etc.) are cultivated on less than 0.5 ha/species.

Production area of each species is very small, generally under one hectare. The total area under production of herbs, spices and medicinal plants was 1 894 hectares in 1997 (Official Statistics of Finland, 1997), most of which was caraway. The production of caraway (*Carum carvi* L.) is organised by contracts of a company (Arctic Taste Ltd.), which exports it to Central Europe. Other cultivated species include for example: *Echinacea purpurea* L., *Solidago virgaurea* L., *Perilla frutescens* L., *Mentha* sp., *Calendula officinalis* L., *Urtica dioica* L., *Agastache foeniculum* L., *Plantago lanceolata* L. and *Plantago major* L. as well as *Melissa officinalis* L.

The suitability of Central European cultivars for Finnish growing conditions are being tested in

field trials for the following plant genera: *Origanum*, *Satureja*, *Thymus*, *Salvia*, *Valeriana*, *Dracocephalum*, *Achillea*, and *Levisticum*. Natural populations are collected and evaluated in several test locations for the following species: *Solidago virgaurea* L., *Hypericum perforatum* L. and *Hypericum maculatum* L. The quality of seed in ecological cultivation is tested for the following genera: *Matricaria*, *Achillea*, *Myrrhis*, *Hyssopus*, *Dracocephalum*, *Agastache*, *Levisticum* and Angelica. The possibility of using machinery in ecological seed production is investigated for the following genera: *Matricaria*, *Achillea*, *Agastache*, *Hyssopus*, Viola and Angelica. Vegetative propagation in ecological cultivation conditions is tested with *Mentha* species.The growth possibilities in Finnish conditions, cultivation methods and quality is investigated for the following pharmaceutical herbs: *Rhodiola rosea* L., *Myrica gale* L., *Gentiana lutea* L., *Anthoxanthum odoratum* L., *Artemisia abrotanum* L., *Cynara scolimus* L. and *Myrrhis odorata* L. The growth possibilities in Finnish conditions are investigated for the following new introductions in the following genera: *Acanthopanax*, *Ginseng*, *Althaea*, *Alchemilla*, *Cichorium*, *Inula*, *Chenopodium*.

An interesting example of the research is the development of cultivation methods for sundew (*Drosera* sp.), a plant which in natural growth conditions captures insects for protein. These plants contain several effective compounds, such as droseron, plumbagine, 7-methyl juglone as well as flavonoids and proteolytic enzyme (Galambosi and Galambosi, 1997; Rapcak and Galambosi, 1997).

In order to find new alternative crops suitable for the Nordic climate, a series of acclimatization agronomic experiments were carried out with cold tolerant medicinal plants at Mikkeli, Finland ($61^0$44 N, $27^0$18 E) during 1985-1999. Medicinal plants with adaptogen effects (*Leuzea carthamoides* L. and *Rhodiola rosea* L.), essential oil containing species with anthelmintic and insect repellent effects (*Artemisia abrotanum* l. *Myrica gale* L.), and plants from the high mountains of the Alps for medicinal and aromatic uses (*Arnica montana* L. and *Gentiana lutea* L.) were studied.

Arnica montana is a perennial medicinal plant originated from the high mountains of the Alps and the Carpatians. Its flower contains volatile oils, terpenoides, sesquiterpenes lactones, flavonoides, bitter principles with antiseptic, antifugal, antibiotic and antioxidant effects. The estimated consumption of the dry flower yield is about 20-30 to/year. Due to its intensive collection from the nature, it is now a rare and endangered species in the wild (Lange 1998).

Due to its cold tolerant characteristic, it grows well in Finland (Galambosi et al, 1998).

Gentiana lutea is a perennial medicinal plant originated from the same ecological origin as arnica (the Alps, the Carpatians, mountains of Massive Central in France). Due to its aromatic and bitter constituents, like gentiopicrosides, its root is a significant raw material in the pharmaceutical and liqueur industry. The major part of the annual industrial consumption (more than 2000 tons per year) is collected from the wild, but presently its cultivation has been started in Europe (Lange, 1998).

It seems that yellow gentian can be successfully grown in Finland.

Artemisia abrotanum is a perennial, erect-growing aromatic scrub, native to southern Europe. The content of essential oil in the dried leaves is 0,6-0,9% with 20-66% of 1,8-cineol as a main compound. Due to its aromatic properties, it was used as an anthelmintic, digestive, cholagogue, emmenagoge.

Contrary to its Mediterranean origin, it tolerated quite well the winters at Mikkeli and overwintered 2-3 consequent winters. Its cultivation for dry drug or essential oil production could be mechanized. The essential oil of the dried leaf yield was 1.2%,reaching its maximum at the start of flowering at the beginning of August. The main compound of the oil was 1,8 cineol (57,4%). The total fresh biomass of the first and the second year old plantations was 1.1 and 1.8 kg/m^2, respectively.

Leuzea carthamoides DC. is a perennial plant of Siberian origin. The plant has a woody rhyzome with wiry roots of a length of 20-40 cm.

Its roots, which have a novel type of pharmacological action classified as adaptogenic, are commonly used for medicinal purpose in Russia. Ecdysteroids, flavonoids, polyacetylenes and triterpenes have been isolated from its roots, leaves and seeds.

Based on experiments from 6 years, *Leuzea* has been succesfully introduced in Finland as a novel crop with special biological properties. It has shown a good adaptability to the Finnish climatic and soil conditions.

Legal protection of medicinal and aromatic plants (MAPs)

According to the present Finnish law, the following plant species have been assigned endangered or protected status in Finland.

Endangered and protected plant species in Finland:

- Critically endangered plants (CR): *Pimpinella major*, Rosa *canina*
- Endangered species (EN): *Agrimonia pilosa*, *Arctium nemorosum*
- Vulnerable (VU): *Arnica angustifolia, Asarum europaeum, Carlina vulgaris, Crataegus monogyna, Galium verum, Ononis arvensis*
- Near-threatened (NT): *Allium ursinum, Anchusa officinalis, Cinna latifolia, Galium odoratum, Dryopteris fragrans, Drosera intermedia, Allium schoenoprasum* var. *sibiricum*
- Regionally threatened species
  - regionally threatened: *Agrimonia eupatoria*, *Arctium lappa*, *Convallaria majalis*
  - regionally protected: *Angelica archangelica* subsp. *archangelica*
- Restricted collecting: *Daphne mezereum, Hepatica nobilis, Hippophae rhamnoides, Juniperus communis, Primula veris.*

Ex situ conservation

In Finland there is no special ex situ conservation for medicinal herbs.

Experiences in sustainable use of MAPs

• Organic production

Organic production is expanding continuously in Finland. In 1998 the total organic area controlled by the local authorities was 126 000 ha. Organic herb production is increasing, but is still very small: the organic and converting area was 71 ha in 1995, 121 ha in 1997 and 228 ha in 2001.

Since the health drug stores require organically grown raw materials, all medicinal plants are grown organically. Finnish consumers prefer herbicide-free products, therefore the local producers grow herbs using organic cultivation methods. Since weed control is not mechanized in organic cultivation, the production units and quantities produced remain small.

The areas of organically grown mustard, caraway and coriander are between 3-12 ha, dill and mint about 5 ha, and those of nearly 20 other herbs about 0.5-3 ha.

• Sustainable collecting of herbs

In the guide for wild herb collecting (Mäkinen *et al*. 1994) general instructions are given for sustainable collecting methods. These instructions were given in more detail in some cases, e.g. *Drosera rotundifolia*, which is collected in quite large quantities regularly. According to the new guidelines, the collector must leave 5-10 flowering plants per square metre on the peatland. In theory, this leaves about 400-900 seeds/m2. Additionally, sundew may be collected only once in the summer from each site. 35% of the whole population flowered after the first collecting. Following the new guidelines, also later-flowering plants can produce seeds safely, disperse them and ensure the natural regeneration of sundew populations. These instructions are emphasized in collectors' training programmes.

• Production-oriented dynamic preservation of threatened medicinal plants

According to a recent study of the commercial importance and threatened status of medicinal plants in Europe, about 150 species were reported to be threatened in at least one European country as a result of over-collecting from the wild (Lange 1998). Some of the threatened medicinal plants are cold-tolerant or belong to the original Finnish flora.

A series of 3-year cultivation experiments were carried out in Finland to study the suitability of several cold-tolerant medicinal plants for cultivation and possible raw material production (Bernáth 1988). Reasonable yields were obtained in southern Finland from the following species in organic conditions: *Achillea ptarmica*, *Acorus calamus*, *Alchemilla alpina*, *A. xanthochlora*, *Arnica montana*, *Gentiana lutea*, *Herniaria glabra*, *Leontopodium alpinum*, *Primula veris* and *Rhodiola rosea*.

Summary:

- There are about 50 wild flower medicinal plants of commercial importance. The quantity of dry wildflower medicinal plants can be estimated at about 4000-5000 kg/year.
- The most important wild medicinal plants are stinging nettle (*Urtica dioica*), birch leaves (*Folium betulae*) (1000-5000 kg/year/each), *Calluna vulgaris*, *Juniperus* berries, *Achillea millefolium* flowers (500-1000 kg/year/each), *Solidago*, *Filipendula*, *Taraxacum*, *Epilobium* and *Vaccinium myrtillus* leaves (100-500 kg/year/each). Fresh sundew (*Drosera rotundifolia*) is collected and marketed mainly to Switzerland.
- During the last 15 years, interest in and cultivation of herbs has increased significantly. At present about 30 different herbs and medicinal plants are cultivated in Finland to various extents.
- The most important cultivated herb is biannual caraway (*Carum carvi*) (3600 ha), followed by mustard (*Sinapis alba*) (50-400ha), dill (*Anethum graveolens*) (170 ha), parsley (*Petroselinum hortense*) (20-28 ha), garlic (*Allium sativum*) (24 ha), *Angelica*, *Oreganum*, *Mentha* sp., *Echinacea purpurea*, *Urtica, Artemisia dracunculus* (1-5 ha/each).
- According to the present Finnish law, there are some plants species that have been assigned endangered or protected (*Pimpinella major, Rosa canina, Agrimonia pilosa*, *Arctium nemorosum, Arnica angustifolia, Asarum europaeum, Carlina vulgaris, Crataegus monogyna)*.
- There are interesting experiences in sustainable use of MAPs in Finland: organic production, sustainable collecting of herbs, production-oriented dynamic preservation of threatened medicinal plants.

Information resources:

- B. Galambosi 2002, Medicinal and aromatic plants in Finland. European Cooperative Programme for Crop Genetic Resources network ECPGR. Report of a Working Group on Medicinal and Aromatic Plants.
- www.ienica.net
- B. Galambosi. Acclimatization studies with cold tolerant medicinal plants in Finland. (www.ienica.net)

FRANCE

France is located on the western parts of Europe.

The landscape of France is made up of low-lying plains, older mountain blocks and plateaus. The diversity of relief of France is very much similar to the relief of Continental Europe.

Other specialty crops

France is primarily located in the southern part of the temperate zone. The country is affected by oceanic influences.

The climate of France complements cultivation. The climate of France can be divided into three climatic zones-Oceanic, Continental and Mediterranean.

France ranks first among European countries for acreage planted with medicinal and aromatic plants (≈28,000 ha).

Two types of crops represent the most valuable production in France:

• Crops with low unit value, but extensively planted (lavandin, poppy).

• Crops that are picked or gathered in small quantities, with relatively high unit value (gentian, wild blueberries).

Table 1. Planted acreage of medicinal, aromatic and perfume plants in mainland France

CROP SPECIES PLANTED ON > 10,000 ha		
	Lavandin (13,300 ha)	
CROP SPECIES PLANTED ON > 5,000 et < 10,000 ha		
	Oil poppy (5,000 à 6,000 ha)	
CROP SPECIES PLANTED ON > 1,000 et < 5,000 ha		
Lavender (2,500 ha)		Clary (1,000 ha)
CROP SPECIES PLANTED ON > 100 et < 1,000 ha		
Tarragon	Thyme	Parsley
Bitter fennel	Hyssop	Psyllium
Ginkgo Biloba		
CROP SPECIES PLANTED ON > 10 et < 100ha		
Wormwood	Chervil	Peppermint
Dill	Chives	Passiflora
Angelica	Coriander	Woad
Green anise	Ergot	Horseradish
Artichoke	Sweet fennel	Rosemary
Burdock	Fenugreek	May rose
Basil	Gentian	Savory
Borage	Lovage	Officinal sage
Wild camomile	Melilot	Verbena
Roman camomile	Melissa	
Blackcurrant	Mint	
CROP SPECIES PLANTED ON < 10ha		
Artemisia	Hamamelis (witch hazel)	Meadowsweet

Other specialty crops

Bluet	Jasmine	Saffron
Calendula	Marjoram	Santolina
Cistus	Mallow	Saponaria (soapwort)
Escholtzia	Bitter orange	Valerian
Ginseng	Origanum (oregano)	Red creeper
Grindelia	Mouse-ear (hawkweed)	Violet
Marsh mallow	Dandelion	Others

Table 2. Speciality Crops: Area (ha)

	1995	**2000**	**2002**
Total Parfume Plants	**-**	**21,260**	**-**
Lavandin	13,300	16,274	19,000
Lavender	2,5	3,85	5
Clary	1,000	1,000	-
Other: May Rose, Jasmine, Iris, Violet, Bitter orange	-	136	-
Total Medicinal Plants	**-**	**9,640**	**-**
Oil Poppy	5,000-6,000	7,400	8,000
Ginkgo Biloba	-	490	-
Melilot	-	164	-
Psyllium	-	128	-
Comomile	-	106	-
Other (>40ha): Artichoke (leaf, St John's wort, Borage, Passiflora, Valerian, Echinacea)	-	367	-
Total Aromatic Plants (25 species)	**-**	**2,060**	**-**
Thyme, Tarragon, Parsley, Basil, Mint, Coriander, Wild Rose	-	>100 (each)	-
Other: Officinal Sage, Rosemary, Sweet Mint, Lemon Balm, Origanum, Shive, Savory, Chervil	-	>40 (each)	-
Total Dye Plants	**-**	**-**	**<20**
(cosmos, madder, dyer's greenweed, bukthorn, woad, Chinese indigo,weld, goldenrod)			

Lavandin and lavender cover 60% of the French planted acreage of medicinal, aromatic and perfume plants. France produces 70% of the world supply for these two crops.

Furthermore, many medicinal, aromatic and perfume plants are not grown, but are picked in the wild.

Some examples of perfume plants that are picked or gathered:

• Mimosa: 100 t/yr

• Labdaniferous cistus: 800 t/yr

• Narcissus: 400 t/yr

• Cypress: ~ 10 t/essential oils

• Blackcurrant buds: 35 t/yr

• Tree mosses: 2,000 – 2,500 t/yr

If one includes plants for perfume (lavander, lavandin and Salvia sclarea) France is the second with 23000 ha. 4000 ha are cultivated under commercial contracts with major firms such as Sanophi, Pernod-Ricard. Many other species are grown, but often an small scale. Approximately 4000 tons are also harvested from wild plots, mainly Gentian, lichen and ash leaves. These cultivations are competing with imports from different countries, especially Morocco, Albania and India.

France is European leader for cultivated organic pamp production.

Organic pamp surface area/Total pamp surface area in France: 4 to 5% and 15% of the surface area for aromatic and medicinal plants.

Distribution of cultivated surface areas:

- 40% in the Rhone-Alpes region
- 31% in the PACA region
- 6% in the Languedoc-Roussillon region
- 4% in the Midi-Pyrenees region and the Pays de la Loire region

Organic farming is a farming method which excludes the use of all synthetic chemicals.

Organic farming is a production mode frequently used when cultivating pamp. Organic farming is proportionally much more developed in the pamp channels. Organic farming also concerns picking.

The most cultivated PAMP in France:

- Lavender and lavandin are the plants most produced in organic farming. Their surface areas have been developing rapidly for the last few years and reach 407 ha for lavender and 248 ha for lavandin (organic – conversion). Today there is a strong market demand for lavender and lavendin essential oil.
- Thyme: cultivated for herbal remedies or for chemical type essential oils, this crop is on increase and totals 72 ha.
- Sage: both meadow sage and clary sage are developing.

– Lemon balm: after an important increase during the last few years, the surface areas is stabilizing. This organically farmed plants is used for drying or distilling.

Over 80 plants are also cultivated in France, some on very small surface (<5) and hundreds are harvested for the organic farming market.

Perfume, aromatic and medicinal plants are part of French agricultural heritage. Their growing and harvesting are traditional activities in many French regions: lavender and lavendin in Provence, camomile in the Maine-et-Loire, herbs in the Rhone valley.

The crops are often locally associated with the presence of processing and play a very important role in maintaining agricultural and economic activity in areas where there is often no other alternative culture or industrial development. They are a real asset in the regional development plants.

Some perfume, aromatic and medicinal plants produced in France:

Lavender and lavendin are the best-known of the french perfume plants, but clary sage and monarda are also widely used by the formulators of perfume mixtures.

Thyme, savory, oregano, rosemary and basil are the famous aromatics with make up the mixture known as “herbes de Provence”

For sale of fresh, frozen herbs, or of essential oils, mint and coriander are also crops which are developing fast. The gentian, a traditionally harvested product, enters into the composition of alcoholic drinks.

There are great number of medicinal plants, over 1200 are referenced in French pharmacopoeia. Camomile, valerian, passionflower, linden, these are some of the better known.

Summary:

- Acreage planted with medicinal, aromatic and perfume plants: >30000 ha.
- There are two types of crops which represent the most valuable production in France:

- crops with low unit value, but extensively planted (lavandin-13300 ha/1995, poppy – 5000-6000 ha/1995).

- crops that are picked or gathered in small quantities, with relatively high unit value (gentian, wild blueberries).

- Speciality crops cultivated in France:

- perfume plants: lavandin 19000 ha/2002, lavender, clary, may rose, jasmine, iris, violet, bitter orange.

- medicinal plants: oil poppy 8000 ha/2002, ginkgo biloba, melilot, psyllium, chamomile, artichoke, St. Jonh's wort, borage.

- aromatic plants: thyme, tarragon, parsley, basil, mint, caraway, wild rose, officinal sage,

rosemary, sweet mint, lemon balm, oreganum, shive, savory, chervil.

- dye plants: cosmos, madder, dyer's greenweed, buckthorn, woad, Chinese indigo, weld, goldenrod.

- Many medicinal, aromatic and perfume plants are picked in the wild (4000 tonnes, mainly gentian, lichen an ash leaves.
- France is European leader for cultivated organic pamp production (organic pamp surface area/total pamp surface area: 4-5%).
- The most organic cultivated pamp: lavender, lavandin, thyme, meadow sage, clary sage, lemon balm.

Information resources:

- www.ienica.net
- N. Verlet. Trends of the medicinal and aromatic plant sector in France. ISHS Acta Horticulture 306: International Symposium on Medicinal and Aromatic Plants, XXIII IHC
- www. onippam.fr

GERMANY

Unified Germany has an area of 356959 square kilometers.

As of the mid-1990s, about 37 percent of the country's area was arable; 17 percent consisted of meadows and pastures; 30 percent was forests and woodlands; and 16 percent was devoted to other uses. Geographers often divide Germany into four distinct topographic regions: the North German Lowland; the Central German Uplands; Southern Germany; and the Alpine Foreland and the Alps

Germany's climate is moderate and is generally without sustained periods of cold or heat. Northwestern and coastal Germany have a maritime climate caused by warm westerly winds from the North Sea; the climate is characterized by warm summers and mild cloudy winters. Farther inland, the climate is continental, marked by greater diurnal and seasonal variations in temperature, with warmer summers and colder winters.

In addition to the maritime and continental climates that predominate over most of the country, the Alpine regions in the extreme south and, to a lesser degree, some areas of the Central German Uplands have a so-called mountain climate. This climate is characterized by lower temperatures because of higher altitudes and greater precipitation caused by air becoming moisture-laden as it lifts over higher terrain.

Drugs made from medicinal plants have become ever more popular among doctors and

patients in Germany in recent years. Around 75 percent of customers in German pharmacies reach for a natural product when they buy non-prescription medications. In 2006, so-called phytopharmaceuticals accounted for around 2 billions euros worth of revenue, or about a third of the total revenue in non-prescription medications. That translates into a high demand for the raw materials for these products - medicinal plants and their leaves, flowers, roots and seed.

Pharma Wernigerode, one of the largest pharmaceuticals companies in eastern Germany, processes around a dozen medicinal plants, including five tons of chamomile and one ton of thyme annually. In total, 45000 tonns of medicinal plants are consumed in Germany each year, making it the market leader in Europe. According to statistics from the Federal Agency for Natural Conservation (BfN) around 1500 types of plants are traded in Germany, in larger or smaller amounts.

Internationally Germany is in the third place as importer and also in third place as exporter.

For a variety of reasons, the German herb market up to now has been supplied predominantly with imported botanical raw materials.

The increasing demand for raw drugs and plant essences is covered by the pharmaceutical industry by imports (90%),

Strict quality requirements are valid for the plant raw materials which are used for natural pharmaceutical products with regard to homogeneity and purity of the raw material, minimum content of effective components, limit values for plant-protective agent residues and microbial contamination.

In Germany there are currently approx. 70 different medicinal and spice plant species grown on a surface of 5600 hectares (compared to 2200 hectares in 1987).

The main cultivated herbs in 1999 were: Chamomile, St. John's wort, Milk Thistle, Fennel, Elder, Echinacea, Caraway Seed, Thyme, Common Balm, Valerian.

The cultivation of peppermint leaf (Mentha x piperita) in Germany has a very long tradition. Increased industrialization in Germany as well as increased cultivation abroad however led to a decline in its agricultural importances over the past century. Today the primary cultivation regions for local demand are situated in Southern-and Eastern European countries. Since the mid-1980's however the area of the land in Germany under peppermint cultivation has again been increasing with the benefit of modern harvest and post-harvest processing methods. At the moment, there are about 400 hectares of peppermint acreage in Germany with the largest areas in the States of Thuringia, Palatinate and Bavaria.

German government recommends increased medicinal plant cultivation in Germany. Raw material (quality standards) requirements are increasing and custumers are demanding products with documentation. The shift to this higher value market segment offers German farmers a good opportunity to win back market share,

Summary:

- Germany is the market leader in Europe as concerns the yearly medicinal plants consumption (45000 tonnes).
- Around 1500 types of plants are traded in Germany, in larger or smaller amounts.
- Internationally Germany is in the third place as importer and also in the third place as exporter.
- The German herb market is supplied predominantly with imported botanical raw materials (90%).
- There are currently approx. 70 different medicinal and spice plant species grown on a surface of 5600 hectares (compared to 2200 hectares in 1987).
- The main cultivated herbs are: Chamomile, St. John's wort, Milk Thistle, Fennel, Elder, Echinacea, Caraway, Thyme, Common Balm, Valerian, Peppermint (400 ha).
- The tendency is to increase medicinal plant cultivation in Germany to win back market share.

Information resources:

- www.ienica.net
- http://www.wkf.de
- Rede des Parlamentarischen Staatsekretars Dr. Peter Paziorek: Symposium “Nachwachsende Rohstoffe: Welche Markte haben Zukunft?” des BMELV. Berlin, Deutschland: Bundesministerium fur Ernahrung, Landwirtschaft und Verbraucher schutz (BMELV). 24 May 2007.

GREECE

Greece geography is dominated by either the rocky mountains or the deep blue sea. The geography of Greece is shaped at places by both the brine and the rock. This particular aspect of geography in Greece has given birth to an entirely unique climatic and natural vegetation conditions.

Greece comprises of a rugged mountainous mainland projecting out into the sea to the south of the Balkans. The Peloponnesian peninsula and the innumerable islands (about 2,000), including Euboea, Chios, Lesbos, the Dodecanese, Crete and the Ionian Sea islands as well as the Cycladic groups of the Aegean Sea.

80% of Greece is mountains or hills.

The dominant condition of Greece's climate is the alternation between hot, dry summers and cold, damp winters typical of the Mediterranean.

The use of herbal drugs in Greece has its roots in ancient times.

Other specialty crops

Medicinal plants used traditionally in Greece are, as a rule, recognizable from the following features: (i) they are native or if imported, they have been consolidated in Greek tradition long time ago; (ii) they are found in the market with a Greek local name (sometimes, as a modern influence, a commercial name deriving from the scientific name os is also used); (iii) they are mostly sold in the traditional shops and in the open-air market stalls. The use of most of these plants for therapeutic purposes dates from antiquity. A remarkable number of medicinal plants is cited by Dioscurides.

The utilization of many of Dioscurides plants is uninterrupted until today (e.g. *Artemisia absinthium, Asplenium ceterach, Centaurium erythraea, Foeniculum vulgare, Hedera helix, Hypericum perforatum, Juniperus oxycedrus, Laurus nobilis, Ruta graveolens, Teucrium polium,* etc.).

Examples of plants recently introduced to Greece, under the influence of worldwide trends, are the imported *Astragalus membranaceus, Centella asiatica, Eleutherococcus senticosus, Ginkgo biloba, Hydrastis canadensis, Paullinia cupana, Peumus boldus, Spiraea japonica, Yucca filamentosa.*

Recent decades have seen an effort to expend the cultivation of aromatic plants in Greece, where, previously, only naturally grown quantities were reaching the domestic and foreign markets. The interest in aromatic/medicinal plants was revived in recent years in the search for alternatives to less-marketable products produced in less – favoured areas.

Unfortunately we did not find public available actual data concerning the cultivation and/or collecting medicinal and aromatic plants from the wild in Greece except for *Ceratonia siligna.*

Carob beans (*Ceratonia siligna*)represent a class of Mediterranean tree-crops left outside the CAP effects. The present 20,000 tonnes/year are not an indication of the real potential, which depends upon the demand of particular industrial uses, such as that of roasted beans as cocoa substitute, and carob sugars as substrate of innovative bio-processes. Given the abundance of the crop around the Mediterranean basin, a carob-based technology could have a wider impact on the regional economies concerned.

Table 1. Carobs

Year	Area Harvested (ha)	Production (t)	Yield (t/ha)
2002	12,600	19,000	1,508
2001	12,600	19,000	1,508
2000	12,600	19,000	1,508
1999	12,600	19,000	1,508
1998	12,600	18,494	1,468
1997	12,600	19,134	1,519
1996	12,600	17,034	1,352

Summary:

- Unfortunately, there are very few public available data as concerns the medicinal and aromatic plants potential in Greece.
- The single tree-crop mentioned in Greece IENICA report is *Ceratonia siligna* cultivated on ~ 12600 ha/year during 1996-2002, whose roasted beans are used as cocoa substitute, and carob sugars as substrate of innovative bioprocesses.

Information resources:

- www.ienica.net
- E. Hanlidou, R. Karousou, V. Kleftoyanni, S. Kokkini 2004. The herbal market of Thessaloniki (N Greece) and its relation to the ethnobotanical tradition. Journal of Ethnopharmacology 91, 281–299.

ITALY

The geographical features of Italy are varied; the south-western corner of the country is enveloped by Tyrrhenian Sea, while Adriatic Sea takes care of its north-eastern parts. The south-eastern Ionian Sea and the Ligurian Sea located in north-west Italy encircle the country from al possible sides.

The Geography of Italy has two mountain ranges, namely the Alps and the Apennines.

Next to the mountains and the seas, come the valleys and the plain lands in the Geography of Italy .

Italy has a great diversity of climates ranging from the frigid in the higher elevations of the Alps and Apennines, to the semitropical along the coast of the Ligurian Sea and the western coast of the Lower Peninsula. The temperature, however, is balanced the year round and there is not much fluctuation and ranges between 11^0C to 19^0C (about 52^0F to 66^0F).

Review of the acreage of MAPs under cultivation

In 1999-2000, ISAFA carried out a survey of the acreage and the characteristics of MAPs under cultivation in Italy. According to this survey, the total area occupied by MAPs was 3342 ha and the number of species grown in Italy was over a hundred. However, slightly more than 30 species occupy over 90% of the total area. Beside Citrus bergamia Risso (bergamot), the only species with an area greater than 1000 ha, the other main species are: Mentha x piperita L. (peppermint), Fraxinus sp. (manna ash), Chamomilla recutita Rausch. (chamomile), Glycyrrhiza glabra L. (liquorice), Lavandula sp. (lavender and lavandin), Hypericum perforatum L. (St John's wort) and Linum usitatissimum L. (linseed). The mainspecies cultivated, assembled into six groups according to the area occupied, are

listed in Table 1. Compared with a similar survey carried out 10 years earlier (ISMEA 1989) the list of species has changed: tarragon, orris, roman wormwood, summer savory and jasmine have declined; peppermint, manna ash and saffron have fallen in importance, while chamomile, St John's wort, liquorice, lavenders, linseed, rosemary, fennel, sage, lemon balm and coneflower have greatly increased.

As to distribution, more than 50% of the total area cultivated in MAPs is located in Calabria where, besides bergamot, liquorice and cedar are also grown. Other regions where MAP cultivation has some importance are Piedmont, where excellent peppermint oil is obtained, and Tuscany, where numerous herbs are grown on a huge farm.

Excluding bergamot, from which the famous essence is obtained, about 70% of the total area cultivated in MAPs is used for the production of dried herbs, 20% for essential oil extraction and less than 10% for fresh consumption.

As regards farm size, there are huge individual and regional differences, but in general, only a small part of the arable area (a.a.) is reserved for MAPs. Farms specialized in MAP production (>80% of the a.a. planted to MAPs) represent only 17% of the total and most of them are located in the north. Nevertheless there are some exceptions: in Piedmont numerous large farms specializing in MAP cultivation are present, and in Tuscany the Aboca farm dedicates more than 300 ha to the cultivation of many species.

Concerning field management, most farms adopt organic techniques (61%), the largest proportion of organic farms being in the centre (75%) and the lowest in the south (43%); only bergamot, peppermint and St John's wort are handled as industrial crops, sustainable practices being used for other species.

Taking into consideration different parameters (proportion of specialized farms, postharvest machinery availability, trade association importance, etc.) it might be concluded that in the last 10 years there has been no widespread development of the sector or of associated facilities. This sector could have useful economic potential in Italy, but systems and organizations aimed to match supply and demand are lacking, and besides the supply is widely scattered.

Table 1. Medicinal and aromatic plants grouped according to the cultivated area, 1999

First group: >1000 ha	Surface (ha)
Bergamot	1500

Second group: 250-100 ha	Surface (ha)
Chamomile	171
Lavender and lavandi	133

Liquorice	146
Manna ash	200
Peppermint	239
St John's wort	156
Total	**1045**

Third group: 100-50 ha	Surface (ha)
Linseed	81

Fourth group: 50-10 ha			Surface (ha)
Anise	Flea-wort	Passion flower	593 (in total)
Blue gum tree	Ginkgo	Roman chamomile	
Burdock	Hash	Roman wormwood	
Citron	Hawthorn	Rosemary	
Clary sage	Hyssop	Saffron	
Coneflower	Immortelle	Sage	
Dandelion	Lemon balm	Summer savory	
Dog rose	Mauve	Sweet clover	
Fennel	Oregano	Thyme	

Fifth group: 10-1 ha			Surface (ha)
Alder	Fenugreek	Myrtle	108 (in total)
Artichocke	Genepi	Orange (flower)	
Black currant	Grindelia	Orris (roots)	
Californian poppy	Linden	Tarragon	
Caraway	Marigold	Witch hazel	
Chives	Marjoram	Wormwood	
Coriander	Marshmallow	Yarrow	
Dill	Meadow-sweet	Yew	

Sixth group: <1ha	Surface (ha)
About 50 different species	1

For colourants, a few hectares (6-7) are grown. These are I*satis tinctoria* (in Tuscany), *Chartamus tinctorius, Reseda luteola, Rubia tinctoria* (in Central Italy especially in Marche region).

For biocides, cruciferous crops (mostly radish and mustard) were grown for soil disinfestation from nematodes (sugar beet, vegetables) on about 7000 hectares in 2002 and on about 5000 in 2003 (unfavourable weather conditions).

Other specialty crops

Official statistics indicate that in Italy about one thousand hectares are grown under specialised intensive crop system, largely represented by the most commonly used species such as lavender, lavendin, Florentine iris, sage and gentian. An unestimable surface is occupied by a collection of minor species consisting essentially of various forms of gardening of practically no economic value.

Prior to 1945 Italy could be listed among the countries producing and exporting officinal plants; conversely it now depends on imports from abroad for about 90% of its requirements, including those species which find their natural habitat on Italian soil.

Many of these species originated in the Mediterranean are threatened of genetic erosion, hence the safeguard of this germplasm has become an important task.

Aromatic and medicinal plants are widespead throughout the Mediterranean region, being dominant elements of the natural flora. Nowadays, their cultivation is increasing continously due to the high demand for raw materials, especially products made with the help of “biological” techniques.

Cultivation trials performed in Sparacia – Sicily showed that clary sage (*Salvia silarea* L.), fennel (*Foeniculum vulgare* L.), dill (*Anethum fraveolens* L.), marigold (*Calendula officinalis* L.) and milk thistle (*Solybum marianum* Gaertn.) grew well under semi-arid Mediterranean conditions and gave a satisfactory yield.

Legal protection of medicinal and aromatic plant species and their natural habitats

The fundamental text of Italian legislation concerning medicinal and aromatic plants (MAPs) is still the Royal Decree (R.D.) no. 772 of 1932, in which a list of MAPs is reported and where the maximum quantity allowed to be harvested, upon authorization, is indicated (Table 2).

Table 2. Italy: list of the MAPs cited in the Royal Decree n° 772 of 1932

No.	Species	Quantity allowed to be harvested
1	*Achillea erba-rotta* All.	(aerial parts) 1 kg
2	*Achillea moschata* Wulfen	(aerial parts) 1 kg
3	*Aconitum* sp.	(leaves and roots) 0 kg
4	*Acorus calamus* L.	(roots) 2 kg
5	*Adonis* sp.	(full plants) 0 kg
6	*Angelica archangelica* L.	(seeds and roots) 2 kg
7	*Arctium lappa* L.	(roots) 5 kg
8	*Arnica montana* L.	(flowers and roots) 5 kg
9	*Artemisia absinthium* L.	(aerial parts) 1 kg
10	*Artemisia campestris* L. subsp. *borealis* (Pall.)	(aerial parts) 1 kg
11	*Artemisia genipi* Weber	(aerial parts) 1 kg
12	*Artemisia glacialis* L.	(aerial parts) 1 kg
13	*Artemisia pontica* L.	(aerial parts) 1 kg

17	*Artemisia umbelliformis* Lam.	(aerial parts) 1kg
15	*Artemisia vallesiaca* All.	(aerial parts) 1 kg
16	*Artemisia vulgaris* L.	(flowers, leaves, roots) 2 kg
17	*Atropa bella-donna* L.	(leaves) 0 kg
18	*Bryonia dioica* Jacq.	(leaves) 0 kg
19	*Centaurium erythraea* Rafn	(flowered plants) 5 kg
20	*Urginea maritima* (L.) Baker	(bulbs) 0 kg
21	Citrullus colocynthis (L.) Schrad.	(fruits) 0.5 kg
22	*Cnicus benedictus* L.	(aerial parts) 2 kg
23	*Colchicum autumnale* L.	(bulbs and seeds) 0 kg
24	*Conium maculatum* L.	(leaves) 0 kg
25	*Datura stramonium* L.	(leaves) 0 kg
26	*Delphinium staphisagria* L.	(seeds) 1 kg
27	*Dictamnus albus* L.	(flowered plants) 2 kg
28	*Digitalis purpurea* L.	(leaves) 0 kg
29	*Frangula alnus* Mill.	(bark) 0.5 kg
30	*Fraxinus* sp. L.	(manna) 0.5 kg
31	*Gentiana lutea* L.	(roots) 10 kg
32	*Glycyrrhiza glabra* L.	(roots) 10 kg
33	*Hyoscyamus niger* L.	(leaves) 0 kg
34	*Hyssopus officinalis* L.	(sprigs) 2 kg
35	*Peucedanum ostruthium* (L.) W.D.J.Koch	(roots) 2 kg
36	*Inula helenium* L.	(roots) 2 kg
37	*Juniperus sabina* L.	(sprigs) 0 kg
38	*Lavandula angustifolia* Mill.	(flowered tips) 10 kg
39	*Lavandula latifolia* Medik.	(flowered tips) 10 kg
40	Lycopodium *clavatum* L.	(spore) 0.5 kg
41	*Matricaria recutita* L.	(flowers) 10 kg
42	*Melissa officinalis* L.	owered tips, leaves) 5 kg
43	*Oenanthe aquatica* (L.) Poir.	(seeds) 0.5 kg
44	*Pinus mugo* Turra	(sprigs) 10 kg
45	*Psyllium afrum* (L.) Mirb.	(seeds) 0.5 kg
46	*Rhamnus cathartica* L.	(fruits) 0.5 kg
47	*Saponaria officinalis* L.	(leaves and roots) 10 kg
48	*Solanum dulcamara* L.	(stems)

49	*Tanacetum vulgare* L.	(flowers) 5 kg
50	*Taraxacum officinale* Weber	(roots, 5 kg.)
51	*Teucrium montanum* L.	(aerial parts) 2 kg
52	*Thymus vulgaris* L.	(flowered plants) 10 kg
53	*Tilia* sp.	(flowers) 10 kg
54	*Tussilago farfara* L.	(flowers) 5 kg
55	*Valeriana* sp.	(roots) 2 kg
56	*Veratrum lobelianum* Bernh	(roots) 0 kg

Nevertheless since the 1970s most regions and the two autonomous provinces of Trento and Bolzano have passed bills for flora and/or natural habitat protection. In these laws a list is given of species whose harvesting is forbidden or restricted, but few regional laws contain specific references to MAPs.

Among these, most regions (Piedmont, Liguria, Lombardy and Campania) limit themselves to referring to species and quantities mentioned in the R.D., while only Friuli- Venezia Giulia and Val d'Aosta provide regional lists of MAPs and fix quantities which may

be harvested. In Friuli for instance, it is allowed to collect the edible fresh parts of 26 species maximum quantity/day = 1 kg), while for the species not included in the list, derogations are provided only for scientific, pharmaceutical, medicinal or educational purposes. The list of wild protected MAPs and corresponding quantities allowed in Val

d'Aosta are almost the same as that of the R.D.

Friuli Venezia Giulia: list of MAPs whose harvest is regulated: *Allium schoenoprasum* L., *Arnica montana* L., *Aruncus vulgaris* Rafin, *Asperula odorata* L., *Cardamine pratensis* L., *Chenopodium* sp., *Fragaria vesca* L., *Galium mollugo* L., *Humulus lupulus* L., *Melissa officinalis* L., *Mentha* sp., *Origanum vulgare* L., *Papaver rhoeas* L., *Rosa canina* L., *Rubus fruticosus* L., *Rubus idaeus* L., *Ruscus aculeatus* L., *Ruta graveolens* L., *Silene cucubalus* Wibel, *Symphytum officinale* L., *Taraxacum officinale* Weber, *Tragopogon pratensis* L., *Urtica dioica* L., *Vaccinum myrtillus* L., *Vaccinum vitis-idaea* L., *Valerianella olitoria* L. Poll.

The regional laws to protect flora are more or less severe according to regions. In most regions the harvesting of unprotected species and of plants growing outside protected areas is unrestricted. On the contrary in other regions, in addition to a list of protected plants whose harvest is forbidden, severe limitations in the collection of other species are also provided and only a few specimens are allowed. Derogations to these restrictions are provided only for scientific, pharmaceutical, medicinal or educational purposes, but in any case harvesting needs an authorization. The regional law of Veneto does not provide derogations for "medicinal" purposes and as a consequence, in this region, MAP collecting is forbidden. The only exception is wild asparagus, of which you may harvest 1 kg/day.

Other specialty crops

In the regional lists of protected plants you may also find some "classic" MAPs among which *Dictamus albus* L., *Gentiana lutea* L. and two species of *Ruscus* (R. *aculeatus* L. and *R. ipoglossum* L.) are the most frequently recurring.

Genus	Species	Val d'Aosta	Piedmont	Liguria	Lombardy	Veneto	Trentino	Alto Adige	Friuli V. G.	Emilia Rom.	Tuscany	Umbria	Marche	Lazio	Campania	Abruzzo	Calabria
Achillea	*erba-rotta* All.																x
Aconitum	Sp.	x	x														
Arnica	*montana* L.	x(1)		x					x(2)	x							
Artemisia	*laxa* F.					x											
Artemisia	*umbelliformis* Lam							x									
Atropa	*bella-donna* L.		x											x(4)		x	
Crocus	sp.									x	x			x			
Dictamus	*albus* L.	x	x	x		x	x	x		x					x	x	x
Gentiana	sp.	x(1)	x	x	x	x		x		x		x			x	x	x
Glycyrrhiza	*glabra* L.															x	
Hyssopus	*officinalis* L.		x									x		x			
Iris	sp.		x	x	x				x					x			
Juniperus	sp.		x									x					
Mandragora	*autumnalis* Bert.													x			
Myrtus	*communis* L.															x	
Paeonia	*officinalis* L.	x	x	x	x	x			x		x	x					x
Pistacia	*lentiscus* L.											x					
Ruscus	sp.		x	x	x		x	x	x(2)		x(3)	x			x	x	
Solidago	*virgaurea* subsp. *littoralis* (Savi) *Burnat*										x						
Taxus	*baccata* L.									x		x	x	x		x	x
Thymus	*vulgaris* L.													x			
Urginea	*maritima* Bak.													x(4)			
Viscum	*album* L.										x						

(1) It is allowed to collect 6 flowering stems per day/person and 24 flowering stems per groups >3 people
(2) It is allowed to collect daily 1 kg of edible, fresh parts per person
(3) It is allowed to collect daily 10 flowering stems/person

(4) A collecting authorization is needed

Instead of referring to "protected species", in some regions of southern Italy (Basilicata and Puglia) and in the islands (Sicily and Sardinia), the lawmakers have designated "protected areas" in which every kind of capture (animals) or collecting (plants, lichens and mosses) is forbidden. In the Basilicata region there are 9 natural protected areas, in Puglia there are 33 in total (7 in each of the Bari and Lecce provinces, 11 in the province of Taranto and 4 in each of the Brindisi and Foggia provinces); in Sardinia 9 natural parks are present, covering more than 300 000 ha.

These laws have also undoubtedly contributed to preserving MAP genetic resources; nevertheless, in the meantime the reasons for the increasing rarity and/or extinction of these plants have changed: apart from oregano (*Origanum vulgare* L. subsp. *hirtum* (Link) *Ietswaart*), still abundantly collected in central and southern Italy, and myrtle (*Myrtus communis* L.), collected in Sardinia to make liqueurs, wild collecting has drastically decreased because very few people still take part in this activity.

Conservation ex situ

There are currently 38 botanical gardens in Italian universities. In addition there are 31 alpine gardens, including 16 located in the actual Alpine areas, 15 others in the Apennines (Sicily included) and 12 thematic gardens of which one is dedicated to MAPs, the "Giardino delle erbe" of Casola Valsenio.

Activities at a national level to record MAP natural resources

The main factor threatening the conservation of plant genetic resources (PGR) seems to be the change in land use in the agricultural and pastoral sectors: land abandonment and high-input agricultural practices together account for almost 3/4 (73%) of all the threatening factors identified.

Total number of MAP species in conservation	**1247**
Spontaneous in Italy	731
Endemic in Italy	30
Exotic	407
Cultivated	467

Summary:

- The total area occupied by MAPs: 3342 ha/2002, with over a hundred species grown.
- Beside Citrus bergamia Risso (bergamot), the only species with an area greater than 1000 ha, the other main species are: Mentha x piperita L. (peppermint), Fraxinus sp. (manna ash), Chamomilla recutita Rausch. (chamomile), Glycyrrhiza glabra L. (liquorice), Lavandula sp. (lavender and lavandin), Hypericum perforatum L. (St John's wort) and

Linum usitatissimum L.

- Most farms adopt organic techniques (61%). one thousand hectares are grown under specialized intensive crop system, largely represented by the most commonly used species such as lavender, lavendin, Florentine iris, sage and gentian.
- For colourants, a few hectares (6-7) are grown. These are *Isatis tinctoria*, *Chartamus tinctorius, Reseda luteola, Rubia tinctoria*.
- Italy depends on imports from abroad of medicinal and aromatic plants for about 90% of its requirements, including those species which find their natural habitat on Italian soil.
- The fundamental text of Italian legislation concerning medicinal and aromatic plants (MAPs) is still the Royal Decree (R.D.) no. 772 of 1932, in which a list of MAPs is reported and where the maximum quantity allowed to be harvested, upon authorization, is indicated. Since the 1970s most regions and the two autonomous provinces of Trento and Bolzano have passed bills for flora and/or natural habitat protection, but few regional laws contain specific references to MAPs.

– Because of the huge environmental variation in Italy and the restricted economic importance of MAPs in this country, it is not feasible to record MAP natural resources at the national level. According to the categories adopted by IUCN (International Union for the Conservation of Nature): *Centaurea cyanus* L. and *Marrubium vulgare* L. are considered critically endangered (CR); *Lactuca virosa* L. and *Rosa gallica* L., endangered (EN); *Gratiola officinalis* L., *Hyoscyamus niger* L. and *Hyssopus officinalis* L., vulnerable (VU); *Althaea officinalis* L., *Equisetum pratense* Ehrh., *Leonorus cardiaca* L. and *Lithospermum officinale* L., at low risk (LR).

  Information resources:

  – C. Vender, P. Fusani 2002, Conservation of medicinal and aromatic plants in Italy. European Cooperative Programme for Crop Genetic Resources network ECPGR. Reports of a working group on medicinal and aromatic plants.
  – www.ienica.net
  – G.Laghetti, P. Basso, D. Pignone, P. Perrino, Germplasm of medicinal and aromatic plants from Italy, ISHS Acta Horticulturae 344: International Symposium on Medicinal and Aromatic Plants.
  – A. Carrubba, R. la Torre, A. Matranga, Cultivation trials of some aromatic and medicinal plants in semi-arid Mediterranean environment, ISHS Acta Horticulturae 576: International Conference on Medicinal and Aromatic Plants. Pssibilities and Limitations of Medicinal and

LATVIA

Latvia is nestled in Northern Europe. Latvia is enclosed within dense forest covers, with about 12,000 miniature rivers and over 3,000 meandering lakes passing through the province.

Undulating plains cover 75 percent of Latvia's territory and provide the main areas for farming. About 27 percent of the total territory is cultivable.

The inventory data of MAP natural resources are not suitable for today's requirements, since it was obtained and published 20-30 years ago. Since then, the status of many species has changed, and now information on many species including MAPs is quite problematic.

Collecting of wild medicinal plants

The following medicinal plants are regularly collected from the wild only: *Filipendula ulmaria*, *Tanacetum vulgare*, *Taraxacum officinale* and *Tussilago farfara*.

Most of the marketed raw materials from the following species are collected from the wild: *Achillea millefolium* (~70%), *Bidens tripartita* (~70%), *Thymus serpyllum* (~95%) and *Hypericum perforatum* (~10%).

MAP cultivation in Latvia

Exact data on cultivation are not officially obtainable, since growers seem to be afraid to give accurate information owing to high taxes. The Medicinal Plant Association in Latvia, "Metra", consists of 95 members. Most growers with large cultivated areas are situated in the districts of Limbazi, Valmiera, Cesis and Aizkraukle.

According to the statistical information of Metra, the area cultivated under MAPs in 2001 was about 200 ha, but according to the statistical information of the Central Statistical Bureau of Latvia, the total area cultivated with MAPs is estimated to be about 300 ha.

Table 1. Estimated area of cultivated medicinal and aromatic plants in Latvia

Species	Total area (ha)
Valeriana officinalis	50
Chamomilla recutita	60
Hypericum perforatum	35
Mentha x piperita	30
Calendula officinalis	20
Carum carvi	50
Origanum vulgare	20
Viola arvensis and *V. tricolor*	3
Artemisia absinthium	3

Salvia officinalis	2
Bidens tripartita	2
Helichrysum arenarium	2
Leonorus cardiaca	2
Other MAP species (*Hyssopus officinalis*, *Majorana hortensis*, *Lavandula angustifolia*, *Thymus serpyllum*, etc.)	10
Total	**289**

Legal protection of medicinal and aromatic plant species and their natural habitats

The central executive institution for nature protection in Latvia is the Ministry of Environmental Protection and Regional Development. With the help of the institutions under its supervision, the Ministry is responsible for: preparing and implementing a national policy for nature protection, preservation and rational use of natural resources; drafting legal acts within its jurisdiction; harmonizing government mission statements with the requirements of the European agreements and Commission; and ensuring their implementation.

The Nature Protection Department of the Ministry of Environmental Protection and Regional Development is regulated by the laws of Latvia: Law on Protected Territories and Law on Conservation of Species and Habitats (National Programme of Biodiversity 2000). Medicinal and aromatic plants (MAPs) are included together with other species.

The National Programme on Biological Diversity. Its main tasks are in situ conservation and prevention of the decline in numbers and distribution of local wild species. The programme includes:

- Survey of medicinal plant resources;

- Development of nature reserves for the most important sites of medicinal herbs, where priority is given to resource maintenance and sustainable use;

- Development and implementation of commercial regulations for harvesting and trade in medicinal plants, including requirements for protection of herbs; and

- Popularization and promotion of herb cultivation.

Protected territories in Latvia with medicinal and aromatic plants

- State Nature Reserves (5): Moricsalas (1912), Slitere (1921), Grini (1936), Krustkalni (1977), Teichi (1982)

- National Parks (2): Gauja National Parka and Kemeri National Park

- Nature Parks (21): the most popular are "Tervete" Nature Park and "Daugavas Loki" Nature Park

- Nature Reserves (211): these areas are natural complexes unaltered by human activity, areas

where rare and endangered species can be found.

Ex situ conservation of MAPs

The collections of medicinal and aromatic plants are held in five institutes:

- Botanical garden of Latvia at Salaspils (largest MAP collection)
- Botanical garden of the Latvian University in Rîga
- Latvia University of Agriculture in Jelgava
- State Selection Station at Skriveri
- Bulduri Horticultural College.

Summary:

- The following medicinal plants are regularly collected from wild: *Filipendula ulmaria*, *Tanacetum vulgare*, *Taraxacum officinale* and *Tussilago farfara*. Most of the marketed raw materials from the following species are collected from wild: *Achillea millefolium* (~70%), *Bidens tripartita* (~70%), *Thymus serpyllum* (~95%) and *Hypericum perforatum* (~10%).
- The total area cultivated with MAPs is estimated to be about 300 ha.
- The main cultivated species are: *Valeriana officinalis, Chamomilla recutita, Hypericum perforatum, Menthaxpiperita, Calendula officinalis, Carum carvi, Origanum vulgare, Viola arvensis and V. tricolor, Artemisia absinthium, Salvia officinalis, Bidens tripartita, Helichrysum arenarium, Leonorus cardiaca, Hyssopus officinalis, Majorana hortensis.*
- Medicinal and aromatic plant species and their natural habitats are legal protected.
- “In situ” and “ex situ” conservation are used to avoid potential danger and existing threats to MAP species.

Information resources:

- I. Zukauska 2002. Medicinal and aromatic plants in Latvia. European Cooperative Programme for Crop Genetic Resources network ECPGR. Reports of a working group on medicinal and aromatic plants.

LITHUANIA

Lithuania is a northern European country. It also claims to be the major among the trio of Baltic States. Lithuania lies at the edge of the East European Plain. Lithuania's terrain is an alternation of moderate lowlands and highlands.

The country's climate, which ranges between maritime and continental, is relatively mild.

The use of wild medicinal and aromatic plants (MAPs) is widespread and has old traditions in Lithuania, especially in forested areas in the southern and southeastern parts of the country. About

100 taxa are still harvested from the wild for medicinal purposes, representing a significant part of the Lithuanian natural biodiversity which comprises 1323 vascular plant taxa.

The average annual volume of plant material coming from the wild represents about 29% of the total volume used in pharmaceutics. This means that about 85 t dry raw material is extracted from the wild populations yearly. The most frequently used native species in herbal medicine are *Crataegus* sp., *Arctostaphylos uva-ursi, Menyanthes trifoliata, Hypericum perforatum, Thymus serpyllum, Tussilago farfara, Polygonum aviculare, Urtica dioica* and *Frangula alnus.*

According to import-export data Lithuania can be characterized as a country mainly importing the raw material in contrast to other eastern and central European countries (Bernáth 1999). The average annual volume of imported MAP raw material is about 65% of all material used in the pharmaceutical industry. Exports make up a small part of the trade and are mainly directed to the countries of the former Soviet Union.

Cultivation is one of the solutions to the problem of over-exploitation of wild species. During recent years an ever-increasing number of the rural population became involved in medicinal plant cultivation. The cultivated production covers only 4-6% of the demand for MAP raw material. The main plants under more intensive cultivation are caraway, valerian, marigold, chamomile, peppermint, and lemon thyme.

In Lithuania 189 species are allowed to be used in conventional medicine and food industries, of which only 30 are cultivated species.

According to the crop declaration in 2001, 214 growers had in total 3122 ha area under the plants named as medicinal or etheric-oil plants (peppermint, caraway, etc.).

Caraway

Caraway is the most important specialist crop in today' Lithuania. Caraway, as a medicinal plant, has been cultivated in Lithuania since olden times. The ether oil of caraway contains carvon, which is used in alcohol production, and limonen, which is used in soap and perfumery production.

Table 1. Caraway area in Lithuania (‘000 ha)

	1998	1999	2000	2001	2002	2003
Caraway	0.6	0.9	0.8	2.4	4.8	6.5

The capacity of the domestic market for caraway can be estimated as 500 tonnes. The most active company in caraway production and trade is UAB Agrolitpa. This company contracts caraway with farmers providing them with seeds and purchasing production. Yield level of caraway is 1- 1.5 t/ha UAB Agrolitpa has about 85% of the total caraway exports in Lithuania.

Thyme (*Thymus*)

The raw material of thyme (absolutely dry) contains 0.12-0.27% of ether oil, 11% mineral

materials, ascorbic acid, flavonoids, saponines etc.

Production in Lithuania is several dozens tonnes.

Peppermint (*Mentha* x *piperita* L.)

Peppermint is grown as a herb, medicinal and melliferous plant. Its' ether oil contains 32-61% of menthol. Its green material yield is 10-14 t/ha. Production in Lithuania is several dozen tonnes.

Camomile(*Chamomilla rcutita* L.)

Camomile contains ether oil, ascorbic acids, carotene bitter and other materials. Production in Lithuania is some dozens tonnes.

Sage (*Salvia verticilatta*)

It accumulates biologically active compounds-polyphenols (flavonols, phenol carboxylic acid, and tannins). Research showed that during flowering and even later (August) it is possible to prepare the utmost amount of good quality raw material, which has to comprise not less than 0.15% of flavonols and PCA and 4.6% of tannins. Production in Lithuania is several dozens tonnes.

Lemon-balm (*Melissa officinalis* L.)

Its production in Lithuania is several dozen tonnes.

Valerian (*Valeriana officinalis* L.)

The roots of valerian contain over 100 various chemical materials. The underground part of valerian contains ether oil, valerianic acid, alkaloids, mineral matter, resins, starch. This traditionally important plant today faces market stagnation.

Echinacea purpurea

Echinacea purpurea a medicinal ornamental, melliferous plant. The biggest mass of dry grass is obtained in the fourth - fifth years 1.1 - 1.8 kg/m^2).

Phenological observations and qualitative and quantitative estimation of biological properties, growth development and productivity of the aboveground and underground parts and medicinal raw material proved that *E. purpurea* could be successfully cultivated in Lithuania and provide abundant medicinal raw material of good quality.

Table 2 .Crop area in all farms 1998-2003 ('000 ha)

Crop	1998	1999	2000	2001	2002	2003
Caraways	0.6	0.9	0.8	2.4	4.8	6.5
Medicinal herbs	0.1	0.0	0.0	0.3	0.1	
Etheric and aromatic	0.1	0.0	0.1	0.3	0.3	0.5

• Legislation

The harvest and trade of MAPs are regulated by the *Law on Protected Areas* (1993, 2001), *Law on Endangered Wildlife* (1996), *Law on Wild Vegetation* (1999) and *Law on Plant Genetic Resources Conservation* (2001). Recently, a draft law on the ratification of the *Convention on*

International Trade in Endangered Species of Wild Fauna and Flora was prepared. The Ministry of Environment regulates the gathering of wild MAPs and revises the list of species whose collecting is prohibited on the basis of research carried out by specialists from the Institute of Botany. The State Register (2000) of the *Law on Wild Vegetation* lists MAP species for which gathering from the wild indicated existing or potential conservation problems and whose collecting is therefore limited. Some medicinal plants are included in the National Red Book and are subjected to national legislation.

List of MAP species regulated by law in Lithuania:

Threatened MAP species whose collecting from the wild is regulated by law: A*corus calamus, Arctostaphylos uva-ursi, Angelica archangelica, Centhaurium erythraea, Centhaurium pulchellum, Cetraria islandica, Chimophila umbellata, Digitalis grandiflora, Gentiana cruciata, Hierochloe australis, Hierochloe odorata, Helichrysum arenarium, Lycopodium clavatum, Origanum vulgare, Potentilla erecta, Poleminium caeruleum, Primula veris, Plantago arenaria, Sanguisorba officinalis, Viscum album, Viola tricolor.*

MAP species included in the National Red Book: *Arnica montana, Allium angulosum, Allium vineale, Allium scorodoprasum, Allium ursinum, Arctium nemorosum, Gentiana cruciata, Hedera helix, Hypericum montanum, Hypericum hirsutum, Mentha longifolia, Polemonium coeruleum, Pulmonaria angustifolia, Salvia pratensis.*

• Conservation methods

Different methods are used to avoid potential danger and existing threats to MAP species, i.e. in situ and ex situ conservation. The biological peculiarities of species and their sources of raw material determine the conservation method. MAP species have been divided into three groups according to the source of raw material: sufficient, limited and insufficient:

1. For species with sufficient sources of raw material, the Law on Wild Vegetation regulates the exploitation of common species.

2. Widespread species characterized by a large phenotypic diversity but with low sources of raw material can be or are cultivated. Wild populations of these species are not endangered in their natural habitats; however the sampling of their diversity has been initiated to ensure the conservation of their germplasm and further use in breeding.

3. Species with low sources of raw material and narrow ecological adaptation, which are difficult to introduce into cultivation, are in the most critical situation. This group of species includes rare and endangered plants. The main factor causing the decrease in populations of these species is the changing environmental conditions.

Table 1. Medicinal and aromatic plants of commercial interest grouped according to the sources of raw material

Other specialty crops

Sources of raw material	Species
1. Sufficient	*Achillea millefolium, Artemisia vulgare, Artemisia absinthium, Calluna vulgaris, Crataegus sp., Epilobium angustifolium, Equisetum arvense, Filipendula ulmaria, Frangula alnus, Fragaria vesca, Glechoma hederacea, Hypericum perforatum, Humulus lupulus, Ledum palustre, Menyanthes trifoliata, Pulmonaria officinalis, Rubus idaeus, Tilia cordata, Tussilago farfara, Taraxacum officinale, Urtica dioica, Vaccinium vitis-idaea, Vaccinium myrtillus*
2. Limited	*Arctostaphylos uva-ursi, Arctium lapa, Arctium tomentosum, Agrimonia eupatoria, Angelica archangelica, Bidens tripartite, Chamomilla recutita, Chelidonium majus, Cichorium intybus, Convallaria majalis, Helichrysum arenarium, Inula helenium, Leonurus cardiaca, Malva sylvestris, Oenothera biennis, Origanum vulgare, Plantago arenaria, Primula veris, Plantago major, Polygonum bistorta, Potentlla erecta, Sambucus nigra, Symphytum officinale, Tanacetum vulgare, Viburnum opulus, Verbascum nigrum, Valeriana officinalis, Viola arvensis, Thymus serpyllum*
3. Deficient	*Acorus calamus, Arnica montana, Centhaurium erythraea, Cetraria isandica, Drosera anglica, Gentiana cruciata, Gnaphalium uliginosum, Herniaria glabra, Herniaria hirsuta, Lycopodium clavatum, Mentha longifolia, Petasites officinalis, Polygonum aviculare, Polemonium ceruleum, Viola tricolor, Viscum album*

In situ conservation

This method of conservation is used mainly for those species which are most endangered or for which conservation problems were identified. In situ conservation can be implemented using the existing protected areas that contain a broad range of MAP germplasm material.

The monitoring of the vitality of populations, coenodiversity changes and regeneration has been carried out on *Allium* L. spp., *Arctostaphylos uva-ursi* L., *Arnica montana* L., *Centhaurium erythraea* Rafn., *Origanum vulgare* L. and *Menyanthes trifoliata* L.

Ex situ conservation

Conservation of MAPs in field collections is carried out at the Institute of Botany, at the Kaunas Botanical Garden of Vytautas Magnus University, and at the University of Agriculture.

Target species for ex situ germplasm conservation are the following: *Achillea millefolium* L., *Allium oleraceum* L., *Carum carvi* L., *Helichrysum arenarium* L., *Hypericum perforatum* L., H. *maculatum Cranz*, *Humulus lupulus* L., *Origanum vulgare* L., *Thymus pulegioides* L., T. *serpyllum* L. and *Viola tricolor* L.

Summary:

- The average annual volume of plants material coming from the wild (85 t dry raw material)

represents about 29% of the total volume used in pharmaceutics.

- The most frequently used native species in herbal medicine are: *Crataegus* sp., *Arctostaphylos uva-ursi, Menyanthes trifoliata, Hypericum perforatum*, *Thymus serpyllum, Tussilaga farfara, Polygonum aviculare, Urtica dioica.*
- According to import-export data Lithuania can be characterized as a country mainly importing the raw material (65% of all the material used in pharmaceutical industry).
- The cultivated production (3122 ha/2001) covers only 4-6% of the demand for MAP raw material.
- The main plants under more intensive cultivation are caraway, valerian, marigold, chamomile, peppermint and lemon thyme.
- The harvest and trade of MAP_s are regulated by law.
- "In situ" and "ex situ" conservation are used to avoid potential danger and existing threats to MAP species.

  Information resources:

  - J. Radusiene 2002. Conservation of medicinal and aromatic plants in Lithuania. European Cooperative Programme for Crop Genetic Resources network ECPGR. Report of a Working Group on Medicinal and Aromatic Plants.
  - www.ienica.net

MALTA

The position of the Maltese Islands in the centre of the Mediterranean gives a special significance to their flora. The Maltese flora partakes of the floras of all the other parts of the Mediterranean and thus one finds species with eastern, western and North African affinities. As is to be expected the Maltese flora is most similar to that of Sicily.

The Maltese climate can be considered to be average for the Mediterranean region. Temperatures rarely fall below 5^{-0}C (although grass temperature occasionally falls below zero in winter) and rarely rise above 35^{0}C. The average annual rainfall is 513mm but evapotranspiration may reach 942mm.

Although the Maltese Archipelago has a restricted environment due to its small size, the diversity in biological species is vast. The variation in biodiversity is mainly linked to the connection of the warm North Africa to the cold southern Europe. The bioclimatic conditions of Malta are also found in coastal regions of other Mediterranean countries. In fact, about 66% of the flora of Malta is common to other Mediterranean regions. Common medicinal flora of the Mediterranean region and Malta

include conifers (Pinus halepensis and Cupressus sempervirens), broadleaved trees (*Laurus nobilis*, *Morus nigra*, *Tamarix gallica* and *Rhus coriaria*), fruit trees (*Ceratonia siliqua*, *Ficus carica*, *Punica granatum*, *Cercis siliquastrum*, *Nerium oleander*, *Citrus aurantium* and *Olea europea*) and others (*Allium sativum, Aloe ferox, Arbutus unedo, Capparis spinosa, Myrtus communis, Opuntia ficus-indica, Origanum vulgare, Papaver somniferum, Phytolacca decandra* and *Pistacia lentiscus*). The other 34% of the flora is adapted to cold European conditions (*Populus alba*, *Salix* spp. and *Crataegus monogyna*) and subtropical conditions (*Ceratonia siliqua*, *Ficus carica*, *Myrtus communis* and *Cynomorium coccineum*).

There are about 1264 vascular plant species, including casual or naturalized aliens. Of these, 458 species possess medicinal value. Predominating medicinal plant families include Compositae (15%), Labiatae (7%), Leguminosae (6%), Rosaceae (4%), Umbelliferae (4%), Liliaceae (3%), Solanaceae (3%), Cruciferae (3%), Caryophyllaceae (2%), Ranunculaceae (2%) and Papaveraceae (1%). These aromatic and medicinal herbs are found in small patches throughout the country.

In Malta, commercial natural products, found in pharmacies, are mainly obtained from European countries. Due to the lack of space available for agricultural practices, to date no medicinal or aromatic plants are being cultivated for purposes other than for culinary uses.

Medicinal and aromatic plant status

A considerable number of medicinal plants are under threat, mainly not due to overuse but to degradation by human activities including building and agricultural practices.

Medicinal plants under threat in Malta

	Extinct	Endangered	Vulnerable	Rare	Indeterminate	Total
Medicinal plants	9	9	5	20	1	44

Ex situ conservation

In Malta, few ex situ conservation measures are undertaken for medicinal plants.

In fact threatened medicinal plants are found both at the Botanic Gardens and on the University Campus, and in public gardens or public areas. Amongst these are included plants such as *Ephedra fragilis, Paleocyanus crassifolia, Rosmarinus officinalis, Vitex agnus-castus, Quercus ilex, Coronilla emerus, Viola odorata, Aloe vera, Pancratium maritimum, Salvia triloba, Spartium junceum, Centranthus ruber, Laurus nobilis, Ruscus hyphophyllum, Tamarix africana* and *Orchis morio.*

Conclusion:

Although the Maltese Islands have a high level of biodiversity, the limited land area lowers the potential for large-scale cultivation of medicinal and aromatic plants. Therefore the main aim, as

regards medicinal and aromatic plants, is to sustain and conserve the genetic stock by in situ and ex situ methods.

Information resources:

- www.maltawildplants.com
- E. Attard 2002. Status of medicinal and aromatic plants in Malta. European Cooperative Programme for Crop Genetic Resources network ECPGR. Reports of a working group on medicinal and aromatic plants.

UNITED KINGDOM

The United Kingdom constitutes of England, Scotland, Wales and Northern Ireland. The north and the west are made up of high hills and mountains, while the south and east has a lowland zone with milder climate and better soils for farming. Britain's moist climate with persistent rainfall has given rise to many rivers and lakes.

The climate of United Kingdom is usually moist, accompanied with moderate temperatures. The western coast and the southern regions enjoy warmer temperatures than the eastern coast and the northern regions. Temperatures are ordinarily around 15°C in summer and around 5°C in winter and in rare cases exceed 32°C or drop below -10°C. Frosts, when the temperature dips below 0°C, are also a rare phenomenon.

Current production of herbs in the UK occupies a relatively small area (ca. 4000 ha), mostly of culinary herbs.

A number of factors have been shown to influence the yield and composition of essential oils and bioactives from herb crops. These include genetics (origin, variation), morphogenesis (leaf position and age, harvest, flowering), environment (temperature, day length and light intensity) and finally agricultural practices (nutrition, irrigation, propagation, harvesting and extraction). Selection of plant material and the optimization of agricultural practices is vital for the production of high quality herbs, essential oils and extracts. The need to know how the crop has been produced (traceability of raw materials) and concern over the quality of imports (pesticides, heavy metals) suggests there is scope to supply extracted natural products from herbs grown in the UK to provide high quality raw materials for industry. There is potential to develop the UK herb industry, which encompasses a number of small- and medium-sized companies, if they meet the stringent specifications, supply chain and quality requirements.

The feasibility of work in this area of agriculture is increased by the application of modern technology (modern techniques of seed selection, improved agronomy, mechanised and improved product extraction and processing, and better crop production systems). Considerable promise is seen

for improvement through new varieties, by improving varieties grown overseas and adapting them to UK conditions, and by exploiting and/or domesticating non-crop plants.

Some novel crops of current interest within UK: Alpine plants, Daffodils, Bearberry, Birch, Bitter vetch, Bluebell, Bog bean, Bog myrtle, Borage, Calendula, Camelina, Chamomile, Coriander, Crambe, Cuphea, Dimorphotheca, Echium, Euphorbia, Evening Primrose, Eyebright, Heather, Hypericum, Juniper, Lavender, Lesquerella, Limnanthes, Lunaria, Lupins, Madder, Marjoram, Meadowfoam, Meadowsweet, Mustard, Naked oats, Nepeta, Parsley seed, Peppermint, Plantain, Pyrethrum, Rose, Rowan, Sage, Seabuckthorn, Spearmint, Thyme, Valerian, Vernonia, Weld, Woad, Yarrow, Yellow iris, Yew.

Anglia Industrial Crops Group has the aim to develop the production, processing and marketing of a range of new crops, with particular attention to quality, consistency, control and traceability of product. Marketing is direct to end users in UK and Germany in the food, pharmaceutical, cosmetic and chemical industries.

The programme has 23 crops under development . The target is for 1000 ha of production by the year 2000.

The range of crops includes:

Aromatic crops (dried leaf): Marjoram, Parsley, Sage, Savory, Spearmint, Fennel.

Aromatic crops (essential oils): Mustard, Both Chamomiles, Parsley seed, Peppermint, Spearmint, Thyme.

Extract crops: Calendula, Hypericum, Plantain, Valerian, Rose.

Miscellaneous: Woad, Mustard, Naked oats, Yew, Pyrethrum.

Norfolk Essential Oils (NEO) is a Growers' Co-operative of ten small farms in the East Anglian Fenland area (centred near Downham Market in Norfolk), NEO specialises in the growing and distillation of aromatic herbs for the production of Essential Oils.

English Chamomile (*Anthemis nobilis*) and English Yarrow (*Achillea millefolium*) are now in full commercial production and oils from both crops were commercially available in 1998. Other crops in development include German Chamomile (*Matricaria recutita*), Lavender (*Angustifolia*), rosemary, clary sage and angelica.

Highland Natural Products is a commercial venture to procure, process and market extracts and essential oils from a range of plants indigenous to the Scottish Highlands. Sales will be to the food, pharmaceutical, cosmetic and chemical industries in UK, Europe, US and Japan.

The range of species is likely to include: Birch for sap, Rowan for berries, Bog myrtle, Yellow iris, Eyebright, Meadowsweet, Juniper for berries, Heather, Bog bean, Seabuckthorn, Bitter vetch, Bearberry.

Initially, the material will be procured from wild harvested material from estates and crofts. In the long term, individual plants will be identified as a basis for the development of improved cultivars with high levels of the active ingredients of interest and to develop cultivation systems for them (bog myrtle and seabuckthorn will be the first).

Borage is perhaps the most widely grown specialist oil crop.

Other specialist crops cultivated on small acreages are: peppermint (~100 ha), chamomile, sage, lavender.

There are however no official statistics for the area of herb crops grown in UK. The total UK herb acreage19 was estimated at 1,261ha (1992). This was thought to have increased to 3000 ha by 1996, low in comparison with the potential to replace imported herb products.

The seed borage oil is a good source of essential fatty acids, especially gamma-linolenic acid (8-10%, GLA), which has medicinal properties for many serious diseases and disorders.

Grown only in small areas, mainly 2 to 5 ha. About 1000 ha now grown in UK. The crop is only grown under contract and future production is dependant on the demand for GLA by pharmaceutical companies and the extent to which borage and other sources of GLA are favoured instead of evening primrose.

Borage (*Borago officinalis*)

Indigenous to Britain: both grown wild and cultivated for centuries. Grown for use as a dietary food supplement. The oil has a high gamma linolenic acid (GLA) content - more than twice as much as evening primrose.

Calendula officinalis produced an average yield of 1.4 t ha and a maximum yield of 2.8 t ha. Seed oil content averaged 16.6 % with a calendic acid content of 45.4 %.

Table 1. Specialist crop area information (‘000 hectares)

Crop	1995	1996	1997	1998
Borage	1.111	0.944	0.475	1.708
Chamomille	0.007	0.033	0.027	0.111
Evening Primrose	0.037	0.0125	0.005	0.121
Lavender	0.055	0.020	0.063	0.037

Table 2. Industrial crops grown on set-aside land – Area under production (‘000 ha)

Specialist crops	1990	1993	1994	1995	1996	1997	1998
Borage	-	-	-	-	-	-	0.06
Calendula	-	-	-	-	-	-	0.002
Camelina	-	-	-	-	0.005	0.05	-

Chamomile	-	-	-	-	-	0.03	0.04
Cuphea	-	-	-	-	-	-	-
Dimorphotheca	-	-	-	-	-	-	-
Echium	-	-	-	-	-	0.02	0.19
Euphorbia	-	-	-	-	-	-	-
Evening Primrose-	0.09	0.18	0.13	0.19	0.04	0.05	-
Lavender	-	-	-	-	-	-	-
Lesquerella	-	-	-	-	-	-	-
Lunaria	-	-	-	-	-	-	-
Peppermint	-	0.004	-	-	-	-	-
Woad	-	-	-	-	-	-	-

An analysis of speciality crops grown on set-aside land in the UK (2002)shows that *Papaver somniferum* represents 51.3%, Chamomile 46.4%, Peppermint 0,1%, Valerian 0.1%, Lemon Balm 0.3%, Angelica 0.3%, Yarrow 0,4%, Hyssop 1.1%.

Papaver somniferum (Opium Poppy) has been grown in the UK since 2002. The area grown has dramatically increase from 466 in 2002 (initial commercial year) to 1509 hectares in 2003 to meet production contracts. Cultivated poppies are the source of opium for morphine and codeine. The seed are also used in confectionery and bakery, and high quality artists paints, cosmetics and medicine.

The area of chamomile being produced in the UK has increase significantly since 1998. The area grown has increase from 43 hectares in 1998 to 175 hectares in 2002.

Statistical data show 2800 ha cultivated with borage in 2009, respectively 6800 ha cultivated with crops from aromatic or medicinal use.

International data show that in England collecting of medicinal and aromatic plants from the wild flora is restricted to occasional self-consumation.

Conclusion:

- Current production of herbs occupies a relatively small area (ca. 4000 ha), most of culinary herbs.
- There is a tendency to supply extracted natural products from herbs grown in the UK to know the traceability and the quality of raw materials
- *Borago officinalis* (source of γ- linolenic acid) is the most widely grown specialist oil crop (2800 ha cultivated in 2009 vs. 6800 ha cultivated with crops for aromatic or medicinal use).
- An analysis of specialty crops grown on set-aside land in UK (2002) shows that *Papaver somniferum* represents 51,3%, Chamomile 46,4%, Peppermint 0,1%, Valerian 0,1%, Lemon Balm 0,3%, Angelica 0,3%, Yarrow 0,4%, Hyssop 1,1%.

- Collecting of medicinal and aromatic plants from the wild flora is restricted to occasional self-consumption.

Information resources:

- www.ienica.net
- R. Cole 2002. Medicinal and aromatic plant production in the United Kingdom. European Cooperative Programme for Crop Genetic Resources network ECPGR. Report of a Working Group on Medicinal and Aromatic Plants.
- www. statistics defra.gov.UK

THE NETHERLANDS

The Netherlands is bound on the north and west by the North Sea, on the east by Germany, and on the south by Belgium.As The Netherlands has high mountains, the climate varies a little from region to region. Overall, it has a temperate maritime climate.

In the Netherlands herb growing is only of very small importance. On a total of 800000 hectares of arable land, approximately 450 hectares of herbs are grown (0.05%). This surface includes all more or less 'traditional' aromatic and medicinal herbs. Far the most of it is contracted and dried by three cooperatives, and marketed collectively by the United Dutch Herbs Cooperation . A small part of the production (mainly parsley and celery) is processed fresh by the preserving industry and only a very small acreage is grown and marketed strictly biological. Seed crops like caraway, poppy and, the recently introduced, evening primrose are not included in this surface. These are more freely produced crops, which are easier to be sold on more markets.

Within this surface of 450 hectares about 20 different herbs can be found, in area variating from 1 to 150 hectares. *Digitalis lanata* is most important by far.

During the last decades, the total area of cultivated herbs didn't change a lot. There is a tendency to more different herb-crops, resulting in a further splitting up. of the acreage. Relatively new one's are, for instance, *Plantago*, thyme, *Taraxacum* and *Chrysanthemum*. By means of new selections and better cultivation tehniques, the production of traditional grown herbs increase and could take place on a smaller surface.

In total there are about 140 Dutch farmers involved in this production.

Summary:

- Herbs growing is only of very small importance. On a total of 800000 ha of arable land approx. 450 ha of herbs are grown (0,05%)
- About 20 difference herbs can be found, in area variating from 1 to 150 hectares. *Digitalis lanata* is the most important by for.
- Plantago, Thyme, *Taraxacum* and *Chrysanthemum* are relatively new cultivated herbs.

Information resources:

- H. Mheen. The cultivation of herbs and research of the cultivation of herbs in the Netherlands. ISHS Acta Horticulturae 331: WOCMAP I – Medicinal and Aromatic Plants Conference: part 3 of 4.

POLAND

Poland Geography is marked by a long unbroken plain that runs from the Baltic Sea in the North to the Carpathian Mountains in the south. There are obviously variation in the terrain of Poland Geography which generally runs in band from the Eastern side to the West. The total area of Poland Geography is 312,683 square kilometers.

Poland's long-term and short-term weather patterns are made transitional and variable by the collision of diverse air masses above the country's surface. Maritime air moves across Western Europe, Arctic air sweeps down from the North Atlantic, and subtropical air arrives from the South Atlantic. Although the Arctic air dominates for much of the year, its conjunction with warmer currents generally moderates temperatures and generates considerable precipitation, clouds, and fog. When the moderating influences are lacking, winter temperatures in mountain valleys may drop to -40° C.

Poland is an important producer of medicinal and aromatic plant (MAP) raw materials. About 200 MAP species are collected in larger or smaller amounts from natural sites, including 80 for commercial purposes 70 species are cultivated. The average annual harvest of raw materials from natural sites is estimated at 3000-5000 t. About 20000 t of MAP raw materials originate from cultivation.

Over 10 000 people in Poland are directly or indirectly involved in herb collecting, cultivation, processing and trading.

The distribution of medicinal plants grown wild in Poland is irregular. Most of them, taking into consideration both the number of species and the area of natural sites, occur in the east of Poland. It is a special region representing the transitional area between continental and Atlantic climates. It is one of the ecologically cleanest parts of Poland, without heavy industry, large urban agglomerations or large agricultural farms.

There is no detailed documentation so far concerning the distribution of wild-growing MAP species in Poland. The investigations on natural habitats have been made only for some species (e.g.

Achillea sp., *Centaurium umbellatum*, *Hypericum* sp., *Euphrasia* sp., *Adonis vernalis, Atropa belladonna, Arctostaphylos uva-ursi*) and for chosen areas.

Wild-growing MAP species are endangered by two main factors: the first, not specific to MAPs, is connected with irreversible abiotic changes of the environment (e.g. lowering of ground water level, pollution of the environment and eutrophication of natural water reservoirs); the second is specific to MAPs, i.e. uncontrolled and excessive harvesting.

The most important MAP raw materials collected from natural sites are (in descending order of tonnage of purchased raw material): *Urtica dioica* (leaves) > *Hypericum perforatum* (herb) > *Tilia cordata* (inflorescences) > *Frangula alnus* (bark) > *Sambucus nigra* (fruits) > *Rosa canina* (fruits) > *Equisetum arvense* (herb) > *Betula verrucosa* (leaves) > *Solidago virgaurea* > *Quercus robur* (bark) > *Salix purpurea* (bark) >*Aesculus hippocastanum* (bark) > *Pinus sylvestris* (buds) > *Agropyron repens* (rhizomes) > *Taraxacum officinale* (roots) > *Potentilla erecta* (rhizomes) > *Juniperus communis* (fruits) > *Crataegus oxyacantha* (fruits) > *Sambucus nigra* (flowers) > *Helichrysum arenarium* (inflorescences).

The harvest of individual medicinal species is differentiated, from 100 kg to several hundred per year.

As concerns MAPs cultivation, it is difficult to present exact data on the acreage and production volume of MAPs in Poland owing to the increasing number of new Polish private enterprises involved in MAP production and the activity of many foreign firms on this market.

Herbal cultivation in Poland occupies an area of 20000-25000 ha. Herbs are cultivated by almost 20000 farms. There are about 70 medicinal species in cultivation.

The total mass of raw materials from cultivations according to data for the last 5 years amounts 17000.

The main cultivated species are (in descending order of acreage and tonnage of purchased raw material): *Oenothera* sp. (seeds) > *Carum carvi* (fruits) > *Silybum marianum* (fruits) > *Mentha piperita* (leaves) > *Chamomilla recutita* (inflorescences) > *Origanum majorana* (herb) > *Valeriana officinalis* (roots) > *Thymus vulgaris* (herb) > *Melissa officinalis* (herb) > *Coriandrum sativum* (fruits) > *Borago officinalis* (seeds) > *Cynara scolymus* (herb) > *Althaea officinalis* (roots) > *Archangelica officinalis* (roots) > *Levisticum officinale* (roots) > *Salvia officinalis* (leaves) > *Echinacea purpurea* (herb and roots) > *Ribes nigrum* (seeds) > *Ruta graveolens* (herb) > *Plantago lanceolata* (leaves).

The main MAP raw materials exported by Poland are: *Carum carvi* (fruits) > *Oenothera* sp. (seeds) > *Valeriana officinalis* (roots) > *Mentha piperita* (leaves) > *Thymus vulgaris* (herb) > *Chamomilla recutita* (inflorescences) > *Potentilla erecta* (rhizomes) > *Hypericum perforatum* (herb) >

Borago officinalis (seeds) > *Tilia cordata* (inflorescences).

The cultivation of MAPs in "ecological farms" (practicing organic farming) in Poland started in the beginning of the 1990s. Unlike that of agricultural and animal organic production, the increase in organic MAPs' acreage is relatively slow. Organic MAP production is currently concentrated mainly in southeastern Poland. Seven major MAP species are cultivated in 80 organic farms and about 15 other MAP species are cultivated on smaller areas.

Major MAP species cultivated in organic farms in Poland

Species	Cultivated area (ha)
Oenothera sp.	25
Borago officinalis	5
Valeriana officinalis	3
Thymus vulgaris	3
Nigella sativa	3
Mentha piperita	2
Ribes nigrum (leaves)	5

The legal protection of MAPs in Poland is based both on:

- international conventions ratified by Poland in 1995: Convention on the Conservation of European Wildlife and Natural Habitats, Bern Convention 1982; Convention on Biological Diversity, Rio de Janeiro 1992; and

- national regulations: Preservation of Nature Act (16.10.1991); Decree of the Minister of Environment Protection, Natural Resources and Forestry on the protection of plant species (06.04.1995); Decree of The Minister of Environment Protection, Natural Resources and Forestry in consultation with the Minister of Health and Social Welfare and the Minister of Agriculture and Food Management, concerning the rules of harvesting of wild-growing medicinal plants or those important for pharmaceutical industry, as well as the management of the plantations of those plants (in preparation); and the Polish Red Book of Plants.

The official control organizations involved in the preservation of MAPs in Poland are the National Conservatory of Nature (attached to the Ministry of Environment), Provincial Conservatories of Nature, and Nature Preservation League (inspectors). Other institutions are also interested in this issue such as the Ministry of Agriculture and Rural Development, the Scientific Council for the Conservation of Plant Genetic Resources affiliated to the above Ministry, universities and research institutes.

According to the law, 111 species of Polish flora are strictly protected, including 20 species of herbaceous medicinal plants (*Lycopodium* sp., *Gypsophila paniculata,Cimicifuga europaea, Aconitum*

sp., *Adonis vernalis, Nymphaea alba, Nuphar luteum, Drosera sp., Archangelica officinalis, Polemonium coeruleum, Echium rubrum, Atropa belladonna, Digitalis purpurea, Gentiana* sp., *Arnica montana, Veratrum* sp., *Colchicum autumnale, Leucoium vernum, Galanthus nivalis and Hierochloe odorata*).

Sixteen other MAP species are partly protected (*Cetraria islandica, Ribes nigrum, Ononis spinosa, Frangula alnus, Ledum palustre, Arctostaphylos uva-ursi, Viburnum opulus, Polypodium vulgare, Asarum europaeum, Primula elatior and P. officinalis, Asperula odorata, Centaurium umbellatum, Gentiana asclepiadea, Helichrysum arenarium, Convallaria maialis, and Hierochloe australis*). Their harvesting is possible in specified amounts and time limits, with the permission of the Provincial Conservatories of Nature.

The cultivation of several special species is regulated or forbidden: *Papaver somniferum*, *Digitalis* sp., and *Cannabis sativa*. Special, official permissions are required to cultivate those plants, provided by local authorities and the Ministry of Agriculture and Rural Development.

Collections of both wild and cultivated MAP species are maintained in botanical gardens. Six of the numerous botanical gardens in Poland maintain large MAP collections and offer the seeds of those plants according to the *Index Seminum*. These are mainly the seeds of plants cultivated in those gardens (1765 accessions from 110 families). However some botanical gardens (e.g. Botanical Garden of Medicinal Plants, University of Medicine, Wrocław) also possess seeds of wild medicinal plants collected from natural sites (208 accessions).

The Department of Vegetable and Medicinal Plants, Warsaw Agricultural University also maintains ex situ collections of some MAP species.

Summary:

- Poland is an important producer of medicinal and aromatic plants (MAP) raw material.
- About 200 MAP species are collected in larger or smaller amounts from natural sites. The average annual harvest is estimated at 3000-5000 tonnes.
- 70 species are cultivated on 20000-25000 ha/year by almost 20000 farms. About 20000 t of MAP raw material originate from cultivation.
- The most important MAP raw materials collected from the wild are (in descending order of tonnage): *Urtica dioica* (leaves), *Hypericum perforatum* (herb), *Tilia cordata* (inflorescences), *Frangula alnus* (bark), *Sambucus nigra* (fruits), *Rosa canina* (fruits), *Equisetum arvense* (herb), *Betula verrucosa* (leaves), *Solidago virgaurea, Quercus robur* (bark), *Salix purpurea* (bark), *Aesculus hippocastanum* (bark), *Pinus sylvestris* (buds), *Agropyron repens* (rhizomes), *Taraxacum officinale* (roots), *Potentilla erecta* (rhizomes), *Juniperus communis* (fruits), *Crataegus oxyacantha* (fruits), *Sambucus nigra* (flowers), *Helichrysum arenarium*

(inflorescences).

- The main cultivated species are (in descending order of acreage and tonnage of purchased raw material): *Oenothera* sp. (seeds), *Carum carvi* (fruits), *Silybum marianum* (fruits), *Mentha piperita* (leaves), *Chamomilla recutita* (inflorescences), *Origanum majorana* (herb), *Valeriana officinalis* (roots), *Thymus vulgaris* (herb), *Melissa officinalis* (herb), *Coriandrum sativum* (fruits), *Borago officinalis* (seeds), *Cynara scolymus* (herb), *Althaea officinalis* (roots), *Archangelica officinalis* (roots), *Levisticum officinale* (roots), *Salvia officinalis* (leaves), *Echinacea purpurea* (herb and roots), *Ribes nigrum* (seeds), *Ruta graveolens* (herb), *Plantago lanceolata* (leaves).
- Poland is the third largest EU exporter of medicinal and aromatic plants (17 thousand tonnes in 2006). The total Polish imports of MAPs amounted to 7,1 thousand tonnes/ 2006 (Leading supplier: Germany 28%). Export exceeds import of MAPs.
- The main MAP raw materials exported by Poland are: *Carum carvi* (fruits), *Oenothera* sp. (seeds), *Valeriana officinalis* (roots), *Mentha piperita* (leaves), *Thymus vulgaris* (herb), *Chamomilla recutita* (inflorescences), *Potentilla erecta* (rhizomes), *Hypericum perforatum* (herb), *Borago officinalis* (seeds), *Tilia cordata* (inflorescences).
- Major MAP species cultivated in organic farms are: *Oenothera* sp. (25 ha), *Borago officinalis* (5 ha), *Valeriana officinalis* (3 ha), *Thymus vulgaris* (3 ha),*Nigella sativa* (3 ha), *Mentha piperita* (2 ha), *Ribes nigrum* (leaves) (5 ha).
- The legal protection of MAPs in Poland is based both on international convention ratified by Poland and national regulations. According to the law, 20 species of herbaceous medicinal plants are strictly protected, 16 other species are partly protected.
- The cultivation of *Papaver somniferum*, *Digitalis* sp. and *Cannabis sativa* is regulated or forbidden.

  Information resources:

  - www.ienica.net
  - K. Seidler-Lozykowska 2009. Medicinal plant seed as an element of increasing biodiversity of grassland. SALVERE - Regional Workshop in Poland, 45-47.
  - Z. Weglarz, A. Geszprych 2002. The status of medicinal and aromatic plants in Poland. European Cooperative Programme for Crop Genetic Resources network ECPGR. Reports of a working group on medicinal and aromatic plants.
  - J. Jambor 2007. Herbal cultivation and processing in Poland – status quo and tendencies. Herba Polonica 53(2), 25-26.

- CBI Market Information Database.
- URL: www.cbi.eu

Romania

Romania is situated in the south-eastern part of Central Europe inside and outside of the Carpathians Arch, on the Danube lower course and has an exit to the Black Sea.

The relief of Romania is distributed harmoniously: the mountains form an arch in the central part of the country and represent 31% of the total area of the country. Hills and plateaus covering 33% of the country surround the Carpathian mountain chain, and the plains, situated to the south and to the west of the country, represent the remaining 36%.

Romania's climate is temperate – continental of transition, with oceanic influences from the west, Mediterranean from the south–east and continental–excessive from the north–east.

The Romanian flora includes 3450 chromophyte species which represent 30% of the vascular European flora. Among these, 283 species have therapeutic effects and 180 species are studied, but only 52 species are cultivated.

There is a big diversity of vegetable species with medicinal and aromatic properties in Romania. Agronomist researchers established the cultivation technologies for about 50 species in pedoclimatic conditions specific to Romania

The dynamic of areas cultivated with MAP over a fifteen year period (1995-2009) depended on many factors, among which the relief and climatic conditions are decisive. Social factors and local customs, economic factors and agricultural policy also had great influence. Whilts in 1995 the area covered with MAP was 26,500 ha, in 2009 it has decreased at 10,684 ha. The same situation as regards the yields: 20,900 tonnes/1995 vs. 9,100 tonnes/2009.

Cultivated area (‘000 hectares) and production (‘000 tonnes) of medicinal and aromatic herbs in 1995-2009

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Area ('000ha)	26,5	35,8	23,4	15,9	20,6	22,5	10	10,6	9,52	9,1	4,6	25,1	10,76	9,95	10,68
Production ('000t)	20,9	21,5	12,1	6,3	12,1	6,6	6,5	5,35	5,39	9,2	3,3	14,77	5,1	8,99	9,1

The main cultivated species are: Coriander (*Coriandrum sativum* L.), Common marigold (*Calendula officinalis* L.), Artichoke (*Cynara scolymus* L.), Garden thyme (*Thymus vulgaris* L.), Common fennel (*Foeniculum vulgare* Mill.), Hyssop wort (*Hyssopus officinalis* L.), Balm (*Melissa officinalis* L.), Peppermint (*Mentha piperita* L.), Common spearmint (*Mentha crispa* L.), White mustard (*Sinapis alba* L.), Shapsage (*Salvia officinalis* L.), Milk thistle (*Sylibum marianum* L.).

The production is partly used domestically.

As concerns the exports of cultivated and wild medicinal herbs, the situation for the period 2000-2008 is the following:

Export of medicinal and aromatic plants

Year	2000	2001	2002	2003	2007	2008
Quanity (tonnes)	39,7	32,7	35,7	62,0	282,2	337,7
Value ('000 EUr)	461,1	215,4	151,4	455,8	1216,0	2448,7

In the same time the import of medicinal and aromatic plants was the following:

Import of medicinal and aromatic plants

Year	2000	2001	2002	2003	2007	2008
Quanity (tonnes)	195,2	1635,2	2067,6	2568,2	3141,7	3721
Value ('000 EUr)	964,3	5085,7	7019,4	9777,3	10054,9	10450

The import of medicinal and aromatic plants exceed the export.

Besides the cultivated plants, the following medicinal and aromatic plants are collected from the wild:

- Flores: *Robinia pseudoacacia* L., *Artemisia absinthium* L, *Althaea rosea*, *Delphinium consolida* L., *Matricharia chamomilla* L., *Crataegus monogyna* Jacq., *Centaurea cyanus*, *Aesculus hippocastanum* L., *Lamium album* L., *Malva species*, *Melilotus officinalis* L., *Achillea millefolium* L., *Sambucus nigra* L., *Sophora japonica* L., *Tilia cordata* Mill., *Tilia tomentosa* Moench., *Trifolium repens* L., *Trifolium pratense* L., *Filipendula ulmaria* L., *Verbascum phlomoides* L., *Viola odorata* L.
- Folium: *Abies alba* Mill., *Betula verrucosa* Ehrh., *Castanea sativa* Mill., *Corylus avellana* L., *Crataegus monogyna* Jack., *Fragaria vesca* L., *Fraxinus excelsior* L., *Hedera helix* L., *Aesculus hippocastanum* L., *Hyoscyamus niger* L., *Juglandis regia* L., *Malva species*, *Mentha species*, *Morus alba* L., *Vaccinium myrtillus* L., *Picea abies* L. *Karstga*, *Pinus mugo* Turra, *Pinus silvestris* L., *Plantago lanceolata* L., *Plantago major* L., *Plantago media* L., *Ribes nigrum* L., *Ribus fructicosus* L. et. Sp., *Rubus idaeus* L., *Sambucus nigra* L., *Taraxacum officinalis* Web., *Urtica dioica* L., *Viscum album* L., *Vaccinium vitis idaea* L.
- Herba: *Artemisia absinthium* L., *Adonis vernalis* L., *Alchemilla arvensis* L., *Agrimonia eupatoria* L., *Potentilla anserina* L., *Artemisia vulgaris* L., *Asarum europaeum* L., *Asperula odorata* L., *Atropa belladona* L., *Capsella bursa pastoris* L., *Centaurium umbellatum* L.,

Chelidonium majus L., *Convolvulus arvensis* L., *Chamanerion angustifolium*, *Dracocephalum moldavica* L., *Equisetum arvense* L., *Eryngium planum* L., *Eupatorium cannabinum* L., *Geum urbanum* L., *Gentiana asclepiadea* L., *Geranium robertanum* L., *Geranium macrorrhizum* L., *Glechoma hederacea* L., *Lamium album* L., *Leonurus cardiaca* L., *Marrubium vulgare* L., *Melilotus officinalis* Medik., *Mentha species*, *Achillea millefolium* L., *Origanum vulgare* L., *Lythrum salicaria* L., *Sarothamnus scoparius* L., *Thymus vulgaris* L., *Solidago virgaurea* L., *Stellaria media* L. Cyr., *Symphitum officinale* Web., *Tanacetum vulgare* L., *Taraxacum officinale* Web., *Hibiscum trionum* L., *Filipendula ulmaria* L., *Urtica dioica* L., *Vinca minor* L., *Viola odorata* L., *Viola tricolor* L., *Xanthium spinosum* L.

- Radix: *Aconitum napellus* L., *Althaea officinalis* L., *Arctium lappaL*., *Atropa belladonna* L., *Cichorium intybus* L., *Acorus calamus* L., *Driopteris filix mas* L. Sch., *Geum urbanum* L., *Gentiana asclepiadea* L., *Iris germanica* L., *Inula helenium* L., *Glycyrrhiza glabra* L., *Ononis spinosa* L., *Petasites hybridus* L.G.M., *Primulla officinalis* L. Hill., *Gypsophila paniculata* L., *Saponaria officinalis* L., *Scopolia carniolica* Jacq., *Symphytum officinale* L., *Taraxacum officinale* Web., *Urticae dioica* L., *Veratrum album* L.
- Fructus: *Berberis vulgaris* L., *Cornus mas* L., *Crataegus monogyna* Jack., *Rosa canina* L., *Sambucus ebulus* L., *Hippophae rhamnoides* L., *Juniperus comunis* L., *Vaccinium myrtillus* L., *Papaver somniferum* L., *Phaseolus vulgaris* L., *Prunus spinosa* L., *Ribes nigrum* L., *Rubus idaeus* L., *Sambucus ebulus* L., *Vaccinum vitis idaea* L.
- Semen: *Colchicum autumnale* L., *Rosa canina* L., *Aesculus hipocastanum* L., *Cerasus avium* Moench., *Cerasus vulgaris* Mill., *Fagus silvatica* L., *Evernia furfuracea* L. Ach., *Evernia furfuracea* L. Ach., *Humulus lupulus* L., *Zea mays* L., *Pinus silvestris* L., *Populus nigra* L., *Evernia prunastri* L. Ach.

Table 1. Production of wild collected plants

Year	Quantity (kg)
1997	850,220
1998	830,280
1999	786,340
2000	734,530

The quantities of raw materials gathered in the wild and processed in 2001 are presented in Table 2.

Table 2. Quantities of raw materials gathered in the wild and processed in 2001

Other specialty crops

Harvested organs	Quantity (tonnes)	No. of species gathered
Flowers	1680	27
Leaves	3500	36
Stems, leaves	5000	63
Roots, tubers, bulbs	1000	18
Seeds and fruits	100	10

In situ and ex situ preservation are achieved in natural reserves and on farms respectively, in the institutions and agricultural research stations that have breeding programmes and by the Suceava Genebank, a governmental institution.

Legal protection of MAP species and their natural habitats

The decrease of biological diversity on a global level has led to the elaboration of a Red List which includes medicinal and aromatic plants. Table 3 lists the endangered medicinal plants from the spontaneous flora which are included in the Red List.

Table 3. Endangered medicinal plants from the spontaneous flora of Romania

Plant organs harvested	Species
Flowers	*Arnica montana* *Primula officinalis* *Tussilago farfara*
Leaves	*Atropa belladonna* *Allium ursinum* *Althaea officinalis*
Stems, leaves	*Adonis vernalis* *Galium verum* *Lycopodium clavatum*
Roots, bulbs, tubers	*Gentiana lutea* *Arnica montana* *Helleborus purpurascens* *Angelica archangelica*

There are currently 450 reserves in Romania, including:

- 1 World Heritage Site - Danube Delta (591 200 ha)
- 2 biosphere reserves: Retezat (54 400 ha) and Rodna (56 700 ha)
- 12 national parks covering 287 084 ha
- 2 natural parks (10 150 ha)
- 161 ornamental plant collections (22 000 ha)
- 52 forestry reserves of over 113 668 ha

Thus, the total protected areas cover 1 072 498 ha, i.e. 4.59% of the whole country.

Activities dealing with the preservation of plant genetic resources present in parks and natural reserves are coordinated at national level by the Romanian Academy, Commission for the Protection

of Nature Monuments.

The following laws are currently active (Anonymous 1994, 2000, 2002):

- Law of the protected areas (5/2000), which includes rules for the protection of natural areas and for the conservation of natural habitats and of the wild flora and fauna of Romania;

- Law 69/1994, referring to the international trade agreement related to species of the Romanian wild flora and fauna threatened with extinction.

At the beginning of 2002, the law regulating the use of medicinal, aromatic, toxic and drug plants was under discussion in the Romanian Parliament.

Ex situ conservation of MAP genetic resources

This is accomplished in Romania through field conservation and medium- and long-term conservation.

Field conservation is carried out in the following institutions:

- Central Research Station for MAP Fundulea (931 samples - 297 species)
- Agricultural University Iassy (80 samples - 67 species)
- Agricultural University Timisoara (74 samples – 66 species)

Regarding medium- and long-term conservation, two institutions hold MAP collections: the Suceava Genebank and the Agricultural University Iassy.

The Suceava Genebank holds 246 samples (174 species) in the active and base collections.

The Agricultural University Iassy holds a collection of 1200 species kept under medium- term conditions. In 2001 a genetic centre for medicinal, aromatic and tinctorial plants collected from 52 Asian and European countries was established.

Sustainable use of MAPs in Romania

This is accomplished in the following ways:

1. MAP breeding
2. Research on biology and cultivation of new MAP species
3. Foundation of a genetic centre of medicinal, aromatic and tinctorial plants and their use in herbal medicine.

1. MAP breeding is carried out in Romania out by the Central Research Station Fundulea.

The species being bred include *Cynara scolymus, Digitalis lanata, Dracocephalum moldavica, Foeniculum officinale, Hyssopus officinalis, Coriandrum sativum, Lavandula angustifolia, Matricaria chamomilla, Mentha piperita, Ocinum basilicum, Papaver somniferum,* etc. The research activity during 1980-2002 resulted in 27 advanced cultivars of *Cynara scolymus, Ocimum basilicum, Thymus vulgaris, Coriandrum sativum, Digitalis lanata, Calendula officinalis, Datura innoxia, Lavandula angustifolia, Mentha piperita* and *Matricaria chamomila*. In addition, 31 local landraces were certified

(*Pimpinella anisum, Capsicum annuum, Silybum marianum, Satureja hortensis, Tagetes patula, Digitalis purpurea, Foeniculum vulgare,* etc.).

2. Cultivation of new MAP species: during the period 1995-2000 the researchers from Central Research Station Fundulea introduced into cultivation five species (*Aconitum napellus*, *Artemisia abrotanum, Gentiana lutea, Leonurus cardiaca* and *Lychnis coronaria*), taking into consideration their mode of use, pharmacodynamic action, chemical composition and environmental requirements.

3. The foundation at the Agricultural University Iassy of a genetic centre for medicinal, aromatic and tinctorial plants and their use in herbal medicine was carried out through the following activities:

- Inventory of MAPs from the wild and cultivated flora;
- Establishment of a biological collection conserved in the Iassy Genebank;
- Foundation of a herbal medicine library;
- Development of some complex therapeutic prescriptions;
- Testing of the efficacy of the elaborated products;
- Organization of a network of collaborators interested in herbal medicine.

Summary:

- The Romanian flora includes 3450 chromophyte species which represent 30% of the vascular European flora. Among these, 283 species have therapeutic effects and 180 species are studied, but only 52 species are cultivated.
- Cultivated area with medicinal and aromatic plants varied between 26500 ha/1995 and 10680 ha/2009. Social factors and local custums, economic factors and agricultural policy had a great influence.
- The same situation as regards the yield: 20900 tonnes/1995 vs. 9100 tonnes/2009.
- The main cultivated species are: Coriander (*Coriandrum sativum* L.), Common marigold (*Calendula officinalis* L.), Artichoke (*Cynara scolymus* L.), Garden thyme (*Thymus vulgaris* L.), Common fennel (*Foeniculum vulgare* Mill.), Hyssop wort (*Hyssopus officinalis* L.), Balm (*Melissa officinalis* L.), Peppermint (*Mentha piperita* L.), Common spearmint (*Mentha crispa* L.), White mustard (*Sinapis alba* L.), Shapsage (*Salvia officinalis* L.), Milk thistle (*Sylibum marianum* L.).
- Besides the cultivated plants there is a long list of medicinal and aromatic plants collected from the wild. Among them: *Robinia pseudoacacia* L., *Althaea rosea*, *Matricharia chamomilla* L., *Crataegus monogyna* Jacq., *Centaurea cyanus*, *Aesculus hippocastanum* L. (flores), *Abies alba* Mill., *Hedera helix* L., *Aesculus hippocastanum* L., *Vaccinium vitis idaea* L., *Plantago* sp., *Urtica dioica* L.(folium), *Artemisia absinthium* L., *Alchemilla arvensis* L., *Potentilla anserina* L., *Capsella bursa pastoris* L., *Chelidonium majus* L., *Convolvulus*

arvensis L., *Lamium album* L., *Leonurus cardiaca* L., *Taraxacum officinale* Web. (herba), *Aconitum napellus* L., *Althaea officinalis* L., *Arctium lappaL*., *Cichorium intybus* L., *Acorus calamus* L., *Driopteris filix mas* L., *Inula helenium* L. (radix), *Berberis vulgaris* L., *Cornus mas* L., *Crataegus monogyna* Jack., *Rosa canina* L., *Sambucus ebulus* L., *Hippophae rhamnoides* L., *Juniperus comunis* L., *Vaccinium myrtillus* L., *Ribes nigrum* L.(fructus), *Colchicum autumnale* L., *Rosa canina* L., *Aesculus hipocastanum* L., *Cerasus vulgaris* Mill., *Fagus silvatica* L., *Humulus lupulus* L., *Pinus silvestris* L., *Populus nigra* L. (semen).

- Production of wild collected plants: 11280 tonnes/2001.
- As concerns the export – import of medicinal and aromatic plants, the import exceeds the export. For instance, in 2008 Romania exported 337,7 tonnes MAPs and imported 3721 tonnes MAPs.
- There are 3 Romanian laws currently active regarding the protection of MAP species and their natural habitats.
- The Red List includes 13 endangered medicinal plants from the spontaneous flora of Romania.
- The total protected areas cover 1072498 ha (4,59% of the whole country).
- Ex situ conservation of MAP genetic resources is accomplished in Romania through field conservation and medium- and long-term conservation.
- Sustainable use of MAPs in Romania is accomplished through MAP breeding, research on biology and cultivation of new MAP species, foundation of a genetic centre for medicinal, aromatic and tinctorial plants and their use in herbal medicine.

Information resources:

- www.ienica.net
- www.mapam.ro
- D. Murariu, S. Strajeru, C. Milica, S. Radu 2002. Status of the Romanian medicinal and aromatic plant collection. European Cooperative Programme for Crop Genetic Resources network ECPGR. Reports of a working group on medicinal and aromatic plants.

SLOVENIA

Slovenia is a small Central European country but despite of its small area (20256 km^2, 2 mil inhabitants), it is very rich in plant's diversity. The territory of Slovenia covers 3 centers of diversity (Mediterranean, European-Siberian, Near Eastern). However, vegetation and flora in Slovenia is considered as degraded, what can be attribute to antropogenic factors and habitat loss.

That's why already in 80-ies Slovenia botanists have made efforts in making an inventory of Slovenia flora, aimed at securing basis for conservation of remaining natural resourced of rare and/or endangered species. The results of this intensive research work is “The Red Data List of Threatened Vascular Plants in Slovenia” (1989), edited by Institute for the conservation of natural and cultural heritage of Slovenia. This documents is base on IUCN categories and is the result of classification of threatened plants according to the degree of threat (Wraber,1989). The Red Data List of Threatened Vascular Plants in Slovenia covers 28 plants species, (4 of which have medicinal properties – *Cypripedium calceolus* L., *Fritilaria meleagris* L., *Gentiana lutea* L. and *Taxus buccata* L.) protected by law from wild gathering.

Of approximately 3000 plant species known to be autochthonous or well adapted to Slovenia climate centuries ago, about 10% are estimated to be endangered (34 have been injured, 77 vulnerable, 192 are rare). Among species (there are over 100 autochthonous species with potential medicinal properties), which are regarded as endangered, appear more and more frequently medicinal and aromatic plants (MAP).

Being aware of the MAP market fluctuation and of the trends in the European Market, in Slovenia MAP market analysis was made in 1994. The results showed, that in Slovenia MAP were cultivated on only 20 ha mainly on a fragmented areas with minor possibility of usage of modern machinery. Consequently, cost price of domestic plants was too high to compete with imports. Total supply of herbs (drug plants) on target markets in Slovenia was estimated at 1372 t. 84.3% of this amount (1157 t) was imported (3.571.000 USD), main suppliers being Albania, Bulgaria, Czech Republic, Hungary, Poland, Russia, China, Croatia and Macedonia (manpower low price). At least 707 tons of these drug plants could be produced in Slovenia: thyme (*Thymi herba*), St. John's wort (*Hyperici herba*), Chamomille (*Matricariae flos*), sage (*Salviae folium*), peppermint (*Menthae piperitae folium*), gentian (*Gentianae radix*), mallow (*Althaeae radix/folium*), dill (*Anethi fructus*), coriander (*Coriandri fructus*), caraway (*Carvi fructus*). The main consumer of drug plants was condiments' processing industry (400 t), followed by phyto-pharmaceutical industry (170 t), beverage production industry (80 t), tea production industry (3 t) and cosmetic industry (0.2 t).

MAP *in situ* conservation

Conservation of natural heredity for future generations and landscape attractiveness is the first scope of the work in conservation strategy in the field of MAP, and is planned to be achieved by:

- Inventarization of natural resources and estimation of their endangerness in nature
- Their active conservation (conservation *in situ*).
- Reasonable and sustainable use of natural resources (limited on exploitation of germplasm for *ex situ* genebank

- Prevention of massive exploration of natural resources through successive introduction of cultivation of known genotypes in suitable environment.

In order to manage this extensive data/information network, a working group has developed a relational database, which they called MEDPLANT (Baričevič *et al.* 1994).

Considering the principle of sustainable use, natural populations of MAP (*Crataegus monogyna* Jacq., *Plantago lanceolata* L. *Plantago major* L., *Pimipinella major* (L.) Huds., *Gentiana lutea* L., *Arnica montana* L., *Achillea millefolium* L, *Betonica officinalis* L., *Hypericum perforatum* L., *Hypericum montanum* L., *Rhamnus catharticus* L., *Origanum vulgare* L., *Ononis spinosa* L., *Epilobium parviflorum* Schreber, *Sedum maximum* (L.) Krock, *Satureja montana* L., *Anthyllis vilneraria* L., *Agrimonia eupatoria* L., *Lamium album* L., *Solidago virgaurea* L., *Centaurium erythraea* Rafn, *Urtica dioica* L., *Anthyllis vulneraria* L., *Malva sylvestris* L., *Eupatorium cannabinum* L., *Thymus serpyllum* L, *Potentilla erecta* (L.) Räuschel, *Euphrasia rostkoviana* Hayne *subsp. rostkoviana*, *Tussilago farfara* L., *Pimpinella saxifraga* L., *Veronica chamaedrys* L., ...) are successively introduced in the National Collection of MAP, where further activities (multiplication of plant materials, morphological and/or chemical characterization, selection and other pre-breeding studies) needed for future cultivation purposes are foreseen.

MAP *ex situ* conservation

In 1996, the Slovenian Fund for Nature conservation ratified the Resolution on conservation of biological diversity and permanent landscape development, including MAP. In order to ensure gene-pools for future investigations, the genebank (a National Genebank Collection of medicinal and aromatic plants), that contains 650 autochthonous or foreign/introduced medicinal and aromatic plant accessions, has been set up in 1994, officially recognized in 1995 and is annually supported by Slovenian government. *Ex situ* gene bank aims at:

Maintenance of germplasm. The MAP accessions are maintained in the form of seeds (at +4°C or at -20°C) as plantations *ex situ* and as *in vitro* culture. Different propagation techniques are considered with the objectives of maintaining genetic source and of multiplication of plants for future field production (*Cynara scolymus, Salvia officianlis, Origanum vulgare, Mentha piperita, Melissa officinalis, Hyssopus officinalis, Thymus vulgaris, Satureja montana, Hypericum perforatum, Gentiana lutea.....*).

Evaluation of morphologic and chemotaxonomic characteristics of MAP (*Origanum vulgare*, *Origanum hirtum*).

Evaluation of medicinal and aromatic plant ecotypes for quantitative and qualitative differences in secondary metabolites with regard to growth and development (314 genebank accessions).

Evaluation of susceptibility of germplasm descendants to environmental stress (drought, low

temperature, depleted soils,...) in pot trials under the conditions of controlled environment (*Atropa belladonna* L., *Origanum vulgare* L. ssp. *hirtum, Satureja montana* L., *Thymus vulgaris* L.,*Trigonella foenum-graecum,...*).

	Production area (ha)		Index	Number of producers		Index
	2003	2006	2006/2003	2003	2006	2006/2003
Herbs (medicinal herbs and spices)	13	12	92,3	64	57	89,1

Table 1. 2006 Total Map exports/ Quantities in kilograms (kg)

Country	HS0904	HS0909	HS0910	HS1210	HS1211	HS1301	HS1302	HS3301
Slovenia	17,33	19,09	18,22	1,530,910	89,788	2,736	50,741	133,347

- HS0904: Includes fruits of the *Capsicum*, *Pimenta* and *Piper* genera
- HS0909: Includes anise fruit (*Pimpinella anisum*), caraway fruit (*Carum carvi*), coriander fruit (*Coriandrum sativum*), cumin fruit (*Cuminum Cyminum*), fennel fruit (*Foeniculum vulgare*) and juniper fruit (*Junuperus communis*), among others.
- HS0910: Includes ginger rhizome (*Zingiber officinale*), saffron stigma (*Crocus sativus*), thyme herb (*Thymus vulgaris*), turmeric rhizome (*Curcuma longa*), and wild thyme herd (*Thymus serpyllunm*), among many others
- HS1210: Hop strobile (*Humulus lupulus*)
- HS1211: Includes Licorice root (*Glycyrrhiza* spp.), mint leaf (*Mentha* spp.), rosemary leaf (*Rosmarinus officinalis*), sage leaf (*Salvia* spp.), among hundreds of other medicinal herbs
- HS1301: Includes tree gums and other gums and oleoresins
- HS1302: Includes saps and extracts of MAP_S
- HS3301: Includes all essential oils obtained from MAP_s

International Regulations/conventions like Convention on Biological Diversity (Agenda 21 - Rio de Janeiro 1992 and Pan-European Biological and Landscape Diversity Strategy - Sofia 1995); Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); Convention on the Conservation of European Wildlife and Natural Habitats - Bern Convention (1 June 1982), Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (lists 10 species of MAP); Council Regulation (EC) No. 338/97 of 9 December 1996 on the protection of wild fauna and flora by regulating trade therein, obligated Slovenia to prepare national biological and landscape diversity conservation strategy and sectional implementation

programs by the year 2000 and appropriate legislative background. International conventions, that were ratified in Slovenia (in 1996 Rio Convention and in 1999 CITES) and also national legislation (Nature conservation law, adopted in 1999) are considered as general documents, that list more than 35.000 plant or animal species, that are considered as endangered. Only about 50 plant species, covered by this legislation, belong to a group of medicinal and aromatic plants (MAP).

Summary:

- The total surface cultivated with medicinal and aromatic plants is smaller than 20 ha (fragmented areas).
- Total supply of herbs on target markets in Slovenia was estimated at 1372 t; 84.3% of this amount is imported, main suppliers being Albania, Bulgaria, Czech Republic, Hungary, Poland, Russia, China, Croatia and Macedonia.
- Conservation of natural heredity for future generations and landscape attractiveness is the first scope of the work in conservation strategy (in situ and ex situ) in the field of MAP.

Information resources:

- D.Baricevic, J. Rode. Directives of the national program on medicinal and aromatic plants in Slovenia.
- www.stat.si
- United Nations Commodity Trade Statistics Database

SPAIN

With a surface area of nearly 500 000 km , mainland Spain is located on the Iberian Peninsula in south- western Europe. It is a mountainous region isolated from the rest of Europe by the Pyrenees. Its great climatic, geographical, and geological diversity gives rise to biological and ecological diversity. Its vascular flora, numbering about 7000 species, is the richest in Europe. Many of these species are endemic to the Iberian Peninsula or Europe.

The Spanish landscape chiefly consists of forest, scrubland, pasture land, and arable fields, and can be divided into two distinct areas. So-called ‘Green Spain’ in northern Spain has a temperate climate, including a strip of land from Galicia to the Pyrenees. The vegetation predominantly consists of deciduous forest and meadows that remain green throughout the summer. The area often known as ‘Dry Spain’ is much larger. Its Mediterranean climate features a characteristic drought period with high summer temperatures. However, marked variations exist between different areas in terms of annual rainfall, temperature, and duration of the drought period. In general, the climate is more arid in the east and south of the Peninsula, becoming more continental in the centre. The vegetation is mainly

evergreen forest, although mountain ranges contain green areas, especially at a certain altitude.

In Spain, 10-20% of the medicinal and aromatic plant raw material used by the industry comes from Spain and 80-90% is imported, mainly (40-60%) from eastern Europe.

Every year about 100 000 ha are subjected to collecting from the wild in Spain. The main collecting areas are Granada, Almería and Murcia, all in southern Spain.

Some medicinal plants are collected in large amounts (more than 1 t/year). Most of them do not have major conservation problems. However some wild plants collected in significant quantities in Spain have potential conservation problems and it is necessary to update the collecting.

Collected species with no major conservation problems: *Equisetum ramosissimum* Desf. subsp. *ramosissim, E. telmateia* Ehr., *Lepidium draba* L., *Juniperus communis* L., *Taraxacum officinale* Weber., *Arctostaphylos uva-ursi* Spreng., *Gentiana lutea* L., *Malva sylvestris* L., *Viscum album* L., *Rosmarinus officinalis* L., *Thymus* spp., *Salvia* spp.

Species with potential conservation problems: *Arnica montana*, *Cetraria islandica*, *Drosera rotundifolia*, *Gentiana lutea*, *Jasonia glutinosa*, *Menyanthes trifoliata*, *Petasites hybridus*, *Ruscus aculeatus*, *Valeriana officinalis.*

According to various information sources the main species cultivated commercially in Spain are lavandin (*Lavandula* x *intermedia*), mint (*Mentha piperita* and *M. pulegium*), sage (*Salvia officinalis* and *S. lavandulifolia*), fennel (*Foeniculum vulgare*), lemon balm (*Melissa officinalis*), chamomile (*Matricaria chamomilla*), oregano (*Origanum vulgare*, *O. virens*) and anise (*Pimpinella anisum*); there have also been recent experiences in the production of echinacea (*Echinacea purpurea*), lemon verbena (*Lippia citriodora*) and spike lavender (*Lavandula latifolia*). The main cultivation areas are Andalucia, Valencia, Murcia, Catalunya, Aragón and Mallorca, and, although there are no data for the current area cultivated, it can be estimated to be about 6000 ha in the whole of Spain. There are two kinds of farm: the small ones are more or less experimental, while the bigger ones are usually managed directly by foreign companies.

Some allochthonous plants occasionall cultivated in gardens are often gathered from the wild as native species, e.g. *Opuntia maxima*, *Arund donax*, *Robinia pseudoacacia*, *Prunus domestica*, *Prunus cerasus*, *Mespilus germanica*, *Chenopodiu ambrosioides*, *Bidens aurea*, *Coriandrum sativum, Helianthus tuberosus*, and *Asparagus officinalis*.

Some species, such as *Laurus nobilis*, *Corylus avellana*, *Tilia platyphyllos*, *Prunus avium*, *Celtis australis*, *Sorbus domestica*, *Castanea sativa*, *Carum carvi*, and *Rosmarinus officinalis*, are only native to certain regions of Spain, although they are cultivated throughout the country. In some cases, wild forms and cultivars grow together in many areas of the country, e.g. *Matricaria recutita*, *Borago officinalis*, *Melissa officinalis*, *Vicia sativa*, and *Medicago sativa*.

Legal protection of medicinal and aromatic plant species and their natural habitats

In Spain the legal protection of nature is under the responsibility of the Spanish Governement and of the "Autonomous Communities", each regulated by its own laws.

The general legislation at national level includes numerous laws and decrees. Reference documents include, *inter alia:*

- the catalogue of threatened species (*Catalogo de especies amenazadas*); in April 2000 the following categories were identified: threatened species (118), species sensitive to habitat alteration (5), vulnerable species (4) and species of special interest (133).

- the Red List of the Spanish vascular flora (Aizpuru et al. 2000).

The catalogue of threatened species provides local regulations for the communities of Catalunya, Aragón, Asturias, La Rioja, Navarra, Madrid, Euskadi, Valencia, Andalucia, Canarias, Murcia and Castilla-La Mancha. Other by-laws exist for Catalunya, Aragón and Castilla-La Mancha.

Summary:

- Every year about 100 000 ha are subjected to collecting of medicinal and aromatic from the wild.
- Collected species with no major conservation problems: *Equisetum ramosissimum* Desf. subsp. *ramosissim, E. telmateia* Ehr., *Lepidium draba* L., *Juniperus communis* L., *Taraxacum officinale* Weber., *Arctostaphylos uva-ursi* Spreng., *Gentiana lutea* L., *Malva sylvestris* L., *Viscum album* L., *Rosmarinus officinalis* L., *Thymus* spp., *Salvia* spp.
- Estimated area cultivated with MAPs is about 6000 ha in the whole of Spain.
- The main species cultivated commercially in Spain are: lavandin (*Lavandula* x *intermedia*), mint (*Mentha piperita* and *M. pulegium*), sage (*Salvia officinalis* and *S. lavandulifolia*), fennel (*Foeniculum vulgare*), lemon balm (*Melissa officinalis*), chamomile (*Matricaria chamomilla*), oregano (*Origanum vulgare*, *O. virens*) and anise (*Pimpinella anisum*).
- In Spain, 10-20% of the medicinal and aromatic plant raw material used by the industry comes from Spain and 80-90% is imported, mainly (40-60%) from eastern Europe.
- Legal protection of medicinal and aromatic plant species and their natural habitats is under the responsibility of the Spanish Governement and of the "Autonomous Communities", each regulated by its own laws.

Information resources:

- R.C. Cabau, A. van Ginkel, F. Varela 2002. Current status of medicinal and aromatic plants in Spain. European Cooperative Programme for Crop Genetic Resources network ECPGR. Reports of a working group on medicinal and aromatic plants.

- www.ienica.net
- J. Tardio, M. Pardo-De-Santayana, R. Morales 2006. Ethnobotanical review of wild plants in Spain. Botanical Journal of the Linnean Society, 152, p. 27-71.

SWEDEN

Sweden is located in the northwest of the continent of Europe.

The topography of Sweden is basically made of plain and low lands. Most of these flats contain the major lakes. However, to the west of the country the land elevates to form mountains.

Sweden maintains a temperate climate throughout the year.

The production of medicinal and aromatic plants is quite small in Sweden but it has increased during recent years.

In 2000, the production of herbs grown in the field covered an area of 236 ha (154 ha of *Anethum graveolens*, 43 ha of *Petroselinum crispum*, 18 ha of *Amoracia rusticana* and 21 ha of different other kinds of herbs)

The greenhouse production of herbs more than doubled between 1999 and 2000, from 11 000 plants to 26 200.

Within the SPIMED project, material from the following species was collected during the summer: *Arnica* sp., *Helichrysum arenarium*, *Rhodiola rosea* and *Valeriana officinalis*.

SPIDEM -"Spice and medicinal plants in the Nordic and Baltic countries. Strategies for conservation of genetic resources in minor crops" is a project with the aim to develop strategies for conserving cultivated spice and medicinal plants "in situ" or "ex situ" in the Nordic and Baltic countries.

Summary:

- The production of medicinal and aromatic plants is small in Sweden
- The production of herbs grown in the field covered an area of 236 ha/2000 (154 ha of *Anethum graveolens*, 43 ha of *Petroselinum crispum*, 18 ha of *Armoracia rusticana* and 21 ha of different other kinds of herbs).
- There are strategies for conserving cultivated spice and medicinal plants "in situ" or "ex situ".

Information resources:

- K. Wedelsback Bladh 2002. Medicinal and aromatic plants in the Nordic Countries. European Cooperative Programme for Crop Genetic Resources network ECPGR. Report of a Working Group on Medicinal and Aromatic Plants.

- www.ienica.net

HUNGARY

Hungary is located in the central area of Europe and roughly covers a land area of 93,030 square kilometers.

Hungary has three major geographic regions: the Great Plain (Nagy Alfold), lying east of the Danube River; the Transdanube, a hilly region lying west of the Danube and extending to the foothills of the Alps; and the Northern Hills, which is Austrian a mountainous and hilly country beyond the northern boundary of the Great Plain.

The country's best natural resource is fertile land, although soil quality varies greatly. About 70 percent of the country's total territory is suitable for agriculture; of this portion, 72 percent is arable land.

The climate of Hungary is temperate by nature, with little fluctuations all through the country.

In Hungary, the area utilized by medicinal plants is around 37-42 thousand per year in the last decades. The produced drug amount is 35-40 thousand ton/year, of which 25-30 thousand is produced in agricultural plants.

In Hungary 214 medicinal plant species and plant species with aromatic oils can be regarded official based on the 7th Hungarian Drug Code and effective regulations, and the drug of these can be distributed. This means about 180 – 200 domestic plant species.

In the production of medicinal plant sector, species growing in the wild form an important part today and probably in the first half of the 21st century as well. When assessing data of the total Hungarian medicinal plant cultivation it becomes obvious that almost 50% of the total plant mass derives from natural associations, i.e. from species growing in the wild.

The list of medicinal plants cultivated on relatively big areas in Hungary includes many medicinal plants with aromatic oils from the Apiaceae family, like fennel (*Foeniculum vulgare*), caraway (*Carum carvi*), anise (*Pimpinella anisum*), mustard species (*Sinapis* spp.).

Cultivation of these plants is performed in a fully mechanised way, with large-scale technology.

Table 1. Spectrum of medicinal and aromatic plants cultivated on a large scale in Hungary

Name of species	Aproximate size of Hungarian cultivation (ha)
Anethum graveolens	400-600
Artemisia dracunculus	50-150
Borago officinalis	50-200
Carthamus tictorius	100-500
Carum carvi	2000-3000

Claviceps purpurea	50-150
Coriandrum sativum	400-600
Cucurbita pepo var. *styriaca*	250-600
Digitalis lanata	No data
Foeniculum vulgare	1000-1500
Hippophae rhamnoides	20-25
Lavandula spp.	50-100
Matricaria recutita	100-200
Mantha piperita	50-150
Oenothera erythrosepala	200-600
Papaver somniferum	6000-10000
Pimpinella anisum	50-150
Salvia sclarea	250-500
Silybum marianum	1000-2500
Sinapis alba	10000-20000

Paralell to medicinal plants cultivated on big areas, many medicinal plants are cultivated on smaller areas, but which produce higher values from one unit of area. Among other four species can be listed here, known as “Hungaricum”: marjoram (*Majorana hortensis*), valerian (*Valeriana officinalis*), pot marigold (*Calendula officinalis*), or angelica (*Angelica archangelica*).

Table 2. The list of medicinal and aromatic plants cultivated on a small scale in Hungary

Name of species	Aproximate size of Hungarian cultivation (ha)
Alcea rosea f. nigra	1-3
Althea officinalis	4-10
Angelica archangelica	20-25
Anthemis nobilis	2-4
Calendula officinalis	20-50
Chrysanthemum cinerariaefolium	1-4
Cnicus benedictus	2-4
Hyoscyamus niger	5-10
Hyssoppus officinalis	5-10
Levisticum officinalis	10-20
Majorana hortensis	250-400
Malva sylvestris subsp. *mauritiana*	2-4
Melissa officinalis	5-10
Ocimum basilicum	100-150

Ruta graveolens	4-10
Salvia officinalis	5-10
Satureja hortensis	15-20
Tanacetum parthenium	3-4
Thymus vulgaris	25-50
Valeriana officinalis	50-100
Verbascum phlomoides	5-10

When assessing export data according to countries it becomes obvious that the most important country receiving drugs of medicinal plants and plants with aromatic oils is Germany. 85-95% of Hungarian export goes there. Further countries buying primarily specialised products in order of bought amount of products are the followings: Italy, French, The Netherlands, Great Britain, Austria and Switzerland.

In Hungary about 30-35% of the total MAP production is based on the natural flora. This means that about 10 000-15 000 t dry biomass is produced from the wild, from about 120-130 different species (Németh 1997). This places Hungary in an intermediate position considering the European situation as a whole.

List of medicinal and aromatic plants of great importance collected in Hungary:

Medicinal plant drugs produced in natural ecosystems (collected species)

Achilleae* herba*;** *Anserinae* herba; *Apii* herba; *Asarae* herba cum radix, *Asperulae* herba; ***Bardanae* radix*;** *Betonicae* folium, herba; *Betulae* folium; *Bursae pastoris* herba; *Calcatrippae* flos, herba; *Cerefolii* herba; **Chelidonii herba: *Cichorii* herba, radix; *Clematitis* herba; *Coryli* folium; **Crataegi fructus, summitas*;** *Cynodon dactylon* rhizome; **Cynosbati fructus*;** *Echii* herba; Equiseti herba*:*Eupatorii* herba; *Euphrasiae* herba; *Fagopyri* herba; *Farfarae* flos, folium; *Filipendulae* herba; *Fragariae* folium; *Frangulae* cortex; *Fraxini* folium; *Fumariae* herba; *Galegae* herba; *Galeopsidis* herba; *Galli* herba; *Gei* rhizome; *Glandes quercus* testae *pulvis*; *Graminis* rhizome; *Hederae* herba; *Helianthemi* herba; *Herniariae* herba; ***Juniperi* fructus*;** *Lamii albi* flos, herba; *Lepidii* herba; *Linariae* herba; *Menthae aquaticae* herba; *Mori* folium; *Myrtilli* folium, fructus; *Ononidis* radix; *Papaveris rhoeas* flos; *Plantaginis* lanceolatae folium; *Plantaginis majoris* folium; *Polygalae* herba; *Polygoni* herba; *Polygoni hydropiperis* herba; *Populi* gemma; *Primulae* flos, folium, radix; *Pruni spinosae* flos, fructus; *Pulmonariae* folium; *Quercus cerris* folium, lichen; *Rhei* rhizome; *Robiniae* flos; *Salicis* cortex; ***Sambuci* flos*,** fructus; *Sedi* herba; *Serpylli* herba; *Sideritidis* herba; ***Solidaginis* herba***; *Sorbi aucupariae* fructus; *Stellariae* herba; ***Taraxaci* folium, herba, radix*;** ***Tiliae* flos, folium***; *Tormentillae* rhizome; ***Urticae* folium***; *Verbenae* herba; *Veronicae* herba; *Vincae* herba; *Violae odoratae* folium; *Violae tricoloris* herba; *Virgae aureae* solidaginis herba; ***Visci***

stipes*.

Medicinal plant drugs produced in both natural and agrarian systems (collected and/or cultivated species)

Absinthii herba; *Agrimoniae* herba; *Althaeae* flos, folium, radix; *Armoraciae* radix; *Amygdalae dulcis* farina; *Centauri* herba; ***Chamomillae*** **flos*;** *Cotinius* folium; ***Hyperici*** **herba***; *Inulae* radix; *Leonurii cardiacae* herba; *Malvae silvestris* flos, folium; *Marrubii* herba; *Meliloti* flos, herba; *Millefolii* flos, herba; *Origani* herba; *Saponariae albae*; *Saponariae officinalis* herba, radix; *Tanaceti* flos, herba; *Verbasci* flos.

* = about 10-500 tonnes collected per year

Traditional regions for utilization of indigenous flora and main cultivation areas of medicinal and aromatic plants in Hungary are:

Reg. 1 = Great Plain and East Tisza river region

Reg. 2 = North-central mountainous region of Hungary

Reg. 3 = Balaton highland

Reg. 4 = South Hungary

Reg. 5 = Bakony and its surroundings

Reg. 6a = Region suitable for "spring poppy" cultivation

Reg. 6b = Northern part of Transdanubia suitable for "autumn poppy" cultivation

Reg. 7 = Region of plant species which can be cultivated all over the country

- Region 1

The natural occurrence of *Matricaria recutita* in Hungary is one of the model examples illustrating the regional specialization for utilization of species of the indigenous flora. From a biological point of view, chamomile grown in saline habitats was regarded as high quality. This was first based on empirical observations and later confirmed by sophisticated chemical and pharmacological analysis. From a socioeconomical point of view the development of this region was promoted by the abundance of labour locally. According to the data of trading companies, as many as 15 000-20 000 people are involved in gathering chamomile flowers at harvest time, even today. Because of the short duration of the chamomile harvest and processing, the regional activity had to be complemented by utilization of other MAPs indigenous to the region (*Juniperus communis*, *Achillea millefolium*, *Gypsophila paniculata*, *Crataegus* spp., *Rosa* spp., etc.).

- Region 2

The development of special regions for utilization of indigenous plant flora was obvious in the north-central mountainous region of Hungary since the beginning of the 20th century. In the production

areas of *Rosa* spp., *Sambucus nigra*, *Prunus spinosa*, *Crataegus* spp., etc., buying arrangements and centralized processing facilities were installed. Examples of centres of MAP production in the northern part of Hungary include Balassagyarmat, Pásztó, Veresegyháza and other towns and villages.

• Specialization of cultivation areas

In the development of the specialized cultivation areas for MAPs, beside traditional and accidental elements the ecological and economical considerations became ever more important.

- Region 3

The region for lavender cultivation (*Lavandula angustifolia* and *L. intermedia*) was created in the 1930s mostly based on ecological considerations. Suitable ecological conditions had to be chosen for the cultivation of species of Mediterranean origin (Németh 1996). Plantations were established on the southern slopes of the Tihany Peninsula and in the neighbouring territories (Balatonakali, Daránypuszta, etc.) where the ecological conditions show some similarity to the Mediterranean. The importance of lavender plantations has decreased in recent decades; however a relict of the first plantation still exists in the Tihany Peninsula.

- Region 4

Both ecological and economical considerations led to specialization in marjoram (*Origanum majoranna*) and basil (*Ocimum basilicum*) cultivation in the region. The climate of Region 4, situated in the southern part of Hungary, is relatively warm and receives appropriate sunshine. Its climate meets the ecological requirements of species of Mediterranean and subtropical origin. From an economical point of view, this area is also known as a major cultivation area for red pepper. The drying and postharvest processing of red pepper and medicinal and aromatic plant/spices are very similar. This means that the available technology and processing facilities located in the region can be utilized for both plant groups.

- Region 5

The introduction of the cultivation of ergot (*Claviceps purpurea*) in this area was motivated by both ecological and economical considerations. From the wide-ranging cultivation areas of the host plant (*Secale cereale*), a special area possessing suitable ecological conditions for the development of fungi had to be chosen. As a result of compromise the southwestern slopes of Bakony Mountain were selected for the purpose. The cultivation area has since been equipped with valuable cultivation and postharvest technological tools.

- Region 6

The cultivation of poppy (*Papaver somniferum*) has a great tradition in Hungary owing to its wide-scale use as both an important food plant and a source of oil and industrial raw material. Its large-scale cultivation is organized and controlled by the pharmaceutical factory "Alkaloida". The

poppy cultivation region can be divided into two sub-regions. The cultivation of spring-sown varieties is concentrated in the Great Plain of Hungary and some parts of the northwestern regions of the country (Region 6a), while autumn-sown varieties, because of their susceptibility to winter damage, are situated in the western part of Hungary (Region 6b) where winters are usually much milder and snow covers the fields more frequently.

• Species cultivated and collected country-wide

- Region 7

Several MAP species can be cultivated and/or collected in Hungary without much restriction. Such cultivated species include members of the Apiaceae family (*Foeniculum vulgare*, *Carum carvi*, *Anethum graveolens*, *Coriandrum sativum*, *Pimpinella anisum*, etc.), mustard (*Sinapis* and *Brassica* spp.), *Silybum marianum*, *Cucurbita* spp., and among collected plants, examples include *Sambucus nigra*, *Rosa canina*, *Equisetum arvense*, *Crataegus* spp., etc.

Preservation of Hungarian MAP production potential and biodiversity

A considerable proportion of the medicinal and aromatic plant drugs produced and sold by the Hungarian MAP sector comes from indigenous sources. This exploitation of natural plant populations without scientific analysis and control may reduce the productivity of natural plant populations and the biodiversity of the Hungarian flora.

List of the Hungarian protected species which are used as medicinal and aromatic plants according to literature references: *Achillea crithmifolia, Achillea ptarmica, Acorus calamus, Adonis vernalis, Betula pubescens, Colchicum arenarium, Dictamnus albus, Equisetum hyemale, Helichrysum arenarium, Helleborus purpurascens, Hepatica nobilis, Inula helenium, Iris pumila, Lycopodium clavatum, Menyanthes trifoliate,Nigricans, Orchis morio, Polygonum bistorta, Primula elatior, Primula vulgaris, Quercus farnetto, Ribes nigrum, Rosa pendulina, Ruscus aculeatus, Vaccinium vitis-idaea, Valeriana sambucifolia, Alchemilla crinita, Alkanna tinctoria, Armoracia macrocarpa, Arnica montana, Carlina acaulis, Gentiana asclepiadea, Gentiana cruciata, Gentiana pneumonanthe, Globularia cordifolia, Hippophae rhamnoides, Hypericum elegans, Hypericum maculatum, Isatis tinctoria, Petasites albus, Peucedanum officinale, Phyllitis scolopendrium, Plantago maxima, Polygala major, Ruscus hypoglossum, Scopolia carniolica, Sempervivum marmoreum, Sempervivum tectorum, Tamus communis, Taxus baccata, Urtica kioviensis, Vitis sylvestris.*

The factors having an adverse effect on MAP productivity can be divided into two main groups:

1. Direct factors limiting the spectrum and productivity of indigenous MAP populations

- Overexploitation of MAP populations by intensive and inconsiderate collecting may result in irreversible damage. Owing to profit seeking and lack of scientific control, more and more species have to be included in the list of endangered species. Examples include *Adonis vernalis*, *Primula* spp.

and *Dictamnus albus*, which became protected due to their unregulated exploitation from the wild.

- The overall reduction of forest areas resulting from progressive industrialization limits both the spectrum and productivity of MAP populations. The decrease in the populations of *Dryopteris filix-mas*, *Crataegus nigra*, *Primula vulgaris*, *Veronica officinalis*, etc., can be explained by this phenomenon.

- Drainage of marshy-moist ecosystems as a result of the political decision of the former socialist administration (especially in the 1950s) had an adverse effect on the medicinal plant populations after many years. The most valuable species in this respect, which have had to be removed from the list of utilized plants, are *Acorus calamus* and *Menianthes trifoliata*.

- There are huge losses to former ruderal MAP populations, gathered from cultivated field headlands, meadows, farmyards, etc. The biodiversity of these systems has been reduced drastically. Species which were collected from these habitats on a large scale, such as *Marrubium vulgare* and *Fumaria schleicheri*, have become very rare and botanists consider there is a need for their protection.

- The natural distribution of MAPs is limited by pollution. Because of the increasing quality requirements, the production area has to be farther from the main roads, industrial facilities, etc. This means that more and more territories are withdrawn from the production of medicinal and aromatic plants. Some species, especially *Arnica montana* and *Vaccinium* spp., are very susceptible to pollution.

2. Indirect factors limiting the spectrum and productivity of indigenous MAP populations

The overall reduction in the species range in natural plant communities, which is a general phenomenon throughout Europe (plants becoming endangered, rare or extinct) is also observable in Hungary. Medicinal and aromatic plants, as constituents of the different ecosystems, are affected by any factor that damages plants generally. The severe reduction of biodiversity affects all Europe and is reflected in the large number of species now extinct (Bernáth 1988). This reduction also means the extinction of some chemotaxa existing in given natural systems, which may have had potential therapeutic use but are lost forever.

Several indirect factors such as industrial pollution, increasing amount of agrochemicals, harmful human influences, etc., damage the natural ecosystems continuously, including plant species utilized as MAPs.

1. In situ conservation of MAPs

- Complex protection

The complex protection of particular geographical regions or areas regulated by administrative measures is an indirect form of MAP conservation. The MAPs grown in protected areas (with some exceptions) cannot be used as a source of raw material. Their plant spectrum and chemical diversity constitutes a source for scientific studies and further development.

- Controlled utilization of MAP species

There are possibilities for the controlled utilization of MAP species grown in special protected areas. Model examples are the collections of *Juniperus communis* in the Kiskunság National Park and the collection of *Matricaria recutita* in Hortobágy National Park. These species are very abundant in these regions. The well organized collecting of the plants controlled by scientists and experts results in no harm to the plant populations and even contribute to a better knowledge of these *Juniperus* and *Matricaria* populations, which is the basis for further development and increased production. Another advantage of this method is that the plant drugs coming from such areas are very likely to be free of pollutants. This type of collection seems to be profitable from both biological and economic points of view and ought to be extended to other MAP species.

- Protection of individual plants

Protection of individual plants is used in the *in situ* conservation of MAP species in Hungary. However its effectiveness greatly depends on the actual biodiversity of the species existing at the time of protection. The plants can be divided into three groups according to their natural biodiversity status:

a. Individual protection of MAPs which have become extinct or extremely rare is only of limited practical importance. Some representatives of this group include *Arnica montana*, *Digitalis lanata*, *Digitalis ferruginea*, etc. The chemical, morphological and biological product diversity of these species is probably lost. There is little hope for their utilization as a genetic source for further development of the MAP sector.

b. A number of protected MAPs are widely studied for their chemical and biological characters in Hungary. The main representatives of this group include *Achillea* spp., *Adonis vernalis*, *Dictamnus albus*, *Primula* spp. and *Pulsatilla* spp. Many of these species show high chemical and biological diversity which can be utilized for the development of artificial production models or later on for cultivation. The simple protection of these species hardly meets the theoretical and practical expectations. The different bio- and chemotypes must be preserved by other methods of plant conservation.

c. Only very limited information is available for the majority of MAP species under protection. Thus, for this group, protection is only an administrative measure. Again, this simple protection hardly meets the requirements of real plant conservation. The intensification of scientific activities in this respect appears necessary. The biological and chemical diversity of the species listed in this group could be utilized through international cooperation projects.

2. Ex situ conservation of MAPs

In addition to the protection of genetic resources, ex situ conservation of MAPs may contribute to the construction of a valuable genepool which serves as a reserve for the development of highly

productive cultivars or plants possessing diverse chemical characters. The distinction of well defined chemical types seems to have both theoretical and practical importance. It is well known that the need for chemical compounds varies with time. In the case of poppy (*Papaver somniferum*) the demand for morphine, codeine or the baine changes unexpectedly. The need for different chemotypes of *Matricaria recutita* also varies from time to time. In some cases the most recent pharmacological studies generate new requirements, such as requirement for low beta-thujone taxa of *Salvia officinalis*, or pyrrolisidine-free populations of *Scrophulariaceae* and *Asteraceae* species.

- Chemotaxonomical gardens

The simplest way of ex situ conservation of medicinal and aromatic plants is the establishment and management of chemotaxonomical gardens. There are two of these gardens specialized in MAPs in Hungary:

- Chemotaxonomical Garden of the Research Institute of Medicinal Plants, Budakalász
- Medicinal and Aromatic Plant Garden of the Department of Medicinal and Aromatic Plants, Soroksár

- MAP genebanks

The following two genebanks are specialized in MAPs:

- Genebank of the Research Institute of Medicinal Plants, Budakalász
- Genebank of the Department of Medicinal and Aromatic Plants, Soroksár

- Biotechnology

Advanced biotechnological methods are applied for the conservation of MAP species. This is of great importance in the case of MAPs which cannot be propagated from seed or in the case of species whose chemical characteristics can be preserved only by clonal propagation. Microclonal propagation and biotechnological conservation methods have been developed for the following species: *Artemisia dracunculus*, *Lavandula intermedia*, *Melissa officinalis*, *Mentha piperita*, *Salvia officinalis*, *Sempervivum tectorum* and *Tanacetum parthenium*.

- Introduction of protected and endangered MAPs into cultivation

From a practical point of view, this seems to be a most effective *ex situ* conservation method (Bernáth 1992, 1993). It involves complex biological and chemical studies aimed at determining the ecological requirements, biological and chemical diversity as well as effective propagation methods of the given species.

List of protected and endangered MAPs introduced or being introduced into cultivation: *Adonis vernalis, Achillea crithmifolia, Alkanna tinctoria, Arnica montana, Dictamnus albus, Digitalis ferruginea, Digitalis lanata, Equisetum arvense, Glycyrrhiza glabra, Inula helenium, Primula vulgaris, Isatis tinctoria, Marrubium vulgare, Sempervivum tectorum, Solidago virgaurea, Taxus baccata, Valeriana*

sambucifolia.

Summary:

- The area utilized by medicinal plants is around 37-42 thousand ha/year.
- The produced drug amount is 35-40 thousand tonnes/year.
- The spectrum of medicinal and aromatic plants cultivated on a large scale is a broad one. It includes many medicinal plants with aromatic oils like fennel (*Foeniculum vulgare*), caraway (*Carum carvi*), anise (*Pimpinella anisum*), mustard (*Sinapsis* spp.).
- Many medicinal plants are cultivated on smaller areas, but produced higher values from one unit of area (i.e. marjoran (*Majorana hortensis*), valerian (V*aleriana officinalis*), pot marigold (*Calendula officinalis*), angelica (*Angelica archangelica*)).
- About 30-35% of the total MAP production is based on wild flora.
- 85-95% of medicinal and aromatic plants production goes to Germany, followed by Italy, French, The Netherlands, Great Britain, Austria and Switzerland.
- There are 7 traditional regions specialized for utilization of indigenous flora and cultivation ares:

- Great Plain and East Tisza river regions: *Matricaria recutita*.

- North-central mountainous regions of Hungary: *Rosa* spp., *Sambucus nigra*, *Prunus spinosa*, *Crataegus* spp.

- Balaton highland: cultivation of lavender (*Lavandula angustifolia* and L, *intermedia*),

- South Hungary: cultivation of marjoran (*Origanum majorana*) and basil (*Ocimum basilicum*).

- Bakony and its surroundings: cultivation of ergot (*Claviceps purpurea*).

- Great Plain of Hungary and Northern part of Transdanubia: cultivation of poppy (*Papaver somniferum*).

- Region of plants species which can be cultivated all over the country: cultivation of *Foeniculum vulgare*, *Carum carvi, Anethum graveolens, Coriandrum sativum, Pimpinella anisum, Sinapis spp. Brassica spp., Silibum marianum, Cucurbita* spp; collecting of *Sambucus nigra, Rosa canina, Equisetum arvense, Crataegus* spp.

- Presentation of Hungarian MAP production potential and biodiversity is made by:

1. in situ conservation:

- complex protection
- controlled utilization of MAP species
- protection of individual plants

2. ex situ conservation:

- Chemotaxonomical gardens
- MAP genebanks
- biotechnology
- introduction of protected and endangered MAP_s into cultivation.

Information resources:

- http://www.kertnet.hu/HungarianHorticulture/gb/88f.htm
- www.ienica.net
- J. Bernath, E. Nemeth 2002. Perspective and achievements in genetic conservation of medicinal and aromatic plants in Hungary. European Cooperative Programme for Crop Genetic Resources network ECPGR. Report of a Working Group on Medicinal and Aromatic Plants.

2.Quality characteristics of the raw material - good agricultural and collection practices (GACP) for medicinal plants

Quality control systems are important for the production of high-quality herbal products. Lack of quality control may lead to problems due to unidentified problems in the production process that can lead to inferior or inconsistent products. The European Herb Growers Association (EUROPAM) has developed Good Agricultural Practice (GAP) guidelines which where further developed into Good Agricultural and Collection Practice for starting materials of herbal origin (GACP) by the European Agency for the Evaluation of Medicinal Product (EMEA). Also the WHO has developed similar guidelines.

Although the GACP guidelines are not directly legally binding, they have to be followed by all European companies involved in the production and trade of herbal drugs.

In order to meet Pharmacopoeial Quality Standards - current GACPs contribute by:

1. European Herb Growers Association (EUROPAM): Guidelines for Good Agricultural Practice (GAP) of Medicinal and Aromatic Plants — APRIL 2006
2. European Herbal Infusions Association (EHIA): Guidelines for Good Agricultural and Hygiene Practices for Raw Materials used for Herbal Infusions (GAHP) — JUNE 2006
3. Committee on Herbal Medicinal Products (HMPC) of European Medicines Agency (EMEA): Guideline on Good Agricultural and Collection Practices (GACP) for Starting Materials of Herbal Origin — JANUARY 2006
4. World Health Organization (WHO): WHO Guidelines on Good Agricultural and Collection Practices (GACP) for Medicinal Plants — 2003

5. International Standard for Sustainable Wild Collection of Medicinal and Aromatic Plants (ISSC-MAP). The ISSC-MAP provides a practical interface between the general recommendations set out in the revised “Guidelines on the Conservation of Medicinal Plants” (WHO/IUCN/WWF/TRAFFIC forthcoming), the “WHO Guidelines on Good Agricultural and Collection Practices (GACP) for Medicinal Plants” (WHO 2003), and management plans that must be developed for particular species and specific situations.

WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants, EMEA and EUROPAM guidelines should be considered in conjunction with the existing documents and publications relating to the quality assurance of herbal medicines and to the conservation of medicinal plants .

The concept of Good Manufacturing Practice for the manufacture, processing, packaging and storage of Active Pharmaceutical Ingredients (APIs) also applies to medicinal plants/herbal substances. In the case of herbal preparations the production and primary processing of the medicinal plant/herbal substance has a direct influence on the quality of the API. Due to the inherent complexity of naturally grown medicinal plants/herbal substances and the limited analytical techniques to characterize constituents solely by chemical or biological means, reproducible quality of starting materials of herbal origin requires an adequate quality assurance system for the collection and/or cultivation, harvest and primary processing.

General guidelines on good agricultural practices for medicinal plants describes general principles and provides technical details for the cultivation of medicinal plants. It also describes quality control measures, where applicable.

1. Identification /authentication of cultivated medicinal plants

-Selection of medicinal plants - Where applicable, the species or botanical variety selected for cultivation should be the same as that specified in the national pharmacopoeia or recommended by other authoritative national documents of the end-user's country.

-Botanical identity - The botanical identity – scientific name (genus, species, subspecies/variety, author, and family) – of each medicinal plant under cultivation should be verified and recorded. For commercially available cultivars, the name of the cultivar and of the supplier should be provided. In the case of landraces collected, propagated, disseminated and grown in a specific region, records should be kept of the locally named line, including the origin of the source seeds, plants or propagation materials.

For cultivated medicinal plants/herbal substances all processing steps have to be documented including the location of cultivation. Field records showing previous crop and plant protect products used should be maintained by all growers. For cultivated medicinal plants/herbal substances, it is

essential to document the type, quantity and the date of harvest as well as the chemicals and other substances used during production such as fertilizers, pesticides, herbicides and growth promoters. The application of fumigation agents must be documented.

-Specimens - In the case of the first registration in a producer's country of a medicinal plant or where reasonable doubt exists as to the identity of a botanical species, a voucher botanical specimen should be submitted to a regional or national herbarium for identification.

2. Seeds and other propagation materials - Seeds should originate from plants that have been accurately identified in terms of genus, species, variety/cultivar/chemotype and origin and should be traceable. The same applies to vegetatively propagated medicinal plants. The propagation or planting materials should be of the appropriate quality and be as free as possible from contamination and diseases in order to promote healthy plant growth. Planting material should preferably be resistant or tolerant to biotic or abiotic factors.

Seeds and/or vegetatively propagated medicinal plants used in organic production have to be certified as organic. The starting material should be as free as possible from pests and diseases in order to guarantee healthy plant growth. Where possible, species naturally resistant or tolerant to disease should preferably be used.

The presence of different species, varieties or different plant parts has to be controlled during the entire production process, and such adulteration should be avoided. The use of genetically modified medicinal plants or seeds must comply with regional and/or national regulation.

3. Cultivation of medicinal plants requires intensive care and management. The conditions and duration of cultivation required vary depending on the quality of medicinal plant materials required. If no scientific published or documented cultivation data are available, traditional methods of cultivation should be followed, where feasible.

The principles of good plant husbandry, including appropriate rotation of plants selected according to environmental suitability, should be followed, and tillage should be adapted to plant growth and other requirements.

Cultivation –

-Ecological environment and social impact The social impact of cultivation on local communities should be examined to ensure that negative impacts on local livelihood are avoided. In terms of local income- earning opportunities, small-scale cultivation is often preferable to large-scale production, in particular if small-scale farmers are organized to market their products jointly.

-Climate Climatic conditions, for example, length of day, rainfall (water supply) and field temperature, significantly influence the physical, chemical and biological qualities of medicinal plants. The duration of sunlight, average rainfall, average temperature, including daytime and night-time

temperature differences, also influence the physiological and biochemical activities of plants, and prior knowledge should be considered.

-Soil Optimal soil conditions, including soil type, drainage, moisture retention, fertility and pH, will be dictated by the selected medicinal plant species and/or target medicinal plant part. The use of fertilizers is often indispensable in order to obtain large yields of medicinal plants. It is, however, necessary to ensure that correct types and quantities of fertilizers are used through agricultural research. In practice, organic and chemical fertilizers are used.

-**Irrigation and drainage** should be controlled and carried out in accordance with the needs of the individual medicinal plant species during its various stages of growth. Water used for irrigation purposes should comply with local, regional and/or national quality standards. Care should be exercised to ensure that the plants under cultivation are neither over- nor under-watered.

-Plant maintenance and protection The growth and development characteristics of individual medicinal plants, as well as the plant part destined for medicinal use, should guide field management practices. The timely application of measures such as topping, bud nipping, pruning and shading may be used to control the growth and development of the plant, thereby improving the quality and quantity of the medicinal plant material being produced. Any agrochemicals used to promote the growth of or to protect medicinal plants should be kept to a minimum, and applied only when no alternative measures are available. Integrated pest management should be followed where appropriate. When necessary, only approved pesticides and herbicides should be applied at the minimum effective level, in accordance with the labelling and/or package insert instructions of the individual product and the regulatory requirements that apply for the grower and the end-user countries. of the medicinal plants or medicinal plant materials. Growers and producers should comply with maximum pesticide and herbicide residue limits, as stipulated by local, regional and/or national regulatory authorities of both the growers' and the end-users' countries and/or regions. International agreements such as the International Plant Protection Convention5 and Codex Alimentarius should also be consulted on pesticide use and residues.

4. Harvest

Medicinal plants should be harvested during the optimal season or time period to ensure the production of medicinal plant materials and finished herbal products of the best possible quality. The time of harvest depends on the plant part to be used. Detailed information concerning the appropriate timing of harvest is often available in national pharmacopoeias, published standards, official monographs and major reference books. The best time for harvest (quality peak season/time of day) should be determined according to the quality and quantity of biologically active constituents rather than the total vegetative yield of the targeted medicinal plant parts. During harvest, care should be

taken to ensure that no foreign matter, weeds or toxic plants are mixed with the harvested medicinal plant materials. Cutting devices, harvesters, and other machines should be kept clean and adjusted to reduce damage and contamination from soil and other materials. They should be stored in an uncontaminated, dry place or facility free from insects, rodents, birds and other pests, and inaccessible to livestock and domestic animals.

5. Personnel Growers and producers should have adequate knowledge of the medicinal plant concerned. This should include botanical identification, cultivation characteristics and environmental requirements (soil type, soil pH, fertility, plant spacing and light requirements), as well as the means of harvest and storage.

Inspection and sorting

Raw medicinal plant materials should be inspected and sorted prior to primary processing. The inspection may include:

-visual inspection for cross-contamination by untargeted medicinal plants and/or plant parts;

-visual inspection for foreign matter;

-organoleptic evaluation, such as: appearance, damage, size, colour, odour, and possibly taste.

Primary processing

Primary processing includes washing, cutting before drying, fumigation, freezing, distillation, drying, etc. Where applicable, all of these processes must conform to regional and/or national regulations and should be carried out as soon after harvesting as possible.

Prior to processing, the medicinal plant materials should be protected from rain, moisture and any other conditions that might cause deterioration. Medicinal plant materials should be exposed to direct sunlight only where there is a specific need for this mode of drying. Medicinal plant materials that are to be used in the fresh state should be harvested/collected and delivered as quickly as possible to the processing facility in order to prevent microbial fermentation and thermal degradation. The materials may be stored under refrigeration, in jars, in sandboxes, or using enzymatic and other appropriate conservation measures immediately following harvest/collection and during transit to the end-user. All processed medicinal plant materials should be protected from contamination and decomposition as well as from insects, rodents, birds and other pests, and from livestock and domestic animals.

Drying

When medicinal plant materials are prepared for use in dry form, the moisture content of the material should be kept as low as possible in order to reduce damage from mould and other microbial infestation. Information on the appropriate moisture content for particular medicinal plant materials

may be available from pharmacopoeias or other authoritative monographs. Medicinal plants can be dried in a number of ways: in the open air (shaded from direct sunlight); placed in thin layers on drying frames, wire-screened rooms or buildings; by direct sunlight, if appropriate; in drying ovens/rooms and solar dryers; by indirect fire; baking; lyophilization; microwave; or infrared devices. When possible, temperature and humidity should be controlled to avoid damage to the active chemical constituents. The method and temperature used for drying may have a considerable impact on the quality of the resulting medicinal plant materials. Drying medicinal plant material directly on bare ground should be avoided. For indoor drying, the duration of drying, drying temperature, humidity and other conditions should be determined on the basis of the plant part concerned (root, leaf, stem, bark, flower, etc.) and any volatile natural constituents, such as essential oils. If possible, the source of heat for direct drying (fire) should be limited to butane, propane or natural gas, and temperatures should be kept below 60 °C.

Specific processing

Some medicinal plant materials require specific processing to: improve the purity of the plant part being employed; reduce drying time; prevent damage from mould, other microorganisms and insects; detoxify indigenous toxic ingredients; and enhance therapeutic efficacy. Common specific processing practices include pre-selection, peeling the skins of roots and rhizomes, boiling in water, steaming, soaking, pickling, distillation, fumigation, roasting, natural fermentation, treatment with lime and chopping. Processing procedures involving the formation of certain shapes, bundling and special drying may also have an impact on the quality of the medicinal plant materials. Antimicrobial treatments of medicinal plant materials (raw or processed) by various methods, including irradiation, must be declared and the materials must be labeled as required. Maximum residue limits, as stipulated by national and/or regional authorities, should be respected.

Processing facilities

The following elements should be considered when establishing a quality assurance system and be adapted to the different steps of production and production sites: location, roadways and areas used by wheeled vehicles, buildings, medicinal plant material handling areas, water supply, effluent and waste disposal, changing facilities and toilets, hand-washing facilities in processing areas, disinfection facilities, lighting, ventilation, storage of waste and unusable materials.

Bulk packaging and labeling

Processed medicinal plant materials should be packaged as quickly as possible to prevent deterioration of the product and to protect against unnecessary exposure to potential pest attacks and other sources of contamination. Processed medicinal plant materials should be packaged in clean, dry boxes, sacks, bags or other containers in accordance with standard operating procedures and national

and/or regional regulations of the producer and the end-user countries. Materials used for packaging should be non-polluting, clean, dry and in undamaged condition and should conform to the quality requirements for the medicinal plant materials concerned. Fragile medicinal plant materials should be packaged in rigid containers. A label affixed to the packaging should clearly indicate the scientific name of the medicinal plant, the plant part, the place of origin (cultivation or collection site), the cultivation or collection date and the names of the grower/collector and the processor, and quantitative information. The label should also contain information indicating quality approval and comply with other national and/or regional labeling requirements. The label should bear a number that clearly identifies the production batch. Additional information about the production and quality parameters of the medicinal plant materials may be added in a separate certificate, which is clearly linked to the package carrying the same batch number.

Storage and transportation

Conveyances used for transporting bulk medicinal plant materials from the place of production to storage for processing should be cleaned between loads. Bulk transport, such as ship or rail cars, should be cleaned and, where appropriate, well ventilated to remove moisture from medicinal plant materials and to prevent condensation. Organically grown medicinal plant materials should be stored and transported separately or in a manner that ensures their integrity. Appropriate security measures should be applied to the storage and transport of medicinal plant materials that are potentially toxic or poisonous. Whenever required and when possible, fresh medicinal plant materials should be stored at appropriate low temperatures, ideally at 2−8 °C; frozen products should be stored at less than −20 °C.

3.Selection of the most promising medicinal crops (Lavandula angustifolia, Calendula officinalis, Mentha piperita, Plantago lanceolata, Echinacea angustifolia)

A limiting factor for starting new crops is represented by weather conditions. Scientists widely agree that global climate change is already causing major environmental effects, such as changes in the frequency and intensity of precipitation, droughts, heat waves and wildfires; rising sea level; water shortages in arid regions; new and larger pest outbreaks afflicting crops and forests.

Forecast of climate change and impact on crops development

In general, changes in atmospheric CO2 levels and increases in temperature are changing the quality and composition of crops and grasslands and also the range of native/alien pests and

diseases. These may affect livestock and ultimately humans as well as crops. In addition, the increase in ozone concentrations related to climate change is projected to have significant negative impacts on agriculture, mainly in northern mid-latitudes.

Phenological changes

The timing of seasonal events in plants is changing across Europe, due mainly to changes in climate conditions; 78 % of leaf unfolding and flowering records show advancing trends and only 3 % a significant delay. Between 1971 and 2000, the average advance of spring and summer was 2.5 days per decade. As a consequence of climate-induced changes in plant phenology, the pollen season starts on average 10 days earlier and is longer than 50 years ago. Trends in seasonal events will continue to advance as climate warming increases in the years and decades to come.

Phenological changes will alter growing seasons, ecosystem production, population-level interactions and community dynamics.

-There is evidence that the length of the growing season of several agricultural crops in Europe has changed. A longer growing season increases crop yields and insect populations and favours the introduction of new species in areas that were not previously suitable for these species. These observed facts are particularly important for the northern latitudes. Locally at southern latitudes, the trend is towards a shortening of the growing season, with consequent higher risk of frost damage from delayed spring frosts.

-There is evidence that the flowering and maturity of several species in Europe now occurs two or three weeks earlier than in the past. The shortening of the phenological phases is expected to continue if temperatures continue to increase. Adaptations of farm practices will be crucial to reduce or avoid negative impacts of crop-cycle shortening.

-As a consequence of climatic change, such events are projected to increase in frequency and magnitude, and crop yields to become more variable. Changes in farming practices and land management can act as risk-mitigating measures. While the area under arable cultivation in most of western Europe has decreased over the past 40 years, crop yields have increased almost continuously (Eurostat). This trend has persisted into the 21st century, although crop-yield variability increased as a consequence of several extreme meteorological events in short succession. The production areas of some crops could expand northwards in Europe. Crop yields are also at risk from more intensive precipitation and prolonged periods of drought, particularly in areas bordering the Mediterranean basin.

Soil

-An estimated 115 million hectares, 12 % of the total EU land area, are subject to water

erosion. The projected changes in the climate during the 21st century, with increased variations in rainfall pattern and intensity, will make soils more susceptible to erosion. The off-site effects of soil erosion will increase with climate change and related changes in rainfall pattern and intensity.

-Water retention capacity and soil moisture content will be affected by rising temperature and by a decline in soil organic matter due to both climate change and land-management changes. Projections (for 2071–2100) show a general reduction in summer soil moisture over most of Europe, significant reductions in the Mediterranean region, and increases in the north-eastern part of Europe. Maintaining water retention capacity is important to reducing the impacts of intense rainfall and droughts, which are projected to become more frequent and severe.

-Soil degradation is already intense in parts of the Mediterranean and central-eastern Europe. Soil degradation, together with prolonged drought periods and increased numbers of fires, leading to marginalisation and even land abandonment, is already contributing to an increased risk of desertification. The risk of desertification is expected to be the highest in areas with projected decreases in precipitation, increases in the frequency of summer droughts and the incidence of forest fires, and intensive land-use. In many cases, desertification is irreversible, leading to adverse social, economic and environmental effects.

Water

Between 1975 and 2006 clear trends, both positive and negative, were evident in water requirement across Europe, with marked spatial variability. A significant increase in water demand (50–70 %) occurred mainly in Mediterranean areas; large decreases were recorded mainly in northern and central European regions. Current trends and future scenarios depict an increase in the demand for water in agriculture, potentially increasing competition for water. Crop management will have to be adapted in order to try to avoid crucial development stages sensitive to water-stress (flowering, grain filling, etc.) occurring during generally dry periods.

Information resource

Impacts of Europe's changing climate — 2008 indicator-based assessment, European Environment Agency

Based on statistical survey of existing European medicinal crops, on forecast of climate change and on data received from the most important Romanian manufacturers of phytopharmaceutically products, 5 medicinal and aromatic species showed high potential for

cultivation in order to provide a steady source of raw material for bio-industry. Also, these species have a good potential for further valorification: *Lavandula angustifolia, Calendula officinalis, Mentha piperita, Plantago lanceolata, Echinacea angustifolia.* Although these species are widely cultivated in Europe, the selection is justified by the multi-purpose potential of the plant - a variety of products based on current uses and future projections, various types (herb, seeds, fruits, leaves, flowers, roots) of raw material for industrial use and an important market demand.

Calendula officinalis L. (Asteraceae)

Common names

Atunjaq, calendula, Chinese safflower, cuc kim tiên, djamir, djomaira, feminell, flamenquilla, fleur de calandule, fleur de souci, fleur de souci officinal, fleurs de tous les mois, garden marigold, gold-bloom, Goldblume, gole hamisheh bahar, hen and chickens, Körömvirag, lellousha, maravilla, marigold, mary-bud, ok-hhawan, pot marigold, qaraqus, qawqhan, quaqahan, ringflower, Ringelblüten, saialill, sciure'e Sant'antonio, souci, souci des jardins, tabsoult, toukinsenka, tousslat, uchu k'aspa, vir-reina, xu xi, zergul zerzira, zobeida, zubaydah.(1)

Areas of origin and current cultivation

Indigenous to central, eastern and southern Europe. Cultivated commercially in North America, the Balkans, Eastern Europe and Germany.(1)

Plant anatomy

An annual herb, much branched from the base, very aromatic, up to 0.3–0.6 m high; stem angular, hairy and solid. Leaves sessile, light green, with semiamplexicaul base; entire, undulate or remotely denticulate; glandular hairs on both surfaces; lower leaves spatulate, obtuse, sometimes acute at the apex, 10–20 cm long and 1–4 cm wide; higher leaves oblong and mucronate, 4–7 cm long. Involucral bracts 7–15 mm long, covered with long, glandular hairs; inner involucral bracts with pellucid, scarious margin; marginal flowers in cultivated plants often multi-seriate; corolla oblong-spatulate, bright yellow or orange, 15–25 mm long and 3 mm wide, 1–3-toothed with 4 or 5 veins, marginally entire, covered at the base with patent, long, thick hairs; corolla of disc flowers rounded, 3-dentate top, 1.5–

2.5 cm long and 4–7 mm in diameter, 5 mm long tube and moderately widened limb. Stigma short, thick, hairy; ovary oblong, 0.5 mm in length, pubescent, shrivelling after anthesis. Achenes narrowly oblong, strongly curved, faintly ribbed, thinly pubescent or glabrous, 10–12 mm long, outer achenes warty-ribbed outside, inner achenes prickly-warty, often with broad, thick margins. (1)

Growing conditions – input requirements

Calendula demands no special requirements from climatic factors, it grows on all types of soil and in all areas except the mountain. It has no requirements regarding the previous crop and also itself is a good crop for other future species. *Calendula* should not be grown more than once every 6 years in the same field and not as part of intensive rotations with other susceptible crops such as oilseed rape and sunflowers to avoid specific pests and diseases. On deep soils, well drained with good fertility, which is loose and slightly warm, production increases.

Vegetation period is quite long, being able to give good production, if weather permits, until September.(2)

Minimum physical purity of seeds should be 85% and germination of 70%. Amount of seed used per hectare is 5-6 kg, for a density of 40-50 seedlings/m2, planting depth is 2-3 cm. In the end, plant density should be kept around 30-35 plants/m2.

Marigold culture may be established by seedlings as well, in the same conditions of cultivation. In this case is possible to achieve earlier production, may contribute to harvest on different stages and to plant selection, ensuring consistency and reducing the consumption of seed culture.(2)

Crop management

Calendula species responds very well to application of organic fertilizers such as manure which could be applied in fall, before plowing, in doses of 10-20 t / ha. Plants benefit from the effect of manure through increased production of inflorescences, but also by increasing content in active substances such as carotenoids and bitter principles.

General advice for fertilisation, which can be adjusted for local conditions, is as follows:

Nitrogen (N): 50-100 kg/ha

Phosphate (P2O5): 25-75 kg/ha

Potassium (K2O): 50-100 kg/ha

In some cases excess fertility has resulted in crop lodging. As with all crops, poor fertilisation can result in uncompetitive plants and increased weed problems and an excess of fertiliser, particularly nitrogen can contribute to increased damage by plant diseases.(3)

Weeds must be removed whenever is necessary. Also, the chain flowers that do not correspond in terms of color, that have yellow-light appearance, must be removed. By sowing at the correct time, and into good seedbeds, early growth of *Calendula* will be rapid, suppressing the development of weeds.

Legal options for chemical weed control are limited in most EU countries due to the absence of specific pesticide approvals for *Calendula* and limited approvals on related oilseed crops (which may allow limited uses in *Calendula*). Before sowing, a spray of glyphosate (at rates of 720 g/ha up to 1440 g/ha) can be used to control germinating weeds or perennial weed problems.

Trials in the UK have investigated both pre-emergence and post-emergence applications of herbicides. There are very limited options for post-emergence applications of herbicide.(3)

Botrytis has been reported in crops. This disease is favoured by wet and humid conditions. Mildew has also been observed, particularly in late season, although its effect on seed yields is unknown. *Sclerotinia* has been reported in crops and sclerotia have been found in harvested seed lots. If preventive measures are followed, such as rotation and cultural hygiene, there are no disease or pests which can affect production.(3)

Logistics (harvesting – handling) until the industrial plant gate

Harvest

Calendula harvest is a difficult operation that requires attention and manual labor. The operation is done in several phases, from June to October, as the first flowers have opened their ligulate inflorescences, starting at about 65-70 days after rising.

During the first period, the interval between harvesting is 3-4 days. Immediately after harvesting, the product is placed in baskets and transported for conditioning and drying.(2)

Drying is made in a thin layer in the shade, in well-ventilated rooms, dry and clean. After drying, the product is packed in padded boxes and kept in darkness to keep their natural orange color.(2)

Yields

Yields are 1500-3000 kg / ha ligulate flowers and 4000-9000 kg / ha fresh inflorescences. Drying efficiency is 8:1, resulting in production of dried ligulate flowers around 200-300 kg / ha and the inflorescences of 1000-1500 kg / ha.(2)

Quality

Plant material of interest: dried ligulate florets and composite flowers

General appearance: Ligulate florets consist of a yellow, orange or orange-yellow ligule, 3–5 mm wide and about 7 mm in the middle part, with 3-toothed apex and hairy, partly sickle-shaped, yellowish-brown to orange-brown tube with projecting style and 2-lobed stigma; occasionally with a partly bent yellowish-brown to orange-brown ovary. Tubular florets about 5 mm long, consist of yellow, orange-red or red-violet 5-lobed corolla and yellowish-brown or orange-brown tube, hairy in its lower part, mostly with a bent yellowish-brown to orange-brown ovary.(1)

Organoleptic properties: Odour: faint, pleasantly aromatic; taste: bitter.(1)

Microscopic characteristics: Inner epidermal cells of ray floret elongated, rectangular and almost straight-walled, cuticle faintly striated; stomata absent; outer epidermal cells similar, but with 3 or 4 anomocytic stomata; trichomes very numerous on the tube, bi-seriate; stigma epidermal cells straight-walled, polygonal. In disc floret, outer epidermal cells elongated, straight or slightly sinuous-walled, stomata absent; abundant trichomes on area below point of insertion of the stamens, mainly glandular, uniseriate or biseriate. Within the upper part of the anthers, a layer of isodiametric to elongated, moderately thick-walled, lignified and pitted cells; pollen grains spherical, up to 45 mm in diameter, with 3 germinal pores, exine finely granular with numerous short spines; apex of stigma covered by short, bulbous papillae.(1)

General identity tests: Macroscopic and microscopic examinations, and thin-layer chromatography for flavonoid content.(1)

Adulteration

Is not common as *C. officinalis* is usually cultivated, but other species of *Calendula* (*Calendula arvensis*) and of the Asteraceae family may be mistaken for it.(4)

Regulatory status

In UK and Germany, *Calendula* for external use is included on the general sale List. It is covered by a positive Comission E monograph. *Calendula* is official in the British Pharmacopeia 2002 and the European Pharmacopeia 4.3.

In US *Calendula* does have generally recognised as safe status.(4)

Major chemical constituents

The major constituents are triterpene saponins (2–10%) based on oleanolic acid (i.e. calendulosides) and flavonoids (3-O-glycosides of isorhamnetin and quercetin), including astragalin, hyperoside, isoquercitrin and rutin. Other constituents include essential oil, sesquiterpenes (e.g. caryophyllene)

and triterpenes (e.g. a- and b-amyrins, lupeol and lupenone). Polysaccharides have also been reported. (1)

It contains no less than 0.4% flavonoids, calculated as hyperoside with reference to the dried drug.(5)

The material complies with the monograph of the European Pharmacopoeia.

Experimental pharmacology

Phagocytosis

Three polysaccharides isolated from an aqueous extract of Flos *Calendula*e enhanced phagocytosis in human granulocytes in vitro in the colloidal carbon clearance test. Intraperitoneal administration of an unsaponifiable fraction (0.5 ml) of a hydroalcoholic extract of the flowers weakly stimulated phagocytosis in mice inoculated with Escherichia coli. However, the hydroalcoholic extract was not active.(1)

Antimicrobial activity

The essential oil of the flowers inhibited the growth in vitro of *Bacillus subtilis*, *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa* and *Candida albicans*. A flavonoid fraction isolated from the flowers inhibited the growth *in vitro* of *S. aureus, Sarcina lutea, E. coli, Klebsiella pneumoniae* and *Candida monosa*. However, chloroform, ethanol, methanol or water extracts of the flowers did not inhibit bacterial growth in vitro. Acetone, ethanol or water extracts inhibited the growth in vitro of the fungus *Neurospora crassa*. Extracts of the flowers inhibited the growth *in vitro* of *Trichomonas vaginalis*. Oxygenated terpenes appear to be responsible for the antimicrobial activity.(1)

Antiviral activity

A tincture of the flowers suppressed the replication of herpes simplex, influenza A2 and influenza APR-8 viruses in vitro. However, an aqueous extract of the flowers was not active. A chloroform extract of the flowers inhibited the replication of HIV-1 in acutely infected lymphocytic MOLT-4 cells in vitro (IC50 0.4 mg/ml). A chloroform extract also inhibited HIV-1 reverse transcriptase activity in a dose-dependent manner (ED50 51.0 mg/ml). A 5% hot aqueous extract of the flowers (2 ml) inhibited the replication of encephalitis virus after intraperitoneal administration to mice.(1)

Anti-inflammatory activity

Topical application of a 70% ethanol extract of the flowers to mice at a dose of 1.2 mg/ear (corresponding to 4.16 mg crude drug) reduced croton oil-induced ear oedema by 20%. External application of a carbon dioxide extract of the flowers (300 mg/cm2) suppressed croton oil-induced ear oedema in mice. The triterpene fraction of an extract of the flowers had marked anti-inflammatory activity in mice (1 mg/ear) against ear oedema induced by 12-O-tetradecanoylphorbol-13-acetate. Faradiol es-

ters isolated from the flowers (240 mg/cm2) inhibited croton oil-induced ear oedema in mice. Intragastric administration of an aqueous extract of the flowers (100 mg/kg body weight) inhibited carrageenan-induced footpad oedema in rats. Isorhamnetin glycosides isolated from the flowers inhibited rat lung lipoxygenase in vitro.(1)

Wound-healing activity

External application of a hydroalcoholic extract accelerated the rate of contraction and epithelialization of excision wounds in rats. A 3% freeze-dried aqueous extract of the flowers induced vascularization in the chick chorioallantoic membrane assay. Histological sections of the treated chorioallantoic membranes also indicated the presence of hyaluronan, a tissue glycosaminoglycan associated with neovascularization.(1)

Contraindications

External use-Allergy to plants in the Asteraceae.(1)

Dosage

External use:

-infusion for topical application: 1-2g of dried flower per 150ml of water.

-fluid extract 1:1: in 40% ethanol or tincture 1:5 in 90% ethanol. For the treatment of wounds the tincture is applied undiluted; for compresses the tincture is usually diluted at least 1:3 with freshly boiled water.(1)

-semi-solid preparations containing 2-10% of fluid extract 1:1(5)

Other uses:

***Calendula* as paint additive**

Octadec-8,10-trans-12-cis-trienoic acid (calendic acid) is the main fatty acid (ca. 60%) in the seed oil of *Calendula officinalis*. German specialists obtained calendic acid esters from the native oil by a simple transesterification method using alcohols, i.e. methanol, ethanol or isopropanol and sodium methoxide as catalyst. In a patent by DSM methyl calendulate is described as a very efficient reactive diluent. In addition to this, even better results are obtained for ethyl and isopropyl calendulate as reactive diluent showing low viscosity and good drying properties. In special applications e.g. in coating material used in the outskirt area the substitution of tung oil should be possible by *Calendula* oil. (6)

-The growing plant acts as an insect deterrent, it reduces the soil eelworm population.

The flowers are used cosmetically. They can be used in skin lotions and when added to hair shampoos will lighten the hair colour.

The flowers are an alternative ingredient of 'Quick Return' compost activator. This is a dried and powdered mixture of several herbs that can be added to a compost heap in order to speed up bacterial activity and thus shorten the time needed to make the compost[K].

A yellow dye is obtained from the boiled flowers.

An essential oil is obtained from the plant. It is used rather sparingly, in view of the difficulty in obtaining it, in perfumes that have a rather sharp tang.

The flowers close when wet weather is likely to occur and they can therefore be used as a rough means of weather forecasting.(7)

-*C. officinalis* extracts exert various effects on growth and physiology of *Spodoptera litura* (Fab.), a serious polyphagous pest distributed throughout the tropical and subtropical parts of the world including India, Japan, China and South East Asia causing damage to more than 150 species of host plants. At higher concentrations tested, the larval growth declined associated with reduced food consumption and utilization; probably the triterpenes interfered with the digestion and absorption of ingested food and also with the conversion of absorbed food to biomass.(8)

-3-O-monoglucoside of oleanolic acid secreted to the soil by *Calendula* species possesses very strong allelophatic properties in relation to the dicotyledons and weaker activity to the monocotyledons. (9)

Factors restricting growth and yielding potential

-Interaction between genotype and environment was observed, but improved lines showed good adaptation to differing environments. However, environmental factors do not favour commercialisation of *Calendula* in Southern Europe.(10)

-The short growing season and late sowing date relative to the seasonal increase in incident radiation in the south of the UK appears to limit crop performance. Earlier sowing in mid-March might be beneficial if temperature conditions were favourable for crop growth. This suggests the need to develop more hardy genotypes. Alternatively, autumn sowing or dual cropping approaches might be

appropriate. However, no further work on biennial cropping is recommended with currently-available cultivars.(10)

-Plant density affects greatly yield because the competition for water, light and nutrients, density planting promotes reduction of yield capacity of plants which occurs in high or small level on yield of different species. For *Calendula* cultivation, Luz et al. (2001) recommend spaces between plants from 35 to 45 cm for density of 63.200 plants ha-1; Martins et al. (2000) recommend 25 x 50 cm and Sartório et al. (2000) recommend 20 x 30 cm. (11)

-An experiment carried out during two successive seasons 2005/2006 and 2006/2007 show that spraying *Calendula* crop with gibberellic acid at concentrations of (50. 100. 150 ppm) and cycocel at (1000, 2000, 3000 ppm) and humic acid at levels of (0, 3, 6 kg/ fed.) improved vegetative growth and flowering, increased plant height and dry weight of both leaves and flowers.(12)

Research gaps

-Canadian specialists suggest that, for *C. officinalis*, shallow culture hydroponics, in some respects resembling nutrient film technique, may be a superior system to floating deep culture hydroponics. It is possible that the xerophytic adaptations of the plant are supported by the “ecological mimicking” provided by this hydroponic technique based on provision of an intermittent water and nutrient supply. Additional work should also be conducted to determine the concentrations of active phytochemicals in the capitula when grown in a hydroponic system supplied by contrasting P concentrations, as it has been suggested that increasing P concentrations should increase secondary metabolite production (13)

Information resources

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Echinacea angustifolia DC. (Asteraceae)

Common names

American coneflower, black sampson, cock up head, coneflower, echinacea, Igelkopf, Indian head, Kansas snakeroot, Kegelblume, narrow-leaved purple coneflower, purple coneflower, Sonnenhut

Areas of origin and current cultivation

Echinacea species are native to the Atlantic drainage area of the United States of America and Canada, but not Mexico. Their distribution centres are in Arkansas, Kansas, Missouri, and Oklahoma in the United States of America.

Cultivation areas of *Echinacea angustifolia* in Europe in the last years are the followings: Germany-5ha (2000), France-17ha (2000), Spain-1ha (2002), Switzerland-1ha (2002).(1)

In Estonia OÜ Elujõud operates in the field of growing, packaging and sales of herbs. The main production is carried out in a 5.8 hectare area in Central Estonia. Over 20 herbs are grown on several hectares without mineral fertilisers and chemical control products and the same number of tea mixtures are produced. *Thymus, Salvia, Rosa, Artemisia, Alchemilla, Solidago, Hypericum, Melissa, Ur-*

tica, Plantago, Echinacea and *Achillea* are grown on approximately 2ha in total and are marketed as the health product mixed in the different tea mixtures.

A statistic from 2000 shows that in France, species like echinacea, artichoke, St John's wort, borage, Passiflora, Valerian are cultivated on 367 ha.

Plant anatomy

Echinacea species shows high ecological plasticity. Preferably, *E. angustifolia* should be grown in lower areas, with strong insolation and light and warm soils.

Echinacea are perennial herb that, in a young vegetative state, produce a cluster of leaves to about 30 cm high from a short (20-30 mm) rhizome. *E. angustifolia* has stiff, bristly hairs on its leaves, and is tap-rooted, linearlanceolate entire leaves 5-30 cm long. In its first year of growth, one or more flowering stems are produced, which grow up to 1.5 m high and bear the large (5-15 cm) ray flowers. A characteristic is the conically-arched seed head that, in *Echinacea,* is spiny, and the generic name is derived from the Greek word “rhinos” meaning hedgehog. The flower stems and most of the leaves die off during the winter, but produce numerous short, lateral rhizomes from the base of the stem, each developing into more flowering stems in the second and subsequent years of growth.(1)

Growing conditions – input requirements

E. angustifolia grows best in a more alkaline soil than the other *Echinacea* species, that is, a pH of approximately 8 appears suitable. In Poland, *Echinacea* is grown in soil with a pH of 6.5 to 7.2. *Echinacea* is best suited to well-drained, moderately rich soil types, and an average sandy loam. Plants will not grow well in poorly drained soil. In Finland, overwintering problems have occurred in plain soils with long-term standing water. Soil with stones is undesirable.(2)

For optimal growth, *Echinacea* plants need full sun. *E. angustifolia* is an open plains plant that grows best in hot sun.

Given their original natural habitats, it is not surprising that *Echinacea* species are well adapted to dry growing conditions in Europe. In cultivation, they are an exceptionally drought-tolerant species and stand up to such conditions better than any other perennial. Differences in drought tolerance are based on their morphology. *E. angustifolia* have narrower and hairy leaves, and deep taproots, therefore it tolerates drought better.

In their native habitats, *Echinacea* species are frost-resistant and winter-hardy perennials, and they can tolerate -25ºC to -40ºC temperatures, provided there is snow cover . In Europe, they safely overwinter in all parts of South and Central Europe. Scandinavia is the northern limit of its commercial

cultivation. *Echinacea* overwintered quite safely in southern Finland at Nordic latitudes of 60º to 61º. However, from overwintering, problems occurred mainly after the first year of cultivation, when the seedlings were not well developed (weak growth, late transplanting time. For successful *Echinacea* cultivation in the northern regions, mesoclimatic conditions (continuous snow cover, no standing water) and early transplanting of strong, well-developed seedlings are very important. Under optimal conditions, commercial cultivation has been practiced near the Arctic Circle at Oulunsalo (at the 65º N latitude) in Finland.(1)

Planting

Echinacea crop can be established by seed or planting stock. For a safe and efficient culture is recommended to establish the crop by seedlings. Seedlings will be planted in late April or beginning of May, at distances of 50 cm between rows and 40 cm between plants per row, because plants need space for growth as the bush. In this case, culture density is 40,000 plants per ha. After planting, apply plenty of water (400-500 m3).(2)

Crop management

Echinacea responds well to application of organic fertilizers such as manure, in doses of 15-20 t / ha, applied in the fall, in the plowed field.

German growers apply 100-200 kg/ha of nitrogen in split applications during the life of the crop, and as much as 100 kg of phosphorus and 250 kg of potassium at planting.

Whenever it is need, weeds will be destroyed, depending on the culture condition. Although *Echinacea* grows in meadow ecosystems in wild places, it is not weed tolerant in cultivation. Therefore, although weed control is a very important factor throughout the entire cultivation period, it is especially important in the first year. In small cultivation areas, mechanical weeding is an ideal and easy way to keep populations free from weeds. In the case of larger, industrial production, chemical weed control becomes necessary, especially if direct sowing of seeds has been employed.

In echinacea crops have not noticed important diseases or pests.(2)

Logistics (harvesting – handling) until the industrial plant gate

Harvest

E. angustifolia herba could be harvested since the second year of culture, at flowering. In the third, fourth years of culture, harvested at flowering, both aerial parts and root.

Plants are harvested in autumn. Tops are cut to about 5 cm above ground level before plants are lifted using a digger that can work to a depth of 30 cm. Shoot residue must be removed before roots are cut into 5-10 cm long pieces and thoroughly washed. Clean roots are essential to meet quality standards. Choosing a friable soil with relatively low clay content can make a substantial difference to the ease of root washing. After washing, the roots, which are about 30-35% dry matter, are dried at 40-45EC until brittle.

In Germany, the production of foliage is an additional crop and harvesting is undertaken by mowing the plants at 10 cm above the ground.

According to German experiences and recommendations, harvest possibilities are:

Herb harvest, first year of cultivation: The optimum harvest time occurs when the main flowers are in full flowering. *E angustifolia* may have flowers at the end of the summer. In the northern part of Europe (e.g., Finland), in the case of transplanting in early June, there are no flowers at all during the first year. In the propagation years, flowering and harvesting times are generally in the early autumn: for *E. angustifolia,* the end of September.

Second to fourth years of cultivation: After the propagation year, flowering of well-established populations starts earlier. The optimum harvest time occurs when the plants are in full flowering: for *E. angustifolia,* the end of July. For optimum contents of active ingredients, it is proposed to harvest as many full bloom flowers as possible. During autumn, a second harvest of the herb biomass may be achieved, but the proportions of the flowers then are generally lower. The stem height for cutting should not be lower than 10 cm aboveground. Lower cutting may result in poor overwintering and less growth in subsequent years. The times of the second harvest should not be too late in the year. In Poland, harvest in the second and third years is usually carried out between September 18 and 24, but in the fourth year, it is earlier, such as August 20. The harvest of herb biomass in smaller plots is carried out by hand, but on a larger scale, machinery is used.(1)

The root size of *E. angustifolia* is suitable for harvest beginning after the second growing year. According to Romanian and Polish experiences, root harvest during the end of the third year results in higher root yields. The root harvest can be combined with the herb harvest as well. This means that before the root harvest, the herb could be utilized without harmful effects on root quality. The roots can be harvested in smaller areas by hand but on an industrial scale, machinery must be used. (1)

Drying can be done in the shade or artificially, at temperatures up to 35-45ºC. Drying efficiency is about 4:1 for herba and 3:1 for roots.(2)

Yields

Fresh production of herba may be about 5 tonnes / ha in the second year of vegetation, and 10-12 t / ha in the coming years.(2)

In Germany, *E. angustifolia* yield 2-3 t/ha of dried root in the first year and up to 6 t/ha after two years.

Quality

Plant material of interest: fresh or dried roots

General appearance: Cylindrical or slightly tapering and sometimes spirally twisted, passing imperceptibly into a rhizome in the upper part; rhizome up to about 15 mm in diameter, roots 4–10 mm in diameter; outer surface pale brown to yellowish brown; rhizomes crowned with remains of the aerial stem and sometimes showing surface annulations; roots longitudinally wrinkled and deeply furrowed; fracture short when dry but becoming tough and pliable on exposure to air.(3)

Organoleptic properties: Powdered rhizome and roots are brown with a slight aromatic odour and initially a sweet taste, quickly becoming bitter and leaving a tingling sensation on the tongue. Thin-walled polygonal cork cells with red-brown contents; lignified reticulately thickened vessels; abundant stone cells of various shapes; fragments of oleoresin canals with reddish brown contents; abundant thin-walled parenchyma with spherocrystalline masses of inulin.(3)

Microscopic characteristics: The roots of *E. angustifolia* and *E. pallida* are very similar. The transverse section shows a thin outer bark separated by a distinct cambium line from a wide xylem; a small circular pith in the rhizome. Cork composed of several rows of thin-walled cells containing yellowish brown pigment; cortex parenchymatous; rhizome with occasional small groups of thick-walled, lignified fibres in the pericycle; phloem and xylem composed of very narrow strands of vascular tissue separated by wide, non-lignified medullary rays; xylem vessels lignified, 25–75 µm in diameter, usually reticulate thickening but occasionally with spiral or annular thickening; stone cells, occurring singly or in small groups, varying considerably in size and shape from rounded to rectangular to elongated and fibre-like, up to 300 µm long and 20–40 µm wide, with intercellular spaces containing a dense black deposit; schizogenous oleoresin canals; spherocrystalline masses of inulin occur throughout the parenchymatous tissue. In E. angustifolia oleoresin canals, 80–150 µm in diameter and containing yellowish orange oleoresin, are present only outside the central cylinder, but in E. pallida they are present both inside and outside. In E. angustifolia the narrow, 300–800 µm long, lignified fibres are in scattered groups usually surrounded by phytomelanin deposits.(3)

General identity tests: Macroscopic and microscopic examinations. Chemical fingerprints of lipophilic constituents, echinacosides, and other caffeic acid derivatives in methanol extracts can be obtained by thin-layer chromatography and high-performance liquid chromatography.(3)

Adulteration

Over the last several years, the market for Echinacea has grown rapidly. As a result, there has been an increase in species misidentification or adulteration in the *Echinacea* trade. Inadequate quality control means that ineffective or adulterated products can reach the market. The literature and the media have revealed examples of Echinacea preparations of poor quality and low amounts of characteristic constituents.

Roots of *Parthenium integrifolium* L., commonly known as American feverfew, have been found to be adulterants/substitutes for Echinacea root. Its roots are larger and easier to harvest than Echinacea roots. This adulterant/substitute can be recognized by the absence of any caffeoyl derivatives or through the presence of the sequiterpene esters cinnamoylechinadiol, cinamoylepoxyechinadiol, cinnamoylechinaxathol, and cinnamoyl dihydroxynardol.

Wolf et al. (1999) described the discrimination of the three main species of *Echinacea* by random amplified polymorphic DNA (RAPD) analysis. (1)

Roots of *E. angustifolia* and *E. pallida* are very similar, both macroscopically and microscopically and are often confused, but they can be chemically diferentated.(4)

Regulatory status

UK and Germany-Echinacea is included on the General sale List. E*. angustifolia* aerial parts and roort are covered by a negative Comission E monograph (due to lack of clinical trials for the specific plant parts). Echinacea does not have generaly recognized as safe (GRAS) status in US. (4)

Major chemical constituents

A number of chemical entities have been identified and reported to be biologically active, including a volatile oil, alkamides, polyalkenes, polyalkynes, caffeic acid derivatives, and polysaccharides. The volatile oil contains, among other compounds, pentadeca-(1,8-Z)-diene (44%), 1-pentadecene, ketoalkynes and ketoalkenes. More than 20 alkamides, mostly isobutylamides of C11–C16 straight-chain fatty acids with olefinic or acetylenic bonds, or both, are found in the roots. The main alkamide is a mixture of isomeric dodeca-2,4,8,10-tetraenoic acid isobutylamides. Caffeic acid ester derivatives

present include echinacoside, cynarin, and chicoric acid. Cynarin is present only in *E. angustifolia*, thus distinguishing it from the closely related *E. pallida*.

Polysaccharide constituents are of two types: a heteroxylan of relative molecular mass about 35 000 and an arabinorhamnogalactan of relative molecular mass about 45 000.

Other constituents include trace amounts of pyrrolizidine alkaloids (tussilagine (0.006%) and isotussilagine). At these concentrations, the alkaloids are considered to be non-toxic, and since they lack the 1,2-unsaturated necine ring of alkaloids, they are considered to have no hepatotoxic potential.

Extracts of *E. angustifolia* roots could be distinguished from those of *E. purpurea* and *E. pallida* by the absence of, or only a trace of, cichoric acid, and by the presence of both cynarin and echinacoside. Alkamides are present as dodecatetraenoic acid isobutylamides in *E. angustifolia*. The natural variation of Echinacea within a species can have a tremendous effect on final product quality. This diversity might be due to genetic and environmental differences including variety, cultivation regions, harvest time, and cultivation or processing conditions. In general, the wild E. angustifolia has higher echinacoside content than the cultivated one. (1)

Experimental pharmacology

Current claims for the effectiveness of Radix Echinaceae as a stimulator of the immune system are based on over 350 scientific studies in the past 50 years. Numerous in vitro and in vivo studies have documented the activation of an immune response after treatment with Radix Echinaceae extracts. The immunostimulant effect is brought about by three mechanisms: activation of phagocytosis and stimulation of fibroblasts; increasing respiratory activity; and causing increased mobility of the leukocytes. Chemically standardized extracts, derived from roots and aerial parts, have been assessed for their phagocytotic potential. Ethanolic root extract increased phagocytosis in vitro. Inhibition of hyaluronidase activity, stimulation of the activity of the adrenal cortex, stimulation of the production of properdin (a serum protein which can neutralize bacteria and viruses), and stimulation of interferon production have also been reported after Echinacea treatments. The pharmacological activity of Echinacea spp. has been attributed to five component fractions in addition to the essential oil, namely the alkylamides, caffeic acid derivatives, polyalkynes, polyalkenes and polysaccharides. The lipophilic amides, alkamides and caffeic acid derivatives appear to contribute to the immunostimulant activity of the alcoholic Echinacea extracts by stimulating phagocytosis of polymorphonuclear neutrophil granulocytes. High molecular weight polysaccharides, including heteroxylan, which activates phagocytosis, and arabinogalactan, which promotes the release of tumour necrosis factor and the production of interleukin-1 and interferon beta, have also been implicated in the activity of the aqueous extracts and the

powdered drug when taken orally. The overall immunostimulant activity of the alcoholic and aqueous Echinacea extracts appears to depend on the combined effects of several constituents. Echinacea extracts inhibit streptococcal and tissue hyaluronidase. Inhibition of tissue and bacterial hyaluronidase is thought to localize the infection and prevent the spread of causative agents to other parts of the body. In addition to the direct antihyaluronidase activity, an indirect effect on the hyaluronic acid–hyaluronidase system has been reported. Stimulation of new tissue production by increasing the activity of fibroblasts, and stimulation of both blood- and tissue-produced phagocytosis, appear to be involved in this mechanism. Echinacea extracts have anti-inflammatory activity. An alkylamide fraction from Echinacea roots markedly inhibited activity in vitro in the 5-lipoxygenase model (porcine leukocytes). Topical application of a crude polysaccharide extract from E. angustifolia has been reported to reduce inflammation in the rat paw oedema model.(3)

Contraindications

External use-Allergy to plants in the Asteraceae.

Internal use-Should not be used in serious conditions such as tuberculosis, leukosis, collagenosis, multiple sclerosis, AIDS, HIV infection and autoimmune disorders. Echinacea preparations should not be administered to people with a known allergy to any plant of the Asteraceae. Parenteral administration is rarely indicated owing to potential adverse side-effects.(3)

Other uses:

Veterinary medicine

A new landscape of animal husbandry, and in particular the movement away from antibiotics in livestock feed, has created a whole new incentive and urgency to quantifying the usefulness of botanicals in animal diets. *Echinacea* has been widely researched in laboratory animals for its potential clinical uses. The toxicity of *Echinacea* is reported to be very low. The only toxic response identified is an ability to inhibit the viability and function of sperm, which is of particular concern to those raising livestock for breeding. Research in horses, cattle, and swine has been reported, which provides some rationale for the use of this botanical in livestock feed.

In horses, *Echinacea* extract has reduced infections of strangles, and stimulated immune and oxygen-transport cells.

Cattle research has shown that supplementation with *Echinacea* can stimulate the phagocytic function of bovine polymorphonuclear cells.

Finally, a series of swine studies demonstrated that *Echinacea* could improve performance parameters in nursery pigs to a level not statistically different from a common antibiotic. The research re-

ports available suggest that *Echinacea* can be a rational inclusion into livestock husbandry practices under appropriate conditions, and may provide an effective alternative to subtherapeutic antibiotics.(1)

Christaki et al. (2004) compared the effect of a mixture of herbal extracts containing *E. angustifolia* (plant part not given) to the anticoccidial drug lasolacid in broiler chickens experimentally infected with *Eimeria tenella*. The herbal feed supplement led to a certain coccidiostatic effect, which was however significantly lower than that of lasolacid. (1)

Factors restricting growth and yielding potential

-The natural variation of *Echinacea* within a species can have a tremendous effect on final product quality. This diversity might be due to genetic and environmental differences including variety, cultivation regions, harvest time, and cultivation or processing conditions. Even in germplasm that has been in cultivation for many years, there is still considerable phytochemical variation between individual plants. Cloned plants derived by division of the roots of individual plants in cultivated populations are very uniform and are one method for selecting and producing high-performance cultivars from exceptional plants. (5)

-The use of caffeic acid derivatives (CADs) for product standardization has been shown to be problematic due to the polyphenol oxidases (POs) present in the plant material. POs can lead to the enzymatic degradation and oxidation of CADs in hydroalcoholic solutions during the extraction process. Recent studies show that *Echinacea* markers are unstable in juice, during harvesting and drying, and in storage. However,`losses can be minimized by rapid drying during harvest, protection from oxidation in storage, and use of cooler storage temperatures. (5)

-There are also efforts to use glycoproteins as marker compounds in *Echinacea* products. Classen and co-workers (2004) have developed a monoclonal antibody against an arabinogalactan protein from *E. purpurea* which might be a tool for quality control of *E. purpurea* preparations.(6)

-Quality control is a serious problem in *Echinacea* phytomedicines with multiple actives, species, and formulations. Early industry methods based on the determination of total phenolics are unsuitable for quality control because of the broad distribution of phenolics in all terrestrial plants. For species identification and quality assurance, high performance liquid chromatography (HPLC)

determination of specific phytochemicals is the most appropriate technique (5)

Research gaps

-Quantitative evaluation of phytochemical diversity in *Echinacea angustifolia* DC. populations from different natural geographic areas supports the existence of distinct natural chemotypes within the species. Consumers, growers and manufacturers of phytomedicines are interested in chemotype identification for prediction of phytochemical content in cultivar development.

-As studies concerning the efficacy of *Echinacea* as a growth promoter and immune enhancer in productive livestock are limited, no final conclusions are possible yet. In most of the studies no real growth promoting effect was demonstrated, but in some cases an enhanced feed conversion and also a positive influence on the immune system were found. Generally it is difficult to interpret and compare study results concerning Echinacea, because the tested preparations widely differ in used species, extraction procedure and content of marker compounds.

-Improvement in phytochemical marker consistency and amount can be achieved in a number of ways. For example, phytochemical constituents are well known to be influenced by soil nutrients, and it have been found that the alkamides are inducible by the plant hormone methyl jasmonate.

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Lavandula angustifolia Mill. (Lamiaceae)

Common names

Al birri, alhucema, arva neh, aspic, broad-leaved lavenda, common lavender, Echter Lavendel, English lavender, espi, espic, espliego commun, fi rigla, frigous, garden lavendar, grando, hanan, hanene, hzama, khazama, khirii, khouzamaa, khouzami, khuzama, khuzama fassiya, khuzama zerqua, Kleiner Speik, Lavanda, lavande, lavande femelle, lavande veritable, lavando, lavandula vraie, Lavendel, lavender, lawanda, lofi nda, ostoghodous, postokhodous, spigandos, true lavender. (1)

Areas of origin and current cultivation

Indigenous to the northern Mediterranean region. Cultivated in southern Europe and in Bulgaria, Russian Federation, United States of America and the former Yugoslavia. (1)

It is a native species in Southeastern Europe (Italy) and Southwestern Europe (Andorra, France, Spain) and naturalized elswhere in Europe and Africa.

In Hungary, the region for lavender cultivation (*Lavandula angustifolia* and *L. intermedia*) was created in the 1930s mostly based on ecological considerations. Suitable ecological conditions had to be chosen for the cultivation of species of Mediterranean origin. Plantations were established on the southern slopes of the Tihany Peninsula and in the neighbouring territories (Balatonakali, Daránypuszta, etc.) where the ecological conditions show some similarity to the Mediterranean. The importance of lavender plantations has decreased in recent decades; however a relict of the first plantation still exists in the Tihany Peninsula.

In Austria lavender is suitable for cultivation in the more dry and arid eastern part of the country.

As regards essential oil crops in Bulgaria, *Lavandula angustifolia* is cultivated on 2900 ha (2002 data) and yields about 1.73 t/ha. A statistic from 2000 shows that exports of herba Lavandulae from cultivated areas was about 720kg and of flos Lavandulae from cultivated areas was about 118435kg.

Lavandula angustifolia is cultivated on small areas in Cyprus, Estonia, Latvia and on large areas in Italy. In Italy, most farms adopt organic techniques (61%). one thousand hectares are grown

under specialized intensive crop system, largely represented by the most commonly used species such as lavender, lavendin, Florentine iris, sage and gentian.

Lavandin and lavender (2500ha) cover 60% of the French planted acreage of medicinal, aromatic and perfume plants. France produces 70% of the world supply for these two crops. Lavender and lavandin are the plants most produced in organic farming. Their surface areas have been developing rapidly for the last few years and reach 407 ha for lavender and 248 ha for lavandin (organic – conversion).

Plant anatomy

An aromatic shrub, 1–2 m high. Branches grey-brown to dark brown with long fl owering and short leafy shoots, bark longitudinally peeling. Leaves clustered on leafy shoots, widely spaced on fl owering shoots; petiole very short; blade linear-lanceolate to linear, 17 mm long, 2 mm wide on leafy shoots, 2–6 cm long, 3–6 mm wide on fl owering shoots; grey stellate tomentose, base attenuate, margin entire, revolute, apex obtuse. Inflorescence a crowded, interrupted or nearly continuous spike, 2–8 cm long; verticillasters numerous, with 6–10 fl owers, upper ones densely crowded; peduncle about three times longer than the spike; bracts papery, rhombic-ovate, 3–8 mm long, rust coloured when dry; bracteoles absent or up to 2.5 mm long, pedicel 1.0–1.5 mm long; calyx 4–7 mm long, densely grey stellate tomentose outside, with 13 longitudinal ribs, upper lip entire, appendage obcordate, lower lip four-toothed; corolla 10–12 mm long, blue, base subglabrous, throat and limb glandular hairy, upper lips straight, lower lips spreading. Nutlets narrowly cylindrical . (1)

Growing conditions – input requirements

Lavender (*Lavandula*) can be a long-lived perennial, with a typical productive life of about 10 years, although plants have been known to live for 20 years. English lavenders (*L. angustifolia*) have the finest fragrance. However, their oil production is much lower than the high-camphor lavandin.

Lavender requires high temperatures on germination - about 10-15ºC. During the winter months resists from -15ºC (winters without snow) to -30ºC (covered with snow). Young plants withstand temperatures of -8ºC after sunrise. Regarding moisture, lavender is less demanding, supporting drought well, thanks to a highly developed root system. Lavender is a light-loving plant, if it grows in sunny locations develops large bushes and gather more volatile oil. Lavender has high demands regarding the ground, it grows very well on different soils, sandy or rocky limestone. Cold soils with excess moisture and shallow groundwater are not suitable.(2)

Planting

Lavender can be multiplied by seed (sown directly in the field or planting stock), seedlings or shrubs separation.

The most commonly used method is the establishment of culture through seedling to obtain vigorous plants and good productivity. Seedling will be started in September-October or in spring, very early. Layers will have a height of 8-10 meters in length, 50 cm paths between them and will be 10 cm below ground level. When plants have 2-3 pairs of leaves is necessary to dwindle them, leaving about 5 cm distance between plants on line. 400,000 seedlings can be obtained for one hectare of layers and for a one hectare culture are need 20.000 of transplants.

As regards shrubs separation method, branches from the bushes that formed roots can be used for planting, with the possibility of rooting of shoots. In October bushes will be cut 8-10 cm above the ground and covered with earth. The following year these branches appear aged, but also new well-rooted shoots will develop. In the autumn these new branches are removed and many seedlings will be strengthen during a year. From one bush can get up to 200 seedlings.(2)

Crop management

Lavender produces well on soils that are nutrient deficient for most other crops. Excessive applications of nitrogen can decrease oil quality, make plants unhealthy and will increase weed competition. For the production of 100 kg of inflorescence, lavender extracts 0,8 kg of nitrogen, 0,2 kg of phosphorus and 0,8 kg of potassium from the soil.

First year will pay special attention to the destruction of perennial weeds to simplify work on next years. For young cultures 4-6 weed session are needed and for older cultures only 2-3. Mulching reduces the weed incidence and increases soil moisture retention. Plant density and quick formation of a canopy will decrease the weed population. Drip irrigation suppresses weed growth between rows. (2)

Pest and diseases

Lavender is considered a species resistant to diseases and pests, but there are some diseases such as Septoria (*Septoria lavandulae*), which can attack the leaves, which dry and fall. To combat these diseases, severe hygiene measures are recommend. In wetlands or during wet years green pasture grasshoppers may appear (*Tettygonia viridissima*). For control, the weeds have to be destroyed and, after harvest, some auxiliary work have to be done on the soil.(2)

Good hygiene and regular stock inspections can save vast resources and reduce the need to apply expensive chemicals or biological controls on a regular basis. The first pest that may be encoun-

tered, in the life of a lavender on the nursery, is sciarid fly whose larvae attack the base of cuttings. This pest can be a problem for all lavenders on the mist propagation bench due to the moist atmosphere and can be summarily dealt with using nematodes. At the next stage vine weevil can be a particularly pernicious pest where prevention is definitely better than cure. Vine weevil larvae attack the roots of plants at the base of the stem. The addition of chemical additives when potting to a liner and larger sizes, will provide almost complete protection. Aphids can affect all lavenders, especially in the spring, but are easily controlled biologically with a soft soap spray, or chemically, if persistent.

Not all lavenders are affected by the same pests and diseases, nor to the same extent. *L. angustifolia* and cultivars can suffer with red, and two-spotted, spider mite if kept undercover in a dry atmosphere, in the summer months.

Good hygiene should avoid problems with the water borne disease phytophthora, then, the only fungal disease really affecting lavenders is botrytis. During winter months and warm wet summers botrytis can thrive. The first, preventative action, is to ensure that lavenders are not watered overhead in winter and that there is good air circulation. If botrytis does occur then alternating between two sprays with different active ingredients should be effective. This alternation is required because botrytis is very good at becoming resistant to the active ingredients. (3)

Logistics (harvesting – handling) until the industrial plant gate

Harvest

It is recommended to harvest at full bloom (75% open inflorescences) when volatile oil content is maximum. Must be harvested at high noon, between 10 and 14, the sunny and warm, no wind, dew, fog, for a maximum essential oil content in the inflorescences.

Harvesting could be done manually with the sickle taking care not to cut portions of leaves. After harvest, the shoots are put in baskets and transported immediately to distillation facility. Harvesting can be done with special machines also, whose productivity is high, thereby reducing labor consumption per hectare from 20 workers to 1 ha to 0.5 ha / hour mechanized harvesting.(2)

Drying

To obtain dry inflorescences, is recommended to make the procedure in the shade, in sheds, bridges, in thin layers on frames, for a period of 5-6 days to avoid browning. Inflorescences may be dry and artificial at temperatures exceeding 35ºC. Drying efficiency is 5-7:1.(2)

Distillation

Industrial production of lavender volatile oil is made by water distillation, steam and water distillation and steam distillation. Duration of distillation will be around 90 minutes and over 90% of the total

amount of oil is distilled in the first 60 minutes. During the distillation process must follow the steam temperature entering the boiler to be more than 150-160ºC. Volatile oil extracted and decanted to remove water, will be put in steel barrels for storage and transportation, which will be stored in cool rooms, away from fire.(2)

Yields

Fresh inflorescence production in the first 2-3 years is 2-3 t / ha and in coming years can reach 5-6 t / ha. From a tonne of fresh inflorescences result up to 10 kg volatile oil.(2)

Quality

a) *Plant material of interest: dried flowers*

General appearance: Consists mainly of tubular-ovoid, ribbed, bluish-grey calices with five teeth, four of which are short, while the fi fth forms an oval or cordate projecting lip. Petals, much crumpled, are fused into a tube with a lower lip consisting of three small lobes and an upper lip comprising two larger erect lobes; the colour varies from deep bluish grey to a discoloured brown. Corolla contains four stamens and a superior ovary. (1)

Organoleptic properties: Odour: fragrant, aromatic; taste: aromatic, bitter, somewhat camphoraceous .(1)

Microscopic characteristics: Calyx and corolla bear glandular hairs with a very short unicellular stalk and a head of four to eight cells, of a labiaceous type, and characteristic branching unicellular and multicellular non-glandular hairs with pointed ends and a somewhat streaked or warty cuticle. Corolla bears also, on the inner surface at the throat, characteristic glandular hairs with a unicellular, glandular head and a bicellular stalk, its basal cell being long and knotted and the other cell short and cylindrical. Anthers covered with whipshaped, unicellular, non-glandular trichomes; pollen grains, almost rounded, with six germ pores.(1)

Powdered plant material: Grey-blue with fragments of calyx, elongated epidermal cells with wavy anticlinal walls, and multicellular non-glandular covering trichomes. Encapsulated labiate oil glands. Corolla fragments, almost oval and slightly wavy-walled epidermal cells, labiate oil glands and branched covering hairs; unicellular glandular hairs. Pollen grains spherical to ellipsoidal, 24–30 µm in diameter, with six furrows, six germ pores and lines of pits radiating from the poles. Leaf fragments, almost straight-walled epidermal cells, covering branched trichomes and labiate oil glands, glandular hairs with a unicellular stalk and a bicellular head.(1)

General identity tests: Macroscopic and microscopic examinations, microchemical tests, and thin-layer chromatography for the presence of linalyl acetate and linalool. (1)

Adulteration

No adulterants known (4)

Regulatory status

In UK and Germany lavender oil is included on the General Sale List. Lavender is covered by a positive Comission E monograph. Is officially in the British Pharmacopeia 2002 and the European Pharmacopeia 4.3. Lavender does have generally recognised as safe (GRAS) status.

International Standards specifications have been published for *Lavandula angustifolia* oil (ISO 3515:2002). Lavandulae aetheroleum is also included into the Ph.Eur. 5 (2005) with standard contents of 20 – 45% linalool, 25 – 46% linalyl acetate, terpinene-4-ol up to 6,0% and Cineol less than 2,5%. Lavender oil, stored in a cool and dark place, is stable up to six month.(4)

Chemical assays: Contains not less than 1.3% (v/w) essential oil determined by steam distillation .

Major chemical constituents : Contains 1.0–3.0% essential oil, of which the major constituents are linalyl acetate (30–55%) and linalool (20–50%). Two hydroxycinnamic acid esters, rosmarinic acid and chlorogenic acid, are regularly present in the leaves of Lavandula species.

b)Plant material of interest: consists of the essential oil obtained by steam distillation from the fresh fl owering tops of *Lavandula angustifolia* Mill. (Lamiaceae).

General appearance: A clear colourless or pale yellow liquid, miscible with 90% alcohol, ether and fatty oils.(1)

Organoleptic properties: Odour: characteristic, fragrant, aromatic; taste: aromatic, slightly bitter. (1)

General identity tests: Macroscopic examinations; refractive index, specific gravity and optical rotation measurements; thin-layer chromatography for the presence of linalyl acetate and linalool, and gas chromatography.(1)

Chemical assays: Official analysis by gas chromatography shows the following composition: limonene, cineole, 3-octanone, camphor, linalool, linalyl acetate, terpinen-4-ol, lavandulyl acetate, lavandulol, α-terpineol.(1)

Major chemical constituents: linalyl acetate (25–46%), linalool (20–45%), terpinen-4-ol (1.2–6.0%), lavendulyl acetate (> 1.0%), 1,8-cineole (1,8-cineol, cineol, cineole, eucalyptol) (< 2.5%), 3-octanone (< 2.5%), camphor (< 1.2%), limonene (< 1.0%), and α-terpineol (< 2.0%).(1)

Pharmacodynamic properties

a) Pharmacodynamic properties for flores Lavandulae angustifoliae

Experimental pharmacology

Antimicrobial activity

Aqueous, chloroform, hexane and methanol extracts of Flos Lavandulae, 60.0 µg/ml, inhibited the growth of *Streptococcus pneumoniae* in vitro. A methanol extract of the fl owers inhibited the growth of *Helicobacter pylori* (the bacterium associated with peptic ulcer disease) in vitro, minimum inhibitory concentration 100.0 µg/ml.(1)

Antioxidant activity

A 50% ethanol extract of the fl owers had antioxidant activity in vitro, median effective dose 45.0 mg/ml.(1)

Antiulcer activity

Intragastric administration of 400.0 mg/kg body weight (bw) of an 80% ethanol extract of the flowers to mice signifi cantly ($P < 0.05$) reduced ethanol-induced gastric ulcerations by 62.9%.(1)

Uterine stimulating activity

A hot aqueous extract of the flowers (dose not specified) stimulated uterine contractions in isolated pregnant guinea-pig uterus.(1)

Anticonvulsant and sedative activities

Intraperitoneal administration of 2.5 g/kg bw of linalool to rodents protected against convulsions induced by pentylenetetrazole, picrotoxin and electroshock. In mice, intraperitoneal administration of 2.5 g/kg bw of linalool interfered with glutamate function and delayed *N*-methyld-aspartate-induced convulsions. Linalool acts as a competitive antagonist of [3H]-glutamate binding and as a non-competitive antagonist of [3H]-dizocilpine binding in mouse cortical membranes, suggesting interference of glutamatergic transmission. The effects of linalool on [3H]- glutamate uptake and release in mouse cortical synaptosomes were investigated. Linalool reduced potassium-stimulated glutamate release. These data suggest that linalool interferes with elements of the excitatory glutamatergic transmission. (1)

Adverse reactions

No information available.(1)

Contraindications

Flos Lavandulae is contraindicated in cases of known allergy to the plant material. Owing to their traditional use as an emmenagogue and abortifacient, the fl owers should not be used during pregnancy. (1)

b) Pharmacodynamic properties for aetheroleum Lavandulae angustifoliae

Anaesthetic activity

In vitro, the essential oil, linalyl acetate and linalool, 0.01–10.0 µg/ml in the bath medium, reduced electrically-evoked contractions of a rat phrenichemidiaphragm. In the rabbit conjunctiva test in vivo, administration of an aqueous solution of the essential oil, linalyl acetate or linalool, 30.0–2500.0 µg/ml, into the conjunctival sac increased the number of stimuli needed to provoke the reflex.(1)

Anticonvulsant and sedative activities

Intraperitoneal administration of 2.5 g/kg body weight (bw) of linalool to rodents protected against convulsions induced by pentylenetetrazole, picrotoxin and electroshock. In mice, intraperitoneal administration of 2.5 g/kg bw of linalool interfered with glutamate function and delayed *N*-methyl-d-aspartate-induced convulsions. Linalool acts as a competitive antagonist of [3H]-glutamate binding and as a noncompetitive antagonist of [3H]-dizocilpine binding in mouse cortical membranes, suggesting interference of glutamatergic transmission. The effects of linalool on [3H]-glutamate uptake and release in mouse cortical synaptosomes were investigated. Linalool reduced potassium-stimulated glutamate release. These data suggest that linalool interferes with elements of the excitatory glutamatergic transmission system.(10

Anti-inflammatory activity

The effect of Aetheroleum Lavandulae on immediate-type allergic reactions was investigated in vitro and in vivo. External and intradermal administration of aqueous dilutions of the essential oil, 1:500, 1:100, 1:10, 1:1 and 1:0, to mice inhibited mast cell-dependent ear oedema induced by compound 48/80. Administration of the essential oil (same dose range) to rats inhibited passive cutaneous anaphylaxis induced by antidinitrophenyl (DNP) IgE, compound 48/80-induced histamine release and anti-DNP IgE-induced tumour necrosis factor-α secretion from peritoneal mast cells. Inhalation of 0.3 ml of the essential oil inhibited thromboxane B2 release induced by arachidonic acid in mice, suggesting an anti-infl ammatory effect.(1)

Antimicrobial and acaricidal activities

The undiluted essential oil inhibited the growth of *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa, Staphylococcus aureus* and *Streptococcus pneumoniae* in vitro. The undiluted essential oil, 10.0 µl/disc, inhibited the growth of *Mycobacterium chelonae, M. fortuitum*, *M. kansasii*, *M. marinum* and *M. scrofulaceum*. The undiluted essential oil inhibited the growth of fi lamentous fungi in vitro . The essential oil, linalool, linalyl acetate and camphor had miticidal activity against *Psoroptes cuniculi* in rabbits.(1)

Antispasmodic activity

Addition of the essential oil to the bath medium, 0.02 mg/ml and 0.2 mg/ ml, reduced the twitching response and relaxed the muscle tone of rat phrenic nerve diaphragm preparations in vitro. The antispasmodic activity of the essential oil and linalool was mediated through the cyclic adenosine monophosphate signal transduction system, determined using a guinea-pig ileum smooth muscle preparation.(1)

Central nervous system depressant effects

Inhalation of the essential oil (dose not specified) by mice reduced caffeine-induced hyperactivity, which was correlated with linalool serum levels. Intragastric administration of the essential oil (dose not specified) to rats produced anxiolytic effects and prolonged pentobarbital sleeping time. Intragastric administration of 1.6 g/kg bw of the essential oil increased the lever-pressing response rate during the alarm phase of the Geller-type conflict test in animals, suggesting that the oil had an anti-conflict effect similar to that of diazepam. Intragastric administration of 25.0 ml/kg bw of the essential oil, diluted 60 times in olive oil, prolonged pentobarbital sleeping times in mice. Inhalation of 0.3 ml of the essential oil inhibited strychnine-induced convulsions in mice.(1)

Adverse reactions

Allergic contact dermatitis has been reported in patients previously exposed to the essential oil. (1)

Contraindications

Aetheroleum Lavandulae is contraindicated in cases of known allergy to the plant material. Owing to its traditional use as an emmenagogue and abortifacient, the essential oil should not be used internally during pregnancy.(1)

Dosage

Dosage forms:

Dried fl owers, tablets, capsules, fluid extract, syrup, tincture and tonics. Store in a well closed container, in a cool, dry place, protected from light.

Essential oil. Store in a well-closed container, in a cool, dry place, protected from light.(1)

Posology (Unless otherwise indicated)

Internally as a tea, dried fl owers, 1–2 teaspoonfuls per cup, three times per day; tincture (1:5) in 60% ethanol, 2–4 ml three times per day. Externally as bath therapy, dried fl owers, 20–100 g per 20 l of water. (1)

Essential oil by inhalation, 0.06–0.2 ml three times per day; internally, 1–4 drops (approximately 20–80.0 mg) on a sugar cube per day. (1)

Other uses:

The essential oil that is obtained from the flowers is exquisitely scented and has a very wide range of applications, both in the home and commercially. It is commonly used in soap making, in making high quality perfumes (it is also used in 'Eau de Cologne'), it is also used as a detergent and cleaning agent, a food flavouring etc and as an insect repellent.

The aromatic leaves and flowers are used in pot-pourri and as an insect repellent in the linen cupboard etc. They have been used in the past as a strewing herb in order to impart a sweet smell to rooms and to deter insects. They are also said to repel mice.

The flowering stems, once the flowers have been removed for use in pot-pourri etc, can be tied in small bundles and burnt as incense sticks.

Lavender can be grown as a low hedge, responding well to trimming. There are several varieties, such as 'Hidcote Variety', 'Loddon Pink' and 'Folgate Blue' that are suitable for using as dwarf hedges 30 - 50cm tall.(5)

Acaricidal effect of lavender

L. angustifolia essential oil and its component linalool were effective against *Psoroptes cuniculi*, (mites from rabbits) when presented in the air and linalool was isolated from the dead mites in the ether extract when *L. angustifolia* oil was used, indicating this was an active component. (3)

Essential oils as pediculicides

Lavender, juniper, eucalyptus, geranium, lemon and rosemary were used as mixtures in a pilot study to determine possible novel, safe pediculicides. *Pediculus humanus capitis*, the head louse was not found to be suitable for *in vitro* studies and therefore *Pediculus humanus, the clothing mite*, was studied. The oils and some of their components were tested *in vitro*, impregnated onto filter paper

against the human lice. Some components like _-pinene, camphene and terpineole were very effective. The clinical study involved twenty children, treated with the essential oil mix in a cream/alcohol vehicle at 5 per cent and was very effective. A mild allergic response was, however, obtained in one case, and found to be to rosemary, which was then removed from subsequent mixtures. This was a very small study and more data would be required for acceptance of essential oils as lice killers.(3)

Effects of lavender against house dust mites

Lavender oil was tested against tea tree oil and lemon oil *in vitro* against the house dust mite, *Dermatophagoides pteronyssinus*. The various mites cause diseases like scabies and various veterinary infestations. *D. pteronyssinus* causes asthma. The insecticidal assay was set up using filter paper impregnated with the test substances which made contact with the mites studied in a closed system. The immobility was assessed after 30 min and the mortality after 2 h. Lavender was intermediate between tea tree, with the highest potential and lemon oil with the lowest.(3)

Factors restricting growth and yielding potential

-The yield of lavender was 41.4 litres/ha on 29 July and 44.4 litres/ha on 19 August. The quality of the oil was reasonable but there is a need to increase the levels of linalyl-acetate and linalool by over 50% in order for the oil to attract a premium price on world markets. This improvement in oil quality would be achieved by selection and breeding. There is likely to be interest in the oil from local outlets, from buyers who will blend the oil, or where there is a premium for oils from known sources (traceability of production of the oil).(6)

Free water in contact with the oil during the preheating stage of distillation reduces oil quality and extraction efficiency (3)

Harvesting should not be carried out in too hot weather and very windy conditions as significant volumes of oil can be lost through evaporation. Very cold weather prevents the development of esters, and harvesting has to be delayed until the weather is warmer.(3)

-If the pressure or the temperature is too high it may change the molecular structure of the fragrance molecule, altering the chemical constituents. the yield of the oil may vary considerably from one season to the next, as the age of the bushes and the weather will affect both the quantity and

quality of the product.(3)

-A smaller quantity of lavender and lavandin concretes is produced by solvent extractions. concretes are excreted from fresh plant material using solvents such as toluene and hexane and petroleum ether. the solvents are evaporated off, leaving residue called concretes. concretes find uses in the perfumery industry (particularly soaps) and a further refinement is to mix the concretes with ethanol. the mixture is then cooled and filtered, and then the ethanol is evaporated to produce a wax-free residue called an absolute. there is a frequency of 50 % loss from concrete to absolute. absolutes are more widely used in fine perfumery.(3)

Research gaps

Lavender oil is a popular essential oil which is used widespread for many purposes but there are some problems regarding low productivity, failures from diseases and drought, low incomes and finally the end of cultivations. A Greek study targeted to create a *L. angustifolia* variety from native Greek plants which however present very well adaptation in local fields. The first part of the study started at 1996, has lasted 7 years and after 6 years of handmade cross-pollinations has resulted in a final genotype which was named *L. angustifolia* var. *etherio*. During the study L. angustifolia showed that can be cross-pollinated and produce big number of seeds with high viability. The lavender seeds had given healthy and vigorous plants rich in essential oil. The variety etherio presented 78.8% higher essential oil yield in comparison with the native plants and was richer in branches and inflorescences. The quality of the final essential oil was better due to higher percentages of linalool at 33% and linalyl acetate by 71% whereas the percentage of eucalyptol decreased by 52% and camphor by 36%. In the second part of the study from 2002 up to 2008 the *L. angustifolia* var. *etherio* was tested in the field. The genotype was reproduced by tissue culture and 2 ha were covered by 38,000 plants. The survival percentage for the first year of these had gone over 99.9% and the flower production was rich. The genotype was presented resistant in drought and lavender diseases and was never watered and fertilized. The mean essential oil production under field cultivation was 81.61 kg/ha which is expressed as an average essential oil percentage of 2.3% with refer to fresh weight (5.2%, w/dw). The experiment is still running and vary parameters are monitored for future publishing of the results. (7)

Information resources

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Mentha x piperita L. (Lamiaceae)

Common names

Amentha, american mint, balm mint, brandy mint, cabra-caa, curled mint, doun menta piperita, hierbabuena, hortela pimenta, Katzenkraut, lamb mint, la menta, lamint, menta piemonte, mentea peperina, mentha pepe, menthe, menthe anglaise, menthe poivrée, moto yuyo, nána, ni naa, ni'na el fulfully, pepermin, pepper mint, peppermint, Pfefferminze, Pfefferminzblätter, piperita, pudeena, pum hub, yerba mota (1).

Areas of origin and current cultivation

Widely naturalized and widely cultivated. Commercially cultivated in eastern and northern Europe and the United States of America, and is found in Africa (1).

In the *Mühlviertel* county, province of Upper-Austria, peppermint is one of the most important crops, about 65% of the total herb acreage in this region is organic grown.

As regards essential oil crops in Bulgaria, *Mentha piperita* is cultivated on 140 ha (2002 data) and yields about 1.99 t/ha. A statistic from 2000 shows that exports of herba Menthae piperitae from cultivated areas of Bulgaria was about 291071kg and of folium Menthae from cultivated areas was about 944481kg.

In Czech republic, Italy (in Piedmont, excellent peppermint oil is obtained), Spain and France, peppermint is cultivated in the largest amounts while in Cyprus, Estonia, Finland, Romania is cultivated in small areas. In Latvia estimated cultivated area of *Mentha piperita* is about 30ha, in Lithuania peppermint is grown as a herb, medicinal and melliferous plant (32-61% of menthol, green

material yield is 10-14 t/ha), in UK is cultivated on ~ 100ha, in Hungary ~ 50-150ha. In Poland organic *Mentha piperita* is cultivated on 2 ha.

In Finland vegetative propagation in ecological cultivation conditions is tested with *Mentha* species.

In Germany, the cultivation of peppermint leaf (*Mentha x piperita*) has a very long tradition. Increased industrialization in Germany as well as increased cultivation abroad however led to a decline in its agricultural importance over the past century. Today the primary cultivation regions for local demand are situated in Southern-and Eastern European countries. Since the mid-1980's however the area of the land in Germany under peppermint cultivation has again been increasing with the benefit of modern harvest and post-harvest processing methods. At the moment, there are about 400 hectares of peppermint acreage in Germany with the largest areas in the States of Thuringia, Palatinate and Bavaria.

Plant anatomy

Mentha x piperita is a hybrid mint, a cross between watermint (*Mentha aquatica*) and spearmint (*Mentha spicata*). It is a perennial herb, 30–90 cm high. Stems square erect or ascending, branched, the upper portion always quadrangular. Leaves opposite, petiolate, ovate-oblong to oblong-lanceolate, serrate, pointed; dark green on the upper surface. Flowers purplish, occur in thick, terminal, spicoid racemes of verticillasters; each flower shows a tubular calyx with 5 sharp, hairy teeth, a purplish, irregular, 4-cleft corolla, 4 short stamens, a 4-celled ovary and a projecting style ending in a bifid stigma. Fruit consists of 4 ellipsoidal nutlets (1).

Growing conditions – input requirements

Plant vegetation begins in early spring at temperatures of 3-5ºC, mint stolons being resistant up to -20°C temperatures. Optimum temperature in summer is 18-22°C.

Peppermint is demanding from soil moisture, water is a limiting factor. For the entire period of vegetation plant consumes 6,000 m3 of water.

Peppermint is pretentious and towards light, because it influences volatile oil accumulation in plants.

The plant grows very well on loose soil, permeable and well-supplied nutrients. Alluvial soils and peat, with medium texture, to light and shallow groundwater are recommended. However, it can be cultivated on any soil, in terms of irrigation.

It is recommended to cultivate mint as annual plant; if it is maintained in culture on the same

field for few years, became very dense, will grow more strains and less leaves and the oil production will decrease. In the next years plants will produce only few short stolons with no agricultural interest. Also, pest and diseases will multiply, for example, mint rust (*Puccinia menthae*).

The best prerequisite for mint are vegetables for grains and cereals straw. It is not advisable to grow mint after alfalfa, clover or perennial grasses that shoots and require additional maintenance work.

In turn, the mint is good for some pre-plant row crops or fodder, which, by technology, allow the destruction of mint plants which can regenerate from underground parts.

Peppermint is an herb that valorize good organic fertilizer, because the roots are not well-developed and plant growth rate is very fast. It is recommended to use manure, fermented and applied very evenly, which helps to improve soil fertility status, vegetative mass development, as well as the volatile oil production. May apply 25-40 t / ha of manure in fall, before plantation establishment, under plowing (2).

Planting

Peppermint is multiplied by stolons or by rooting stem cuttings from the start stolons nodes. Before planting, vigorous and turgid stolons should be elected, which are shaped at 12-15 cm in length.

From the best mint plantations can be obtained about 6-8 tons of stolons, and stolons quantity harvested per hectare can be a breeding material for six hectares of new plantation. Over winter, the stolons must be stored in specially built silos, equipped with ventilation and watering facilities to not dehydrate.

It is advisable to plant mint in fall, because it makes a better rooting and density of plants in the field. The vegetation shoots will start earlier in spring, have a faster development, thus obtaining good and high quality productions.

Planting is done either manually or semi-mechanized. Planting require a large amount of manual labor, on average 15 to 17 workers per hectare. Semi-mechanized planting requires only three workers for establishing a hectare of crop area (2).

Crop management

After planting in the fall there is no need to do other work. In the spring is important to keep control of weed emergence.

Irrigation is done between 300 and 350m3/ha in the first part of vegetation and then in the early period of prosperity, with m3/ha 500-600. Always after harvest, mint should be irrigated. Best practices

are irrigation on furrow and drip irrigation. Sprinkler irrigation is not recommended because of the danger of rust attack, which may adversely affect yield(2).

Disease Control (rust, bean), is made by preventive measures which refers to planting of healthy stolons in the fall, rational fertilization with organic fertilizers, destruction of wild mint especially in areas where water can pond and soil is wet, reestablishing mint culture on the same field after 5-6 years.

Mint crops are associated with large numbers of pests and pathogens that cause substantial damage to crops and considerable loss of oil yield. Cutworms damage the young shoots of mint plants after they have sprouted. Polyphagous caterpillars often cause severe damage to the crop by defoliating it within a few days. The polyphagous semiloopers also voraciously devour the tender foliage. White flies lay eggs on the ventral surface of the mint leaves, and the nymphs suck the sap resulting in arrested growth.

A number of microbes have been observed to cause diseases in mint crops. The stolon rot that occurs in the rainy season is caused by *Macrophomia phaseoli* and *Pythium*. In the affected plants, leaves wilt and turn yellow and growth is stunted. Rust is caused by *Puccinia menthae*; orange colour rust postules appear on leaves, which afterwards turn yellow and ultimately get shed. The powdery mildew caused by *Erysiphe cichoracearum* results in circular white powdery patches on the leaves, which subsequently spread to the stem and other parts of the plant; the severely affected leaves drop off. Leaf blight caused by *Alternaria* species during summer months results in the appearance of irregular dark brown spots with concentric zones surrounded by a pale yellow margin on the upper surface of the leaves; heavy defoliation occurs subsequently. The leaf spots caused by *Corynespora* spp. also inflict considerable damage on mint crops.

Several types of control measures, including the use of insecticides and disease-inhibiting chemicals, and breeding of pest and pathogen resistant cultivars have been followed in mints but limited success has been obtained in controlling both pest and pathogens. There is a need for genetically engineered important mint cultivars with heterologous genes for rendering them pest or disease resistant(3).

Conventional pesticides used on mint crops

Applications of gondal mixtures and insecticides like chlordane, dieldrin, heptachlor and toxaphene have been recommended for controlling termites and must be applied at 3 stages; before sowing, at planting, or after planting of suckers. Soil application of aldex or chlorodane before planting or spraying with metasystox, malathion or thiometan gives effective control against cutworms. For the early stage attack of caterpillars, 5% diptrex or 2% folidol, and for advanced stage, spraying with

thiodon or endrin gives effective control. Semilooper infection can be controlled by spraying with endosulfan or carbayl mixed in water. Leaves badly infested with white flies have to be collected and burnt or the crops sprayed with rosin compounds to destroy the insects. Waterlogging promotes infection of pathogens, viz. *Macrophomia* and *Pythium*. This can be avoided by planting *Mentha* on ridges. The treatment of planting stock with fungicides effectively controls the pathogens. Hot water treatment, by steeping the stolons in water or spraying with copper fungicide (0.3% containing 50% metallic copper) or sulfur powder (0.5% containing 50% elemental sulfur) in water, controls rust. Powdery mildew disease can be controlled by spraying with copper fungicides and lime sulfur. Spraying of copper fungicide also helps in checking blight disease caused by *Alternaria*. Apparently, one of the alternative strategies of mint crop protection is the use of biopesticides. Currently, 95% of the commercial biopesticides are derived from B. *thuringiensis*. Formulations of *B thuringiensis* spore crystal sprays, such as dipel and thuricide, are commercially available for use as biological insecticides(3).

Logistics (harvesting – handling) until the industrial plant gate

Harvest

If the raw material will be used in order to extract the essential oil, then harvested when 50% of inflorescences are open; if the raw material will be a component of tea, as dry material, then harvested when 30-40% the plants have bloomed. Aerial vegetative mass harvesting is done by mowing with a mechanical mower. It is recommended that the harvest should follow the distillation rate, to prevent volatile oil losses.

Harvesting can begin when leaves are 5-6 cm in length, in several stages. It can harvest leaf by leaf and so the raw material to obtain will be of the best quality. This work may take 14 to 15 days. Do not harvest too early in early phases because the amount of volatile oil is low and of poor quality.

The harvest should be done at high noon, between 10 and 14, in the sunny and warm days, no wind, fog, so the leaves have maximum essential oil content (2).

Drying of the plant material will be made in the shade, in sheds, bridges, over a period of 5-6 days. Leaves can be artificially dried also at temperatures exceeding 35°C(2).

Distillation

The most common method for the volatile oil obtainment is steam distillation. Best results are obtained by distillation of mint left to wilt in the furrows for 24-48 hours. 75% of volatile oil present in plant material is obtained in the first hour of distillation. After about 2 hours, the entire amount of essential oil is extracted. During the distillation process must follow the parameters: water temperature

entering the condenser should be a maximum of 15-20°C, the temperature of distillate consisting of water and essential oil at the outlet of refrigerant must be 35-40°C, parameters which will allow a rapid settling volatile oil.

Oil extracted and decanted to remove water, will be stored in steel barrels in cool rooms, away from fire(2).

Yields

Reception conditions stipulate that moisture at harvest should be up to 14% more than 3-5 brown leaves on each stem, volatile oil content must be less than 1%, up 1.5% organic foreign bodies, and the maximum mineral 0.5%. Average yields are 10-20 t / ha fresh herba respectively 2.5 to 3 t / ha dry herba or 1000-1300 kg / ha of dry leaves (2).

Quality

b) *Plant material of interest: dried leaves*

General appearance: Green to greenish-brown. Leaves whole, broken or cut; thin, fragile; whole leaf 3–9 cm long and 1–3 cm wide, often crumpled. Lamina oval or lanceolate; apex acuminate; margin sharply dentate; base asymmetrical. Venation pinnate, prominent on the lower surface, with lateral veins leaving the midrib at an angle of about 45°. Lower surface slightly pubescent and secretory trichomes visible under a hand lens as bright yellowish points. Petiole grooved, usually up to 1 mm in diameter and up to 1 cm long.(1)

Organoleptic properties: odour: characteristic, penetrating; taste: characteristic, aromatic.(1)

Microscopic characteristics: Upper epidermis composed of large, clear epidermal cells with sinuous, vertical walls and possessing few or no stomata, few glandular trichomes present; palisade parenchyma, comprising a layer of columnar cells rich in chloroplasts; spongy parenchyma, of 4–6 layers of irregularly shaped chloroplastid-containing cells and intercellular air-spaces. Lower epidermis of small epidermal cells with sinuous, vertical walls and numerous diacytic stomata; in the region of veins and midrib, exhibits non-glandular and glandular trichomes as outgrowths; non-glandular trichomes uniseriate, papillose, 1–8-celled; glandular trichomes have 1–2-celled stalk and 1–8-celled glandular head containing the essential oil. Calcium oxalate crystals absent; pollen grains spheroidal and smooth.(1)

Powdered plant material: Brownish-green. Fragments of leaf tissue with cells of epidermis having sinuous walls, cuticle striated over the veins, diacytic stomata present predominantly on the lower epidermis; epidermis fragments from near leaf margin with isodiametric cells showing distinct beading and pitting in anticlinal walls; covering trichomes short, conical, unicellular, bicellular or

elongated, uniseriate multicellular (3–8 cells) with striated cuticle. Glandular trichomes of 2 types: either with unicellular base with small, rounded, unicellular head 15–25 mm in diameter; or with unicellular base with enlarged, oval multicellular head 55–70 mm in diameter composed of 8 radiating cells; dorsoventral mesophyll fragments with a single palisade layer and 4–6 layers of spongy parenchyma; yellowish crystals of menthol under the cuticle of secretory cells. Calcium oxalate crystals absent.(1)

General identity tests: Macroscopic and microscopic examinations, microchemical analysis and thin-layer chromatography for 1,8-cineole .(1)

Adulteration

Although many *Mentha* species are also used, notably *Mentha spicata* and *Mentha arvensis*, the cultivation of most peppermint makes confusion rare. Peppermint oil is liable to augmentation with extra menthol, synthetic or natural menthofuran and menthyl acetate.(4)

Regulatory status

In UK and Germany peppermint is included on the General Sale List. Peppermint leaf is covered by a positive Comission E monograph and is official in the European Pharmacopoeia 4.3. In US, peppermint does have generally recognized as safe (GRAS) status.(4)

Chemical assays: Whole and cut leaves contain not less than 1.2% and 0.9% (v/w) essential oil, respectively, determined as described in the European pharmacopoeia.

Major chemical constituents : The major constituent of the leaves is the essential oil (0.5–4%), which contains menthol (30–55%) and menthone (14–32%). Menthol occurs mostly in the free alcohol form, with small quantities as the acetate (3–5%) and valerate esters. Other monoterpenes present include isomenthone (2–10%), 1,8-cineole (6–14%), a-pinene (1.0–1.5%), b-pinene (1–2%), limonene (1–5%), neomenthol (2.5–3.5%) and menthofuran (1–9%).(1) Comparison of peppermint oil composition from different samples showed a high variability of concentrations of the majority of biologically active constituents. The highest amount of menthol was found in Grecian peppermint oil (39,5%) and the smallest amount in Russian oil (1,5%). Estonian, French and Hungarian oils contained 31,6-35,8% of menthol, Belgian and Ukrainian oils 17,6% and 24,4%, respectively.(5)

c) *Plant material of interest: Aetheroleum Menthae Piperitae* is the essential oil obtained by steam distillation of the fresh overground parts of *Mentha piperita* L. (Lamiaceae).

General appearance: A colourless, pale yellow or pale greenish-yellow liquid.

Organoleptic properties: odour: characteristic, penetrating; taste: characteristic, pungent, followed by a sensation of cold.

Major chemical constituents:

The major constituents are menthol (30–55%) and menthone (14–32%). Menthol occurs mostly in the free alcohol form, with small quantities as the acetate (3–5%) and valerate esters. Other monoterpenes present include isomenthone (2–10%), 1,8-cineole (6–14%), a-pinene (1.0–1.5%), b-pinene (1–2%), limonene (1–5%), neomenthol (2.5–3.5%) and menthofuran (1–9%).(1)

Pharmacodynamic properties

c) *Pharmacodynamic properties for herba Menthae piperitae*

Experimental pharmacology

Antimicrobial activity

Extracts of Folium Menthae Piperitae have antibacterial and antiviral activity in vitro. Addition of ground leaves to the agar medium inhibited the growth of *Salmonella typhimurium*, *Staphylococcus aureus* and *Vibrio parahaemolyticus* at concentrations of 0.1–2.0% (w/v). Aqueous and ethanol extracts of the leaves reduced the number of plaques of the rinderpest virus at concentrations of 4–8 mg/ml. Aqueous extracts of the leaves demonstrated activity against the following viruses in egg and cell culture: Newcastle disease, herpes simplex, vaccinia, Semliki Forest and West Nile (1).

Smooth muscle contraction.

A 31% ethanol extract of the leaves inhibited both acetylcholine- and histamine-induced smooth muscle contractions in guinea-pig ileum in vitro at a concentration of 10 ml/l. The results were similar to those obtained with 0.13 mg atropine. An aqueous flavonoid fraction isolated from a leaf extract inhibited barium chloride-induced muscle contractions of guinea-pig ileum in vitro at a concentration corresponding to 0.5 g leaves/ml.(1)

Choleretic activity

Injection of a leaf infusion (0.5 ml) or a flavonoid fraction (equivalent to 3.3 g leaves/kg body weight) increased the amount of bile acids in cannulated rats and dogs (dose 0.4 mg/kg body weight). A mixture of flavonoids, isolated from the leaves, had choleretic activity in dogs (2 mg/kg body weight). Flavomentin, a flavonoid isolated from the leaves, stimulated bile secretion and the synthesis of bile acids in dogs (2 mg/kg body weight). Intragastric administration of a 30% ethanol extract of the leaves to rats (1 ml/kg body weight) increased bile flow by 43%. The extract did not induce sedation in mice at doses up to 10 ml/kg body weight. (1)

Anti-oedema activity

Topical application of a methanol leaf extract to mice (2.0 mg/ear) inhibited ear oedema induced by 12-O-tetradecanoylphorbol-13-acetate. (1)

Analgesic activity

Intragastric administration of a 30% ethanol extract of the leaves inhibited phenylbenzoquinone-induced writhing in mice (ED50 2.1 ml/kg body weight).(1)

Toxicology

Intragastric administration of a leaf extract (50 g leaves infused with 500 ml hot water for 10 minutes, then spray-dried) to 12 mice (4 g/kg body weight as a single dose) did not result in central nervous system depression, toxic effects or mortality. (1)

Precautions

Patients with gallstones should not use Folium Menthae Piperitae unless under medical supervision.

No information available on precautions concerning drug interactions; drug and laboratory test interactions; carcinogenesis, mutagenesis, impairment of fertility; teratogenic and non-teratogenic effects in pregnancy; nursing mothers; or paediatric use. Therefore, Folium Menthae Piperitae should not be administered during pregnancy or lactation or to children without medical supervision. (1)

Adverse reactions: No information available.

d) Pharmacodynamic properties for aetheroleum Menthae piperitae

Antimicrobial activity

Aetheroleum Menthae piperitae inhibited the growth in vitro of *Staphylococcus aureus, Pseudomonas aeruginosa, Bacillus subtilis, Enterococcus faecalis* and *Escherichia coli*, but did not affect the growth of *Bacillus cereus, Penicillium cyclopium* or *Aspergillus aegyptiacus*. The essential oil inhibited the growth in vitro of *Trichophyton equinum* and *T. rubrum* (at a concentration of 0.4 mg/ml), *Aspergillus flavus, A. fumigatus* and *A. niger*.(1)

Antispasmodic activity

The essential oil had smooth muscle relaxant activity in guinea-pig ileum (ED50 26.0 mg/l) and trachea (ED50 87.0 mg/l) in vitro, and inhibited electrically induced contractions of guinea-pig ileum (IC50 0.176 mg/ml) in vitro. The essential oil decreased both the number and amplitude of spontaneous contractions, and inhibited spasms induced by barium chloride, pilocarpine and physostigmine in isolated segments of rabbit and cat ileum (inhibitory concentrations 0.05 mg/ml). The essential oil (0.5 mmol/l) inhibited smooth muscle contractions of guinea-pig ileum in vitro induced by barium chloride, carbachol, histamine and potassium chloride. Both the essential oil and menthol act as calcium antagonists, since they inhibited the influx of calcium ions through smooth muscle of

guinea-pig ileum and taenia coli isolated from humans . The essential oil and menthol inhibited smooth muscle contractions of guinea-pig ileum induced by potassium chloride (IC50 28.1 and 21 mg/ml, respectively) and induced electrically (11.5 and 7.7 mg/ml, respectively). Both also inhibited 45Ca2+ uptake induced by potassium ion-dependent depolarization in brain synaptosomes and retinal neurons, and inhibited specific binding of [3H]nitrendipine to ileal smooth muscle, synaptosomes and retinal neurons. The essential oil relaxed carbachol-contracted guinea-pig taenia coli (IC50 22.1 mg/ml), and inhibited spontaneous contractions in isolated guinea-pig colon (IC50 25.9 mg/ml) and rabbit jejunum (IC50 15.2 mg/ml). The essential oil also attenuated contractile responses in guinea-pig taenia coli induced by acetylcholine, histamine, serotonin (5-hydroxytryptamine) and substance P. Contraction of Oddi's sphincter induced by morphine was reversed after intravenous administration of the essential oil to guinea-pigs (1.0 mg/kg body weight). However, intravenous injection of the essential oil to guinea-pigs (25 mg/kg body weight) was found to increase spasms of the sphincter. Intragastric administration of the essential oil exhibited cholagogic activity in rats. This activity was attributed to (-)-menthol, a major constituent of the essential oil.(1)

Antifoaming activity

The essential oil (0.1%) had antifoaming and carminative activity in vitro; however, the antifoaming effect was less than that observed with a combination of dimethicone and silica.(1)

Toxicology

Intragastric administration of the essential oil (100 mg/kg body weight) to rats daily for 28 days induced histopathological changes (scattered cyst-like spaces) in the white matter of the cerebellum. No behavioural or clinical symptoms due to the encephalopathy were observed.(1)

Contraindications

Preparations of Aetheroleum Menthae Piperitae should not be used internally by patients with inflammation of the gastrointestinal tract or gall bladder, or with impaired liver function. Hypersensitivity to the essential oil has been reported.(1)

Warnings

Aetheroleum Menthae Piperitae preparations should not be applied to the face, especially the nose, of infants or young children. Keep out of reach of children.(1)

Precautions

Patients with achlorhydria (due to medication with histamine H2 receptor antagonists) should only use enteric-coated preparations. (1)

Adverse reactions

Following internal administration of Aetheroleum Menthae piperitae, gastric complaints have been reported in individuals sensitive to the essential oil. The use of non-enteric-coated essential oil

preparations has occasionally caused heartburn, especially in patients suffering from reflux oesophagitis. Skin rashes, headache, heartburn, perianal burning, bradycardia, muscle tremors and ataxia have been reported as rare side-effects, usually associated with overdose. Recurrent muscle pain has been associated with the ingestion of the essential oil. Following external administration of Aetheroleum Menthae Piperitae, skin irritation has been reported.(1)

Dosage

Dosage forms:

-Dried leaves. Tincture and infusions. Store in a well-closed container, protected from light. (1)

-Essential oil, concentrated peppermint emulsion, peppermint spirit and other galenic preparations. Store in a well-closed container, protected from light .(1)

Posology (Unless otherwise indicated)

Daily dosage: 1–3 g crude drug three times daily. Infusion: pour 150 ml hot water over 1.5–3.0 g (one tablespoon) dried leaves, steep for 10 minutes, strain and drink three times daily between meals. Tincture: 2–3 ml (1 : 5, 45% ethanol) three times daily. (1)

Essential oil internal use: for digestive disorders, daily dosage: 0.2–0.4 ml essential oil three times daily in dilute preparations or suspensions. By inhalation: 3–4 drops essential oil in hot water. Lozenges: 2–10 mg essential oil per lozenge. For irritable bowel syndrome, daily dosage: 0.2–0.4 ml essential oil three times daily in enteric-coated capsules.

Essential oil for external use: 5–20% essential oil in dilute, semisolid or oily preparations; 5–10% essential oil in aqueous-ethanol; nasal ointments containing 1–5% crude drug.(1)

Other uses:

An essential oil obtained from the whole plant is used in perfumery. It is also an ingredient of oral hygiene preparations, toiletries etc.

Peppermint leaves are used as an ingredient of pot-pourri.

The plant repels insects, rats etc. Rats and mice intensely dislike the smell of mint. The plant was therefore used in homes as a strewing herb and has also been spread in granaries to keep the rodents off the grain.(6)

Factors restricting growth and yielding potential

-Drying method affects the composition of volatile oil in dried herbs. A combined infrared-convection process is a potentially useful method for drying herbs, giving high drying rates al low

drying temperatures. Drying temperature and rate depend on the incident infrared radiation effectively absorbed by the sample. Low temperature drying with infrared radiation normally requires a thin layer bed and large drying areas if a proper quality of dried material is to be achieved. The drying experiments with peppermint revealed that the aerobic plate count of the electric oven-dried samples did not differ from that of the infrared-dried samples. Temperature was the main factor in drying rate. At the highest drying temperature, the energy consumption per unit of evaporated water was the lowest. Water turned out to be much easier to remove from the leaves than from the stipes of the herb plants. To optimize the drying process in terms of drying time and initial moisture content, it is therefore essential that herb plants should be graded before drying. This method is quicker and that is suitable if the processing time is the prime factor. (7)

-Values ranging from 14 to 18 hours of light per day are quoted as the critical day length requirements of peppermint. *M.* x *piperita* has a distinct daylight threshold of around 14 h, below which reproduction of oil is suppressed and both the quantity and quality of oil are low. The different compounds require different light conditions. Generally, the production of peppermint oil requires a day length of 15 to 16 hours.(8)

Leaf, stem ratio and herb yield are positively correlated with oil content and oil yield, whereas plant height is negatively correlated with oil content. When the quality of the yield of three different mint species were compared under different Finnish and Hungarian growing conditions (light and temperature), the yield and oil percentage were higher in Hungary than in Finland, but the menthol percentage of volatile oil was higher in Finland than in Hungary.(8)

-High acidity and low calcium severely impair plant-root development(8)

-Besides the timing of harvest, the numbers of harvests per year greatly influence yield, and composition of oil. The essential oil from the first harvest is richer in menthol than that of the second harvest; first harvest is richer in menthol than that of the second harvest. In the second harvest all the leaves have a higher menthone and lower menthol content The amount of menthol increases as the plant matured. Harvesting of peppermint only once at the stage of full bloom (end of August) give the maximum oil yield of good quality. Furthermore, there is not enough time for the leaves to mature for the second cut. (8)

-Flavonoid pattern is affected by the day length (9)

Research gaps

-The manipulation of medicinal plants is well known and accepted both by scientists and consumers, if the pathways and product yield can be optimized to create precursors for semisyntheses, food components, pesticide resistance and cellular storage conditions as shown for *Mentha x piperita* with enhanced resistance against fungal attack and abiotic stress.(10)

-Quite extensive hybridization studies have been performed in *Mentha*; somatic hybridization was aimed either at modifying the composition of the oil or at combining essential oil quality with disease resistance(11)

-Limonene is the most widely distributed terpene in nature after α-pinene. A low concentration of the (−)-isomer is found in oils from the *Mentha* species. The first data on the microbial transformation of limonene date back to the 1960s. A soil bacteria Pseudomonas was isolated by enrichment culture technique on limonene as the sole source of carbon.(12)

Information resources

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Plantago lanceolata L. (Plantaginaceae)

Common names

Ribwort (plantain), rib grass, small plantain, narrow-leaved plantain (En). Plantain, herbe Caroline, plantain lancéolé, herbe-à-cinq-côtes

Areas of origin and current cultivation

Originally from Europe and northern and central Asia, *Plantago lanceolata* is now cosmopolitan. Plantago lanceolata is a native species in most of the European countries:

Northern Europe: Denmark; Finland; Ireland; Norway; Sweden; United Kingdom
Middle Europe: Austria; Belgium; Czechoslovakia; Germany; Hungary; Netherlands; Poland; Switzerland
East Europe: Belarus; Estonia; Latvia; Lithuania; Moldova; Russian Federation - European part; Ukraine [incl. Krym]
Southeastern Europe: Albania; Bulgaria; Former Yugoslavia; Greece [incl. Crete & Aegean Islands]; Italy [incl. Sardinia, Sicily]; Malta; Romania
Southwestern Europe: France [incl. Corsica]; Portugal; Spain [incl. Baleares] (1)

In UK Plantago is a relatively new crop. In Poland, Plantago lanceolata is a species recommended for enriching grassland biodiversity (K. Seidler-Lozykowska SALVERE - Regional Workshop in Poland, 2009, 45-47, Medicinal plant seeds as an element of increasing biodiversity of grassland), In Romania plantain is collected from the wild.

In Slovenia, considering the principle of sustainable use, natural populations of *Plantago lanceolata* L. are successively introduced in the National Collection of MAP, where further activities (multiplication of plant materials, morphological and/or chemical characterization, selection and other pre-breeding studies) needed for future cultivation purposes are foreseen.

In Austria ribwort plantain is grown in the more humid areas; in the *Mühlviertel* county, province of Upper-Austria, this species is one of the most important crops(about 65% of the total herb acreage in

this region is organic grown).

Plant anatomy

Plantago lanceolata is a perennial rosette herb with lanceolate leaves. It produces nflorescences from the axils of the rosette leaves, each inflorescence being terminated by a dense spike of small flowers. The plant is largely wind-pollinated. The fruit is a circumcissile capsule, that is potentially two-seeded although frequently capsules are found with one or no seeds. The seeds are about 2 mm long.(2)

Growing conditions – input requirements

Ribwort plantain shows high ecological plasticity, being found naturally in grassy areas on roadsides, in pastures and in crops as weeds. Show moderate demands regarding soil and climatic factors. Resist well in drought and cold winters.

This plant is not picky towards previous crop in the field, but is better to be sown after the land is cleaned of weeds and leaves, without plant debris. Is a perennial plant that could be maintained in culture 4-5 years.(2)

Planting

Sowing should be done in autumn or spring, with universal seeders, equipped with distributors for small seeds. The distance between rows is 50 cm. Planting depth should be 1 cm. Amount of seed needed per hectare is 5-6 kg and optimum density about 60-70 plants/m2. It is recommended to mix seeds with inert material (sand, sawdust), for distribution as uniform land surface. Physical purity of seed shall be a minimum of 85% and 75% germination.(2)

Crop management

Plantain exploits nutrients from fertilizer, bringing special production increases. The plant responds well to well fermented manure application of 10-12 t / ha in autumn, before plowing. Also other fertilizers can be used such as compost on smaller surfaces. Along with the application of manure can be applied an additional natural phosphate (P2O5 in doses of 40 kg / ha).

Whenever necessary, weeds have to be removed.(2)

Pest and diseases

In plantain crops have not noticed important diseases or pests. (2)

Logistics (harvesting – handling) until the industrial plant gate

Harvest

Leaves should be harvested when they reached technical maturity (leaf length 12-15 cm), before flower strains develop. The first harvest will be in May, and until autumn there will be 3-4 more harvests. It is good to harvest with sickle in the sunshine, after the dew has evaporated. (2)

Drying can be done in the shade or artificially, maximum temperature 45-50ºC. Drying efficiency is 6:1. Leaf color after drying must be kept green.(2)

Yields

The annual production which can be obtained is about 10-12 tonnes of fresh leaves and 1.5 to 2 tonnes of dry leaves, respectively.(2)

Quality

Constituents

The characteristic constituents are mucilage polysaccharides, iridoid glycosides (principally aucubin and catalpol) and phenylethanoids (acteoside, isoacteoside and plantamajoside). It contains not less than 1.5 percent of total ortho-dihydroxycinnamic acid derivatives, expressed as acteoside and calculated with respect to the dried drug. Ribwort plantain leaf complies with the monograph of the European Pharmacopoeia for ribwort plantain. Until recently, a monograph for ribwort plantain herb appeared in the Deutches Arzneibuch. Fresh material may also be used, provided that when dried it complies with the monograph of the respective pharmacopoeia. (3)

Pharmacodynamic properties:

Therapeutic indications: catarrhs of the respiratory tract, temporary and mild inflammations of the oral and pharyngeal mucosa

Ribwort plantain herb and its characteristic constituents exert anti-inflammatory, antibacterial, spasmolytic and immunostimulatory effects. The pharmacologically active constutuents are considered to be mucilage polysaccharides, iridoid glycosides and phenylethanoids.(3)

According to PFAF (4), ribwort plantain is a safe and effective treatment for bleeding, it quickly staunches blood flow and encourages the repair of damaged tissue. The leaves have a bitter flavour and are astringent, demulcent, mildly expectorant, haemostatic and ophthalmic. Internally, they are

used in the treatment of a wide range of complaints including diarrhoea, gastritis, peptic ulcers, irritable bowel syndrome, haemorrhage, haemorrhoids, cystitis, bronchitis, catarrh, sinusitis, asthma and hay fever. They are used externally in treating skin inflammations, malignant ulcers, cuts, stings etc. The heated leaves are used as a wet dressing for wounds, swellings etc.

The root is a remedy for the bite of rattlesnakes, it is used in equal portions with *Marrubium vulgare*.

The seeds are used in the treatment of parasitic worms. Plantain seeds contain up to 30% mucilage which swells up in the gut, acting as a bulk laxative and soothing irritated membranes. A distilled water made from the plant makes an excellent eye lotion.

Antiinflammatory activity

Four different freeze-dried extracts (ethanol 28%) from ribwort plantain herb were evaluated for anti-inflammatory activity in a modified hen's egg chorioallantoic membrane test using sodium dodecyl sulphate as the membrane irritant. At concentrations of 500µg/ pellet all the extracts inhibited the formation of blood vessels around the granuloma and the total blood vessel net appeared normal. Two extracts inhibited membrane irritation by 100%, the other two by 67 and 93% respectively. The activity of the extracts was comparable to that of hydrocortisone, phenylbutasone and diclofenac, each at 50µg/pellet.(3)

Antibacterial and antiviral activity

Expressed juice and aqueous, methanolic and ethanolic extracts of ribwort plantain leaf have shown inhibitory activity against various microorganisms such as *Bacillus subtilis, B. cereus, Klebsiella pneumoniae, Micrococus falvus, Mycobacterium phlei, Psuedomonas aeruginosa, Proteus vulgare, Staphylococcus aureus, Streptococcus aureus, S-β-haemolyticus* and *S. pyocyaneus* and against several strains of *Salmonella* and *Shigella* in the plate diffusion test. Aucubigenin, the aglycone of aucubin, has been shown to be mainly responsible for antibacterial activity of the drug and extracts. Aucubin preincubated with β-glucosidase suppressed hepatitis B virus DNA replication in HepG2 cell cultures in a dose-dependent manner.(3)

Spasmolytic activity

A fluid extract (1:1) from ribwort plantain herb inhibited contractions of isolated guinea pig ileum induced by acetylcholine, histamine, K+ and Ba2+ by 50% at 10mg/ml and 100% at higher concentrations. The effects were comparable to those of atropine, diphenhydramine and papaverine.

Acteoside inhibited histamine- and bradykinin-induced contractions of isolated guinea pig ileum

with pA values of 6.31 and 6.51 respectively.(3)

Immunostimulant activity

At a concentration of 0.0002% the polysaccharides of ribwort plantain leaf increased phagocytosis of granulocytes by 20.5%.(3)

Dosage

Adults: average daily dose: 3-6g of the drug or equivalent preparations

Elderly: dose as for adults

Children: average daily dose: >1-4 years of age, 1-2g; 4-10 years, 2-4g; 10-16 years, 3-6g (3)

Other uses:

A good fibre is obtained from the leaves, it is said to be suitable for textiles.

A mucilage from the seed coats is used as a fabric stiffener. It is obtained by macerating the seed in hot water.

Gold and brown dyes are obtained from the whole plant.(4)

The seed mucilage is an excellent thickener used in cosmetics (e.g. in lotions and hair wave sets) and as a stabilizer in the ice-cream industry. It is also used in the preparation of chocolate. The seeds can be used as a source of a low-cost gelling agent for tissue culture. The quality is comparable to that of agar, but at about 10% of the cost. (4)

Plantago lanceolata is currently being marketed as a stop smoking aid in the United Kingdom, as it is said that it causes an aversion to tobacco. In the United States *Plantago major* has been patented and marketed for the same purpose.

Leaves are edible and sometimes eaten as vegetable. *Plantago lanceolata* is occasionally grown as a fodder crop and considered to be of better quality than *Plantago major (5*)

Studies have also examined activity of several *Plantago* sp. against plant-parasitic nematodes. *Plantago lanceolata* plants reduced population densities of *Mesocriconema xenoplax* on peach seedlings and is toxic to *Meloidogyne incognita*, a major nematode pest with a wide geographic and host distribution. The compounds found have potential for use in selectively targeting plant-parasitic nematodes in pest management systems. Further research is needed to isolate and identify *Plantago*-specific compounds, to determine their toxicity to additional plant-parasitic nematodes.(6)

Research gaps

-The plant can tolerate maritime exposure.(4)

-Plantain grows well under cool temperatures, improving its productivity in dry. Plantain growth rates in a study developed in US were greater in September than they were in July, increasing by 62% in the normal and 29% in the wet treatment. Imposition of summer drought on plantain increased winter survival from <10% in the normal and wet treatments to 41% in the dry treatment. (7)

-*P. lanceolata* may be transformed by *Agrobacterium rhizogenes* and two phenylethanoid heterosides, i.e. p-cumaroyl-glucose and feruloyl-glucose are neo-synthesized and accumulated in the roots of seedlings fed with cinnamic acid.(8)

Information resources

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Conclusions

In Europe as a whole, only 130–140 MAP species are cultivated and the number of MAP species currently in formal cultivation for commercial production does not exceed a few hundred worldwide – less than 1% of the total number of medicinal plants used.

There are countries with a very long tradition in medicinal and aromatic plants cultivation which develop this sector on large areas:

- In Bulgaria about 30-40 medicinal and aromatic plants are cultivated on an area of about 43200 ha;
- In France acreage planted with medicinal, aromatic and perfume plants exceeds 30000 ha;
- In Poland 70 species are cultivated on 20000-25000 ha/year by almost 20000 farms ;
- In Hungary the area covered by medicinal plants is around 37000-42000 ha/year
- In Romania cultivated area with medicinal and aromatic plants varied between 26500 ha/1995 and 10680 ha/2009.

In other countries, medicinal plants are cultivated on smaller areas (in some cases, despite to some defaourable climatic or geographic conditions):

- in Finland, more than 100 medicinal and culinary herbs grow wild and some are cultivated;
- There are currently approx. 70 different medicinal and spice plant species grown on a surface of 5600 hectares in Germany;
- The total area occupied by MAPs: 3342 ha/2002, with over a hundred species grown in Italy;
- The total area cultivated with MAPs in Latvia is estimated to be about 300 ha;
- in UK, current production of herbs occupies a relatively small area (ca. 4000 ha), most of culinary herbs;
- in Netherlands, 450 ha of medicinal herbs are grown (0,05% from total area of arable land)
- In Slovenia the total surface cultivated with medicinal and aromatic plants is smaller than 20 ha
- In Spain, estimated area cultivated with MAPs is about 6000 ha
- In Sweden, the production of medicinal and aromatic plants is small - the production of

herbs grown in the field covered an area of 236 ha.

- In al countries, a high quantity of vegetal raw material is still wildharvested.

- A limiting factor for starting new crops is represented by climate changes. Scientists widely agree that global climate change is already causing major environmental effects, such as changes in the frequency and intensity of precipitation, droughts, heat waves and wildfires; rising sea level; water shortages in arid regions; new and larger pest outbreaks afflicting crops and forests.

-Quality control systems are important for the production of high-quality herbal products. The European Herb Growers Association (EUROPAM) has developed Good Agricultural Practice (GAP) guidelines which where further developed into Good Agricultural and Collection Practice for starting materials of herbal origin (GACP) by the European Agency for the Evaluation of Medicinal Product (EMEA). Also the WHO has developed similar guidelines.

- Based on statistical survey of existing European medicinal crops, on forecast of climate change and on data received from the most important Romanian manufacturers of phytopharmaceutically products, 5 medicinal and aromatic species showed high potential for cultivation in order to provide a steady source of raw material for bio-industry: *Lavandula angustifolia, Calendula officinalis, Mentha piperita, Plantago lanceolata, Echinacea angustifolia.* Although these species are widely cultivated in Europe, the selection is justified by the multi-purpose potential of the plant - a variety of products based on current uses and future projections, various types (herb, seeds, fruits, leaves, flowers, roots) of raw material for industrial use and an important market demand.

Calendula officinalis - Annual herb, demands no special requirements from climatic factors, Plant material of interest: dried ligulate florets and composite flowers, seeds*;* applications: pharmaceutical (antimicrobial activity, antiviral activity; anti-inflammatory activity; wound-healing activity), insecticide, cosmetics, tinctorial, strong allelophatic properties.

Echinacea angustifolia – Perennial herb with high ecological plasticity, grows best in an alkaline soil and is frost-resistant and well adapted to dry growing conditions in Europe, weed control is very important; *E. angustifolia* herba could be harvested since the second year of culture and in the third, fourth years of culture, harvested both aerial parts and root; plant material of interest: fresh or dried roots, herba; applications: pharmaceutical (stimulator of the immune system both in human and veterinary medicine), cosmetics, ornamental value.

Lavandula angustifolia – aromatic plant, long-lived perennial, requires high temperatures on germination, it grows very well on different soils even on nutrient deficient ones, supports drought well and is a light-loving plant, smaller yield in first 2-3 years; plant material of interest: dried flowers; applications: pharmaceutical **(**antimicrobial, antioxidant, antiulcer, anticonvulsant and sedative activities), cosmetics, perfumery, insecticide, ornamental value.

Mentha piperita – perrenial herb, demanding from soil moisture, water is a limiting factor, pretentious and towards light, grows very well on loose soil, permeable and well-supplied nutrients, associated with large numbers of pests and pathogens; plant material of interest: dried leaves; applications: pharmacology (antimicrobial activity; smooth muscle contraction, choleretic activity, anti-oedema activity, analgesic activity); cosmetics, perfumery, insecticide.

Plantago lanceolata – perennial herb, shows high ecological plasticity, moderate demands regarding soil and climatic factors, resist well in drought and cold winters; plant material of interest: dried leaves, seeds; applications: pharmacology (anti-inflammatory, antibacterial, laxative, spasmolytic and immunostimulatory effects), cosmetics, fibres for textiles, dye, gelling agent, stop smoking aid, fodder crop, antiparasitic.