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TRUMAP

BEST PRACTICES FOR CULTIVATION OF MEDICINAL AND AROMATIC PLANTS

TRUF MANTARI VE TIBBI AROMATIK BITKILER AĞI PROJESI

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Produced by:
Eva Moré and Saadet Tuğrul Ay

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Rafel Rodell

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TRUMAP: BEST PRACTICES FOR CULTIVATION OF MEDICINAL AND AROMATIC PLANTS

1. Introduction[2]

Medicinal and Aromatic Plants (MAPs), also known as herbs or spices, are plants used for: flavouring foods and beverages; for medicines, cosmetics, dyes, and perfumes; and for other household and economic uses.

MAPs are the oldest known health care products in traditional medicine, which existed before the arrival of the modern medicine, and are still used as such in many countries. Plants are considered *medicinal*, due to their content in active ingredients that have therapeutic properties. They can be used whole as botanical (e.g. liquorize – *Glycyrrhiza glabra*), or just the active compound extracted and isolated, to be used as medicine ingredient (e.g. poppy – *Papaver somniferum*). The content in active compounds is very important when valorising a medicinal plant, depending on the variety and/or the growing conditions. Each medicinal plant may have more than one application, varying from one culture to another, and can be used alone or mixed with others.

Medicinal plants are considered *aromatic* when, other than healthy properties, their active compounds are fragrant, due to their content in essences, known as essential oils. There are two types of aromatic plants: source of condiments and of perfumes.

Plants for *condiments* are those, known as herbs and spices, used for seasoning food in order to confer them a taste more palatable. Generally, the concept of *herbs* as flavouring agents excludes those plants commonly known as vegetables and is further limited to plants grown in temperate regions (e.g. basil – *Ocimum basilicum*, rosemary – *Rosmarinus officinalis*, mint – *Mentha* sp.); they can be used fresh, frozen or dried. Spices are usually understood to be plants from the tropics that bear aromatic fruits, seeds, or woody barks and are used today primarily for seasoning foods (e.g. cinnamon – *Cinnamomum zeylanicum*, ginger – *Zingiber officinale*, black pepper – *Piper nigrum*); they are usually sold dried.

Plants for perfumery are those aromatic plants that are intended for extracting their essential oils, that will be further used to manufacture flavours and fragrances (e.g. lavender – *Lavandula* sp., rose – *Rosa* sp.).

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2. From wild collection to cultivation: main features of the MAPs supply[1]

Since time immemorial, people have gathered plant and animal resources for their needs. Among the wide variety of wild products there are herbs, spices and gums for food, medicinal and cosmetic uses. Even today, hundreds of millions of people, mostly in developing countries, derive a significant part of their subsistence needs and income from gathered plant. Gathering of high-value products such as medicinal plants also continues in developed countries for cultural and economic reasons.

Among these uses, 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. Hereafter, the term "medicinal and aromatic plants" (MAPs) is defined to cover the whole range of plants used not only medicinally but also in the neighbouring and often overlapping fields of condiments, food and cosmetics.

Demand for a wide variety of wild species is increasing with growth in human needsand commercial trade. **With the increased realisation that some wild spices are being over-exploited, a number of agencies are recommending that wild species be brought into cultivation systems**.

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 as well as loss of incentives to conserve wild populations.

The relationship between *in situ* and *ex situ* conservation of species is an interesting topic, with implications for local communities, public and private land owners and managers, entire industries and, of course, wild species. Identifying conservation benefits and costs of different production systems for MAPs should help guide policies to whether species conservation should take place in nature or the nursery, or both.

How many MAPs are used worldwide?

The number of plants species that have been used at one time or another, and even the number in current use in some culture for medicinal purposes, can only be estimated. An enumeration of the WHO from the late 1970s listed 21,000 medicinal species. Schippmann et al (2006), according to the percentage of used medicinal plants in China in relation to the existing flora, estimates that the number of **plant species used worldwide for medicinal purposes could be around 72,000 (from a global total of 442,000 flowering plants).**

How many MAPs species are traded?

It is difficult to assess how many MAPs are commercially traded, either on a national or even an international level. The bulk of the planta material is exported from developing

countries while major markets are in developed countries. Different sources estimate that about 4,000 to 6,000 botanicals are of commercial importance. Europe is dominant as an import region, leading Germany country. An investigation of German medicinal plant trade identified a total of 1.543 MAPs being traded or offered on the German market. Recognising the role of Europe as a sink for MAPs traded from all regions of the world, it is a qualified guess that **total number of MAPs in international trade will be around 3,000 species.**

How many MAPs are threatened worldwide?

To satisfy regional and international markets, plant sources for expanding local, regional and international markets are harvested in increasing volumes and largely from wild populations. Supplies of wild plants in general are increasingly limited by deforestation from logging and conversion to plantations, pasture and agriculture.

In many cases, the impact through direct off-take goes hand-in-hand with decline owing to changes in land use. Species favoured by extensive agricultural management go into decline with changes in farming practices. This requires habitat management as the key factor in managing species populations.

Around 21% of the world's flora have become threatened by non-sustainable harvest and other factors, being estimated in **about 15,000 MAPs species threatened at least to some degree.**

How many MAPs are under cultivation?

Many medicinal plants, specially aromatic herbs, are grown in home gardens, some are cultivated as field crops, either in sole cropping or in intercropping systems and rarely as plantation crops.

Based on different sources, Schippmann et al (2006) assume that the number of **MAPs species currently in formal cultivation for commercial production does not exceed a few hundred worldwide**; less than 1% of the total number of used medicinal plants. On the other hand, however, they recognise that many more MAPs species are cultivated on a small scale in home gardens, either as home remedies or by herbalists. Cultivation by local people can take also place as enrichment planting.

Wild or cultivated?

Market needs

Given the demand for a **continuous and uniform supply** of medicinal plants and the **accelerating depletion of forest resources,** increasing the number of medicinal plant species in cultivation would appear to be an important strategy for meeting a growing demand.

But there are few species cultivated. One explanation may be found in the observation

that **cultivated plants are sometimes considered qualitatively inferior** when compared with wild-gathered specimens. Scientific studies partly support this. Medicinal properties in plants are mainly due to the presence of secondary metabolites which plants need in their natural environments under particular conditions of stress and competition and which perhaps would not be expressed under monoculture conditions. Active-ingredient levels can be much lower in fast-growing cultivated stocks, whereas wild populations can be older due to slow growth rates and can have higher levels of active ingredients.

While it can be presumed that cultivated plants are likely to be somewhat different in their properties from those gathered from their natural habitats it is also clear that certain values in plants can be deliberately enhanced under controlled conditions of cultivation.

In general, in all countries, **the trend is towards a greater proportion of cultivated material**. The majority of companies, the mass-market, over-the-counter pharmaceutical companies as well as the larger herb companies, prefer cultivated material, particularly since cultivated material can be certified "biodynamic" or "organic".

From the market perspective , domestication and **cultivation provide a number of advantages over wild-harvest for production of plant-base medicines**:

- While wild-collection often offers material adulterated with unwanted, sometimes harmful other plant species, cultivation provides **reliable botanical identification**.
- Wild-harvest volumes are dependent on may factors that cannot be controlled, and irregularity of supply is a common feature. Cultivation guarantees a **steady source of raw material**.
- Wholesalers and pharmaceutical companies can **agree on volumes and prices** over time with growers.
- The **selection and development of genotypes with commercially desirable traits** from the wild or managed populations may offer opportunities for the economic development of the MAPs as a crop.
- Cultivation allows **controlled post-harvest handling** and, therefore,
- **Quality controls** can be assured, and
- Products standards can be **adjusted to regulations and consumer preferences**.
- Cultivated material can be **easily certified** "organic" and "biodynamic" although certifiers and other agencies are also offering wildcrafting standards (e.g. Fairwild).

However, **domestication of the resource through farming is not always technically possible**. Many species are difficult to cultivate because of certain biological features or ecological requirements (such as growth rate, special soil requirements, interactions with pollinators and other species, low germination rates, susceptibility to pests). Lack

of secure, long-term tenure over high-value, long-lived species is also often a concern amongst farmers. These social and biological factors in turn affect the economic viability of MAPs cultivation.

Economic 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.

Lower 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. Domestication of a previously wild-collected species does not only require substantial investment of capital but also requires several years of investigations (at least 10 years).

People needs

There is a worldwide trend of increasing demand for many popular, effective species in Europe, North America and Asia, growing between 8 and 15% per year. **Rapid urbanization and the importance of herbal medicines stimulated a growing trade**. Demand for medicinal plants also reflects distinct cultural preferences (i.e. more use in Germany than in USA).

The level of herbal medicine use in most developing countries is much higher. While most traditional medicinal plants are gathered from the wild, these are not static health-care systems, and introduced species are commonly adopted into the repertoire of plants used by African and South-American herbalists. In many cases, herbal medicines can also be cheaper than western medicines, particularly when access to traditional healers is easier. Demand for traditional medicine continues in the urban environment even if western medicine is available.

Wild-harvesting of medicinal plants is a chance for the poorest to make at least some cash income. Especially those people who do not have access to farm land and all depend on gathering MAPs to earn at least some money. However, **local people generally get a low price for unprocessed plant material** (e.g. in Mexico, medicinal plant collectors only received an average of 6,17% of the medicinal plant consumer price).

In addition, whether fruits, roots, bark or whole plants are involved, **the potential yield from wild stocks of many species is frequently over-estimated**. Commercial harvesting ventures based on wild populations can be characterized by a “boom and bust” situation where initial harvests are followed by declining resource availability.

Small-scale cultivation, which requires low economic inputs, can be a response to declining local stocks, generating incomes and supplying regional markets. This can be a more secure income than from wild-harvest, which is notoriously inconsistent. For farmers that integrate MAPs into agroforestry or small-scale farming systems, these

species can provide a diversified and additional source of income to the family. Home gardens are increasingly a focus of medicinal plant propagation and introduction programmes intend to encourage the use of traditional remedies for common ailments by making plant sources more accessible.

Nevertheless, commercialisation is both necessary and potentially harmful to farmers. Without commercialisation, the market for products is small and the opportunity does not exist for rural people to generate income. A degree of product domestication is therefore desirable.

On the other sense, **large-scale cultivation has a number of socio-economic impacts on rural people**. Commercialisation is potentially harmful to rural people if it expands to the point that outsiders with capital to invest come in and develop large-scale monocultural plantations for export markets. Rural people may benefit from plantations as a result of available employment and hence off-farm income. However, plantations may also distort market forces to their advantage, for example, by imposing low wages which will restrict the social and economic development of local people. The major beneficiaries of large-scale exports will probably be the country's elite and, perhaps, the national economy.

Also, those socially disadvantaged groups who actually depend on gathering MAPs for their survival and cash income may not have access to farm land at all, and therefore, may not be able to compete with large-scale production of MAPs well-established farmers. Other limitations to the domestication approach include boom-bust and fickle markets that let farmers down when consumers turn their attention elsewhere.

Species and ecosystem needs

Cultivation of MAPs is widely viewed not only as a means for meeting current and future demands for large-volume production of plant-based drugs and herbal remedies, but also as a **means for relieving harvest pressure on wild.**

Booming markets with rapidly rising demands often have devastating effects on wild-collected species. But **not all species are affected in the same way by harvesting pressures:**

- According to **seven forms of rarity** (described by Rabinowitz, 1989), a species which has a narrow geographic distribution, is habitat-specific, and has small population sizes everywhere, is more easily over-harvested than species of any other pattern.

- The **susceptibility or resilience to collection pressure** varies among species owing to biological characters such as different growth rates (slow-growing vs fast-growing), reproductive systems (vegetative or generative propagation; germination rates; dormance; apomixis) and life forms (annual; perennial; tree).

We can state that species most susceptible to over-harvest are habitat-specific, slow-

growing and destructively harvested for their bark, roots or the whole plant (e.g. salep).

Cultivation is a conservation option for threatened MAPs species because the constant drain of material from their populations is much higher than the annual sustained yield. If the demand for these species can be met from cultivated sources the pressure on the wild populations will be relieved. In these cases, the need for strict conservation of remaining populations, improved security of germplasm ex situ and investment in selection and improvement programmes are very important.

However, among the species that can be marketed at a high enough price to make cultivation profitable, only few are in the highest threat categories. With respect to economic viability many highly endangered MAPs do not qualify for cultivation. This group of plants will enter cultivation only with the help of public domestication programmes.

For all other harvested MAPs species, the **priority conservation option is sustainable harvest from wild populations**, for a variety of reasons:

- *Case 1:* a valuable medicinal plant is exploited by local collectors. A pharmaceutical company has domesticated and begun to cultivate the plant on a commercial scale. When the company no longer needs the wild-harvested material, local harvesters have to abandon the harvest, and **any incentive the local collectors might have had to protect the wild populations is gone.**

- *Case 2:* collectors and collecting communities are involved in the development of propagation and management methods. The likelihood of their having an interest in protecting the wild populations from over-exploitations, particularly if these are understood to be the **genetic resource "bank" for the domestic enterprises**, will be greater.

Another aspect to consider is the **genetic diversity** of the species beingin demand. Selection of favoured growth forms and concentration on certain harvesting areas which may hold certain ecotypes will lead to a degradation of genetic diversity of the wild populations. The same is true under domestication: industry requirements for standardization encourage a narrow genetic range of material in cultivation. Domestication will not achieve conservation of genetic diversity because a narrow group of high-yielding individuals will be selected for planting.

Table 1. *Wild-harvesting versus Cultivation of Medicinal and Aromatic Plants: Summary of advantages and disadvantages*

For species and ecosystems it is better to…	
Wild-harvest because…	**Cultivate because**
👍 It puts wild plant populations in the continuing interest of local people. 👍 It provides an incentive to protect and maintain wild populations and their habitats and the genetic diversity of MAPs populations.	👍 It relieves harvesting pressure on very rare and slow-growing species that are most susceptible to threat.
But…	**But…**
👎 Uncontrolled harvest may lead to the extinction of ecotypes and even species. 👎 Common access to the resource makes it difficult to adhere to quotas and the pre-cautionary principle. 👎 In most cases knowledge about the biology of the resource is poor and the annual sustained yields are not known. 👎 In most cases resource inventories and accompanying management plans do not exist.	👎 It devaluates wild plant resources and their habitats economically and reduces incentive to conserve ecosystems. 👎 It narrows the genetic diversity of the gene pool of the resource because wild relatives of cultivated species become neglected. 👎 It may lead to conversion of habitats for cultivation. 👎 Cultivated species may become invasive and have negative impacts on ecosystems. 👎 Reintroducing plants can lead to genetic pollution of wild populations.
The market demands…	
Wild-harvested plants because…	**Cultivated plants because**
👍 It is cheaper since it does not require infrastructure and investment. 👍 Many species are only required in small quantities that do not make cultivation economically viable. 👍 For some plant parts extra-large cultivation areas are required (e.g. Arnica production for flowers). 👍 Successful cultivation techniques do not exist (e.g. for slow-growing, habitat-specific taxa). 👍 No pesticides are used. 👍 It is often believed that wild plants are more powerful.	👍 It guarantees continuing supply of raw material. 👍 It makes reliable botanical identification possible. 👍 Genotypes can be standardized or improved. 👍 Quality standards are easy to maintain. 👍 Controlled post-harvest handling is possible. 👍 Production volume and price can be agreed for longer periods. 👍 Resource price is relatively stable over time. 👍 Certification as organic production is possible.
But…	**But…**
👎 There is a risk of adulterations. 👎 There is a risk of contaminations through non-hygienic harvest or post-harvest conditions.	👎 It is more expensive than wild harvest. 👎 It needs substantial investment before and during production.

From a perspective of the people it is better to…	
Wild-harvest because…	**Cultivate because**
👍 It provides access to cash income without prior investment. 👍 It provides herbal medicines for health-care needs. 👍 It maintains the resources for rural populations on a long-term basis (if done sustainably).	👍 It provides access to cash income without prior investment. 👍 It provides herbal medicines for health-care needs. 👍 It maintains the resources for rural populations on a long-term basis (if done sustainably).
But...	**But...**
👎 Unclear land rights create ownership problems. 👎 This income and health-care resource is becoming scarce through over-harvesting.	👎 Capital investment for small farmers is high. 👎 Competition from large-scale production puts pressure on small farmers and on wild harvesters. 👎 Benefits are made elsewhere and traditional resource users have no benefit return.

Source: R.J. BOGERS, L.E. CRACKER and D. LANGE (eds.). Medicinal and Aromatic Plants, 75-95. 2006 Springer.

3. From raw material to final product: cultivation and processing[3,4]

Characteristics of MAPs production

Specific characteristics of MAPs production could be given as follows:

- There is a huge diversity of species, implying specific cultivation techniques.
- Active ingredients are considered to be of crucial importance, therefore the selection of specific chemical varieties is needed.
- Agro-ecological conditions have more impact on active ingredients, therefore the selection of the field according to the species is important.
- Multiple processing techniques, due to the diversity of raw materials obtained (fresh, frozen, dry, essential oils, extracts, essences, etc.).
- A multiform industry is using these raw materials (food, flavours, fragrances, cosmetics, perfumery, pharmaceutical, etc.), which force to trade a raw material with industrial features.
- So, specific production procedures and equipment are required.
- The market is relatively small and sensitive, prices are instable, and there is worldwide competition.
- There is a huge influence of technological advances and consuming trends.

MAPs Raw materials

Beyond traditional uses, MAPs are valuable raw crops for manufacturing different kinds of industrial products.

MAPs could be traded as living plants, the plant itself (fresh or dried material) or their derivatives (thermos-chemically processed material).

Living plants

It is referred mainly to **ornamental plants** sold in container, but also to the selling of **seedlings,** in both cases needing adequate facilities (nurseries) and knowledge in propagation. In this case, the varieties differentiation is very important, getting to be selected according to their visual or flavour features for ornamental purposes (e.g. *Rosmarinus officinalis* var. *postrata*). When seedlings are addressed to MAPs producers is imperative that varieties are specific to the final raw material intended to produce (e.g. L*avandula x hybrida* var. *grosso*, for essential oil).


Figures 1, 2. Thyme (Thymus sp.) seedling (left) and plant in container (right)

The plant itself

Among the MAPs traded "such as" we can find plants for seasoning in **fresh** (preserved by refrigeration) or **frozen** format. Anyway, most often is offered **dry** (obtained by dehydration), either medicinal plants for *herbal medicines*, aromatic plants for condiments or for *fragrant decorations* (e.g. potpourris, lavender sachets).



Figures 3, 4, 5. From left to right, fresh, frozen and dry parsley (Petroselinum crispum).

MAPs derivatives

These could be, among others, essential oils, extracts and essences.

Essential oils (obtained by steam distillation) can be addressed to *aromatherapy*, if considered medicinal, to *food flavouring*, if come from plants for seasoning, or to further manufacturing of *essences*, if they are plants for perfumery.

Extracts (obtained by different chemical processing systems, with solvents suitable for human consumption) can be addressed to medicinal or cosmetic industry if they are obtained from plants with medicinal properties (e.g. water-alcohol extract, tincture, etc.); or to food industry if the origin is in aromatic plants for seasoning (e.g. oleoresins, antioxidants, etc.).

Essences (obtained by different chemical processing systems, with solvents not always suitable for human consumption) mainly come from fragrant plants, being most used materials in the perfumery industry (e.g. concretes, absolutes).

Figures 6, 7. Essential oils and extracts from plants.

The most common raw materials obtained by MAPs producers are: fresh herb, dry herb and essential oil, because the processing facilities are simple. Other materials require more complex units and specific industrial/chemical expertise.

MAPs Industrial uses

Industrial uses could be classified in three main sectors:

- MEDICINAL: from medicinal plants.
- FOOD: from aromatic plants for flavours.
- PERFUMERY: from aromatic plants for fragrances.

There are other sectors that are also using any of these plants: SCENTED DECORATION, TOURISM, etc.

Medicinal sector

In this sector medicinal plants are used, both as botanical drug (dry raw material) or as derivatives (extracts, essential oils, etc.). All herbal medicinal products are subject to medicines legislation, being strict in relation to the processing and commercialisation.

There are different subsectors and materials dealt with:

- **Pharmacy** (isolated active ingredients).
- **Phytotherapy**
    * Herbal remedies (dry plant).
    * Phytomedicine (dry plant, extracts, essential oils).
    * Aromatherapy (essential oils).
    * Homeopathy (mother tinctures).
    * Bach flowers (floral elixirs).
- **Dermopharmacy** or high cosmetic industry (extracts, essential oils, fat oils).

Food sector

In this sector aromatic plants for flavouring are used, either directly in condiments for seasoning (fresh, frozen or dry) and in herbal teas within the food scope, or their derivatives in the industry for manufacturing food products (extracts, essential oils, oleoresins, etc.)

All products are regulated by the food legislation.

There are different subsectors and materials dealt with:

- **Products addressed to the end-consumer:**
    * Condiments/seasonings (dry plant).
    * Herbal teas (dry plant).
- **Products addressed to the industry:**
    * Food ingredients and additives (flavours, colours).
    * Food supplements (dry plant, extracts, essential oil).
    * Functional food (dry plant, extracts).

Perfumery sector

In this sector extracts and essential oils are used to manufacture fragrant products. Anyhow, , there is a huge competition of synthetic compounds that should be outlined.

There are different subsectors:

- **Perfumes** (eau de cologne).
- **Toiletries** or low cosmetic industry (soaps, moisturising creams, deodorants, insect repellent).
- **Drugstore** (detergents and air fresheners).

Scented decoration

Both visual and fragrant aspects are features to bear in mind when elaborating scented decoration products, using fresh or dry plants and essential oils or essences.

Different products could be elaborated: bouquets, garlands, flower arrangements, potpourris, scented sachets, brooms, pillows, candles, wooden or pottery elements, etc.

Tourism

Visual and fragrant features of aromatic plants can also be landscape tourist attractions, engaged to a tourism service offer, both in gardens or in crops designed for this purpose.

MAPs ethnobotanical characteristics may also be the guiding thread of an educational offer, with visits for botanical identification or workshops for the elaboration of traditional products.

Other

There are other sectors where MAPs could have an important role, with increasing demand: antioxidants, dyes, natural pesticides, feed additives, etc.

Types of MAPs production

MAPs production comes mainly from the wild-harvesting activity, but certain species of large consumption are cultivated, using either conventional or organic techniques.

Once some decisions are previously taken, like the type of MAPs species to work with, the target market, final products to be sold and raw materials to be obtained, it is necessary to design and size the cultivation, keeping in mind machinery requirements, available labour force and specific needs of each species.

Some general features are described in the cultivation process chapter, but different types of cultivation related to the MAPs production can be also discussed.

According to agricultural techniques

There are mainly two types: conventional and organic.

The use of **conventional agricultural techniques** implies the use of chemicals accepted, despite there are not many pesticides allowed in the MAPs production, and sometimes is difficult to find specific herbicides. In addition, the producer should be careful with the abuse of chemical substances and the compliance with the safety period and residence time of applied pesticides. Please, find more information in Good agricultural and collection practices chapter.

In the case of **organic and/or biodynamic agricultural techniques**, chemical substances are avoided and natural ones prioritised, with the help of mechanical and preventive methods, always respectful with the environment. The uses of these techniques implies a lot of labour force, which increases production costs. The producer should be very careful and do a correct maintenance of the field, in order to avoid the spread of weeds, as this is the main problem in this type of cultivation. It is necessary to obtain a label from any official or private certification body, and could be both national or international, even specific (e.g. Demeter for biodynamic), to give the product its organic consideration in the market, thus assuring consumer confidence; this certification implies a time of conversion and a control system. Also wild harvesting can be certified organically.

More info in:

-Organic certification in the EU: https://ec.europa.eu/agriculture/organic/organic-farming/what-is-organic-farming/organic-certification_en

-Control authorities and control bodies in the EU: https://ec.europa.eu/agriculture/organic/consumer-trust/certification-and-confidence/controls-and-inspections/code-numbers_en

-IFOAM accredited certification bodies: http://www.ifoam.bio/en/ifoam-accredited-certification-bodies

Organic production is a promising sector, EU markets (leaded by Germany) are demanding more and more organic production because of the consumer demand for natural and healthy products. This implies a production addressed to exports, because organic demand in Turkey is still not enough to assimilate the offer. Nevertheless, existent MAPs products in Turkey are mainly from wild origin, which implies natural features, making it difficult to compete with "organic" MAPs coming from cultivation, because the Turkish consumer will not probable see any difference and "organic cultivation" products will be more expensive than wild collected ones.

Anyway, big urban area like Istanbul should be taken into account, because "organic trend" is growing up.

According to plants association

A producer could specialise in a specific culture (monoculture) or complement with other traditional cultures (mixed culture).

A **monoculture of a single species** simplifies the use of machinery and allows a huge production, but it is submitted to the risks of market fluctuations.Otherwise, to diversify the risk, different MAPs species could be cultivated. In this case, the production per species will be less than with just one species, being less convenient for bulk selling, unless big surfaces would be cultivated. Cultivating many species at the same time also increases technical difficulties.

***Figures 8, 9**. . Monoculture of a single species, Melissa officinalis L. (left) and monoculture of MAPs, different species (right).*

In some cases, MAPs culture could be complemented with other traditional cultures, having then a **mixed culture (MAPs + other)**. One example is the cultures association in organic horticulture, where it is usual to mix vegetables with MAPs, which have a crop protection function (i.e. many aromatic plants are used as insect repellents) jointly with the productive one. It is also used with tree crops (e.g. olives and fruit trees), where wide spacing would allow the insertion of MAPs rows (e.g. in Spain, there are crops mixing olives trees with thyme). Another opportunity is with oak orchards for truffle production. In these crops, inoculated oaks are planted young in the field and until the 7th or8th year the production of truffles does not start. During this time, the field is underused, but some MAPs rows could be planted meanwhile trees are small letting sunlight to reach the aromatic plants (e.g. in France, truffle orchards are mixed with lavender, which has a cultivation length of 8-10 years).

Figures 10, 11. Mixed culture with tree orchards: olive + thyme (left) and truffle + lavender (right). Photo right (www.escapado.fr)

Another type of mixed production would be culture + wild collection. It is wise to cultivate those MAPs species that are demanded in high amounts and easy to cultivate, and combine them with wild collection of those species being abundant in the nature and having commercial interest (e.g. lavender crops + bay laurel harvesting).

According to raw material

The most usual raw materials obtained by a MAPs farmer are: alive material, fresh herb, dry herb and essential oil. Each type has different production requirements.

The first one, **alive material**, is mainly addressed to ornamental purposes. It involves two types of productions:

- **Nursery:** business activity consisting in MAPs plants propagation. It can be producing seedlings for gardening or plant in container to sell in garden centres. It can also produce plantlets for farmers producing MAPs.

- **Garden:** business activity consisting in the implementation and maintenance of a garden with a specific aim (ornamental, educational, conservation, etc.), many times linked with tourism activities (countryside accommodation, restaurants, museums, farm schools, etc.).


***Figures12, 13**. MAPs nursery production (left) and a MAPs botanical garden (right).*

Fresh herbs can be produced with similar techniques to vegetable crops, both cut herbs or aromatic herbs in containers, both for culinary purposes. To produce them it is needed:

- **Intensive cultivation:** in temperate areas with irrigation.
- **Nursery:** similar to the previous described before, but allowing the plant to develop more (in containers or in substrate sacks).

Both cases, imply a fast processing and distribution of the plant, and refrigeration facilities, because fresh herbs are perishable in few days. A 4th range packaging is also advisable in order to reach supermarkets and groceries in urban areas.


***Figures 14, 15**. Fresh herb production, intensive crop in the field (left) and basil in a nursery (right).*

When herbal medicinal and food sector wants to be addressed, it is preferable to ***produce dry herb.*** This production is done in open fields and in medium surfaces (from 2 to 15 ha), the activity implies the existence of dryer facilities and processing equipment of dry herb. This is the most common type of MAPs production.

Dry herb material could be sold to herbal teas and condiments conditioners, to herbal medicinal wholesalers and to extracts manufacturers.

Figures 16, 17*. MAPs crops for dry herb production.*

Another possible activity is the ***production of essential oils***, addressed to fragrances, flavours or medicinal industry. This production should be done in large surfaces (more than 50 ha) due to the few yield on essential oils within the plant, and implies the existence of steam distillation facilities or extraction equipment (if essences are obtained with solvents).

Essential oil is any aromatic extract coming from a natural vegetal source. The quality requirements of consumer industries are very specific, and makes that commercial relationships between suppliers and buyers are loyal and stable once found the adequate product. If producers aim at working in this type of production, must offer quality products with constant compounds content, and provide a regular and competitive supply.

Another type of ***MAPs industrial productions*** is addressed to obtain frozen herbs for food sector (crops linked to fast-freezing facilities) or to obtain extracts (crops linked to complex extraction systems), mainly contracted by the processing industry, which normally provides the vegetal material and just rent the fields and labour, therefore no transformation equipment should be invested by the producer.

***Figures 18, 19**. Lavandula sp. crop for essential oil production (left) and Papaver somniferum crop for medicinal extracts production (right).*

According to sale

MAPs production type also depends on the sales of the obtained products. A production activity could be addressed to bulk or retail sale.

A production activity addressed to ***bulk sale*** requires obtaining large amounts of plant material from few species (large surfaces), in order to obtain an industrial raw material (dry herb, essential oil, etc.) to supply wholesalers and will be distributed to manufacturing industries. This requires less work and more salability(few clients and shipments), but with lower prices and a risk of losing usual clients.

In turn, a production activity addressed to ***retail sale*** means obtaining few quantities of raw material from several species, which serve at manufacturing end-products (herbal teas, seasonings, scented products, beverages, cosmetics, soaps, etc.). This requires more work (and the existence of workrooms and processing equipment) and sale difficulties (norms, procedures, distribution, marketing, etc.), but an added value and a diversified risk (because different species are produced, and the adaptation to market demand changes is easier).

MAPs cultivation conditions

Climate

Rainfall regime

In rainfed conditions, where there is no irrigation possibility, rainfall is a constraining factor to decide the species to plant:

- ARID AREAS (pluviometry < 200 mm/year): it is difficult to obtain competitive yields. Several adapted species could be cultivated (e.g. *Aloe* sp., *Foeniculum vulgare*, *Pimpinela anisum*), but it should also be considered if these species resist the frost (usual in harsh continental climate).

- DRY AREAS (pluviometry 200-500 mm/year): some aromatic species adapted to these conditions could be cultivated (e.g. *Satureja* sp., *Thymbra* sp., *Lavandula* sp., *Thymus* sp., *Rosmarinus officialis*, etc.) but considering that biomass yield is not very high, is better to allocate to essential oil production.

- FRESH AREAS (pluviometry 500-700 mm/year): the range of suitable species is wider (e.g. *Borago officinalis, Calendula officinalis, Anethum graveolens, Artemisia dracunculus, Hypericum perforatum, Origanum* sp., *Glycyrrhiza glabra, Salvia* sp., etc.) and dry herb production is suitable.

- WET AREAS (pluvometry > 700 mm/year): all water demanding species would be adequate (e.g. *Echinacea purpurea, Matricaria chamomile, Mentha* sp., *Melissa officinalis, Valeriana officinalis, Althaea officinalis, Achillea officinalis*, etc.) for dry herb production, and in the case of mint also for essential oil production.

Temperature regime

Temperatures could also be a limiting factor when selecting the species, mainly referred to the frost occurrence.

There are some species that do not resist low temperatures, below 0oC (e.g. *Aloe* sp., *Stevia rebaudiana, Aloysia triphylla*, and other tropical species), not being adequate for cultures in continental or mountainous climate, but suitable in temperate or coastal climates (with warm winter).

Altitude

Altitude affects the content of active ingredients in some species.

Therefore, in case of species adapted in mountain areas (e.g. *Arnica montana, Gentiana lutea, Valeriana officinalis, Colchicum autumnale, Leontopodium alpinum*, etc.) their active compounds content decreases if they are cultivated in low lands.

On the contrary, precious compounds of essential oils from other species decrease with the altitude (e.g. *Thymus vulgare, Rosmarinus officinalis, Lavandula latifolia*). In the wild, rosemary does not usually grow after 600 m and spike lavender after 800 m.

There are always exceptions, because the terrain shape diverse microclimates, allowing the adaptation of specific flora, sometimes endemic, or the appearance of chemotypes.

Field characteristics

Type of soil

Many times, soil types determine the adaptability of species, being restrictive for some of them according to pH or texture.

For pH:

- ACID SOIL (pH<7): many mountainous species are suitable for this soil type (e.g. A*rnica montana, Taraxacum officinale, Inula helenium, Rubus idaeus, Gentiana lutea, Humulus lupulus, Thymus serpyllum*, etc.), other Mediterranean ones are specific (e.g. *Lavandula stoechas, Cistus ladanifer*, etc.).

- BASE SOIL (Ph>7): most Mediterranean species are common in this type of soil (e.g. *Cichorium intybus, Satureja montana, Calendula officinalis, Coriandrum sativum, Lavandula angustifolia, Hypericum perforatum, Chamomila recutita, Rosmarinus officinalis, Mentha* sp., *Salvia* sp., etc.).

For texture:

- SANDY: this soil texture suits the underground organs development, such as roots, rhizomes or bulbs, being useful for species aiming at obtaining this raw material (e.g. salep - *Orchis* sp., liquorice - *Glycyrrhiza glabra*, *Cichorium intybus, Arctium lappa, Colchicum autumnale, Symphytum officinale, Taraxacum officinale, Echinacea* sp., *Iris germanica, Althaea officinalis, Armoracia rusticana, Ruscus aculeatus, Valeriana officinalis*, etc.).

- STONY: this type of soil texture is not adequate for species intended for root or small sized or creeping plants (difficult to mechanise their harvest) like as *Thymus* sp. or *Mentha* sp. Plastic mulching could help the harvest.

- CLAYEY: sensitive species to waterlogging (root asphyxia) or to fungi diseases should be avoided in this soils type (e.g. *Thymus* sp., *Aloysia triphylla, Hypericum perforatum, Salvia officinalis*).

***Figure 20**. . MAPs cultivation in stony soil. Mentha pulegium (rear) does not suits well for harvesting.*

Size and access to land plots

When total land surface is very large, big size farm machines are cost-effective. Still, the owner has to consider if the land is formed by small plots, scattered or with difficult access. The size of the plots will enable, more or less easily, the mechanisation of farm labours: in small plots big sized machinery will not manoeuvre adequately, being more suitable to have small tractors or motorized ploughs.

***Figure 21**. Small plot of Satureja fruticosa (L) Briq. culture in Catalonia,Spain.*

Slope

In case of too much slope, farm machines will not work optimally and there will be risk of rollover.

Rows direction have to be previewed when designing the field, because if they follow the slope direction, rain could form furrows and cause erosion. Therefore it is recommended to establish plant rows following the slope line (perpendicularly to the slope).

***Figure 22**. Thyme rows arranged following the slope line.*

A good option is to plant bush or tree species (e.g. *Prunus* sp, *Juniperus* sp., *Crataegus* sp., *Sambucus nigra, Laurus nobilis, Tilia* sp., etc.), that do not need as much passing of machinery.

Water resources

In rainfed conditions, species adapted to arid or Mediterranean climate could be cultivated, mainly aromatic ones. It is very recommended mainly for essential oil crops, and inadvisable for dry herb, because they resist the drought but do not produce too much biomass, being the part used (e.g. leaves).

To cultivate species for dry herb production, with profitable yield, it is needed a pluviometry superior to 500 mm per year, or to irrigate.

If irrigation is available, species with high water requirements could be cultivated (e.g. *Ocimum basilicum, Allium schoenoprassum, Echinacea purpurea, Matricaria chamomile, Mentha* sp., *Melissa officinalis*, etc.). This is essential for alive plants and fresh herbs production.

Cultivation process

Planning

The selection of the species to cultivate is a key success point. It is necessary to find the intersection point between market needs, field characteristics, species requirements (both from cultivation and processing point of view) and availability of resources (facilities, machinery, labour, etc.).

Plant material

In MAPs sector chemical quality is of great importance, so agronomic adapted varieties with high richness in active ingredients have to selected. This plant quality depends on the commercial destination (medicinal and cosmetic industries demand specific chemotypes, while food industry is not so much strict).

Nowadays, there are few breedings in MAPs Mediterranean species for medicinal and flavouring purpose; the breeding efforts are mainly in ornamental sector. In other cases, selected varieties are issued from private industries (e.g. *Papaver somniferum* for morfine production) or producers associations (e.g. *Thymus vulgaris* QT carvacrol in Provence, France, for condiments), not always available for the common producer. Nevertheless, some commercial varieties could be found in the market, but many times adapted to Northern European conditions (e.g. Pharmasaat in Germany, DSP Semences in Switzerland).

The optimal solution will be to domesticate local populations which will be better adapted to country conditions, but always taking into account that a breeding program (considering both chemical content and agricultural adaptation) will mean about 10 years before obtaining a commercial variety/cultivar.

Field installation

MAPs could be installed in the field by sowing or planting. **Sowing** means putting the propagation material (seeds or rhizomes) directly in the field, and **planting** is when propagation material is previously grown to obtain seedlings, which are after planted in the field.

The sowing by seed is the cheaper way to do the field installation, but at the same time the risky one. It can only be done with those species with good germination, rough, cheap and preferably annual cropped (e.g. *Pimpinella anisum*).

The sowing by rhizomes (underground stem) can be done with species that cannot be propagated by seed but easily by rhizome (e.g. *Mentha x piperita, Artemisa dracunculus*).

Seedling is the most common way to plant multiannual crops, because the field installation is more assured. It is more expensive that sowing, but allows the implantation of species with germination difficulties, with high cost of seed or those having delicate needs in first stages of development.

The **seedling propagation** could be prepared from seeds or from cuttings, for those species that have to be propagated asexually or for clons when preserving the mother plant characteristics and obtaining a uniform crop is desired. The price of the seedling coming for cuttings could be three times the one coming from seed. *Division of plants* is a less usual propagation method, but could be useful for small field crops.

***Figures 23, 24**. Seedling obtained by cutting, mint (left) or by seed, chives (right).*

Previous to **preparing the field for planting**, it is recommended to analyse the soil and the irrigation water, in order to know the starting conditions of files and needs for fertilisation. The field preparation labours will be the same for any other crop: ploughing, clearing of stones, fertilising, breaking down clods of soil, etc.

The **planting season** will be chosen according the field and crop conditions. In rainfed fields is it advisable to plant in autumn to take advantage of the rain and assure the crop establishment. In irrigated lands, the crop could be planted at beginning of spring.

The **density of planting** (number of pants per hectare) depends on the water availability, the size of the plant and the *planting pattern*.

- Between rows: the planting pattern will be designed according the farm machinery used for maintenance and harvest. Tractor wheels' distance are the main aspect to consider. In case of simple rows, the usual distance is 0.8-1.8 m. It can also be planted in double or triple rows, to better use the space.

- Between plants, within the row: the distance could be 0.30-0.40 for smaller plants (e.g. *Thymus* sp., *Mentha* sp.) up to 0.80 m for bigger plants (e.g. *Echinacea* sp., *Lavandula x hybrida, Salvia sclarea* etc.).

***Figure 25**. Single row spacing (Lavandula sp.).*

***Figures 26, 27**. Doble row Satureja montana (left) and triple row, Petroselinum crispum (right).*

Planting machines for vegetables, coupled to the tractor, could be used and the distance adjusted.

***Figures 28, 29**. Planting machine for thyme (left) and lemon balm (right) seedlings.*

If weed control with plastic mulching wants to be applied, planting should be done after the installing of the mulching.

Crop maintenance

Crop maintenance is limited basically to two labours: weed control and fertilisation.

Weed control is very important and implies one of the main costs in a MAPs cultivation. The prevention is based on the adequate crop rotation, mowing vegetal fringes, avoiding excessive irrigation and fertilisation, adding only mature and well composted manure and do false sowings.

The weed control once the crop has been established has to be done periodically, between rows and between plants in the row. In the market is possible to find specialised devices and machines for the mechanical control of weeds, many of them from horticulture. *Between rows*, the weeding can be done with motorized ploughs, rotary cultivators or harrows. For the weeding *within the row*, there is specialized machinery, but usually has to be done by hand. The use of *herbicides* is restricted to resistant species, and have to be applied in the correct moment, respecting applications doses. Producer should check if herbicides are permitted and test before large-scale uses.

During the first year of cultivation, and until the plants are not covering the row, the labour force devoted to this task is very important. The second year, as a result of the crop vegetative development, and always if the plant spacing is adequate, the working dedication is reduced a third, because the soil is covered with adult plants.

***Figures 30, 31**. Mechanical soil labours for weed control.*

To reduce the needs of labour force during the first year, but not for all species, some kind of *mulching* could be used, taking into account that it allows the correct development of the plant or the harvest. For large crop surfaces a plastic or fabric mulching could be used. Biodegradable plastics are convenient for organic cultivation, but not very useful for perennial crops, as they degrade after few years. Fabric mulching is expensive, but allows perspiration of plant roots and drainage of rain. Both cases, should be complemented with fertirrigation (by installing a drop irrigation system under the mulching). Other types of organic mulchings could be considered, like using tree bark or

straw, which incorporates organic matter in the soil when degrades (in the case of pine bark, there is soil acidification).

***Figures 32, 33**. Lemon verbena crop with fabric mulching (left) and plastic mulching (right).*

***Figure 34** . Mulching with straw.*

Additionally, it is very important to follow a balanced **fertilisation** program, considering the field features and nutrients demand of each species (e.g. *Lavandula* sp. is few demanding in nutrients as usually grows in poor soils, while *Mentha* sp. Is very demanding). The moment to add the fertilisation is during the sprouting in spring and/or after the harvests. The part of the plant to be produced also influence in the type of fertilisation (e.g. leaf crops like *Thymus* sp. are very demanding on nitrogen, fruit species like *Foeniculum vulgare* require phosphorous, and root species like *Valeriana officinalis* prefer potassium).

With regard to **irrigation** needs, although most aromatic plants are not very demanding, watering will lead to yield increase for any of them. There are species very sensitive to waterlogging (e.g. *Salvia officinalis* and *Rosmarinus officinalis*). On the contrary, other

species will have a limited production if they are not fully irrigated (e.g. *Mentha* sp. and *Melissa officinalis*). Some producers argue that watering essential oil crops leads to a decrease of the essential oil content (less concentration in the plant), but as there will be more biomass, the final amount of essential oil will be higher. The success is in knowing the exact quantity of water to add (cost-efficient rate).

Different irrigation systems can be used. Blanket (by gravity) irrigation system could be used if water available is in high quantities, but will lead to weeds growth. Sprinkler systems can also be used, but sometimes leave water above the leaves causing quality defects by light or fungi diseases, and plants become dirty when splashing on the soil. So, the most common system is the drip irrigation, which is localised and saves water (very important in dry areas).

***Figures 35, 36**. Drip irrigation system in double row and triple row spacing.*

Harvesting

The productive **length of crops** varies according to the species and the intensity of cultivation. It is about 2-3 years for *Achillea millefolium, Mentha* sp., *Echinacea* sp., *Hypericum perforatum, Artemisia dracunculus*, etc., up to 4-5 years for *Thymus vulgaris, Origanum vulgare, Melissa officinalis, Salvia officinalis*, etc. and up to 8-9 years for *Lavandula* sp. and *Rosmarinus officinalis*. There are also annual crops, like as A*nethum graveolens, Foeniculum vulgare, Cuminum cyminum, Silybum marianum, Ocimum basilicum*, etc.

For multiannual crops, the production starts from the second year, thus the first year the plant will establish in the field; only in few cases, and depending on the planting season a first cut could be done.

According to species and cultivation conditions, a different **number of cuts** could be implemented. *Lavandula* sp. and *Rosmarinus officinalis* only admit 1 per year. 2 harvests could be done with *Origanum vulgare, Thymus vulgare, Satureja montana, Salvia officinalis, Artemisia dracunculus*. While some species like *Melissa officinalis, Mentha, Ocimum basilicum, Petroselinum crispum* could reach to 3 or 4 cuts per year. Good climate conditions, or water disposal, could encourage extra harvests.

The **moment for harvesting** is fixed by the plant part to be obtained (seeds, leaves, flowers or roots) and is a key factor for obtaining a raw material of quality with high content in desired active ingredients. Leaf species intended for herbal products should be cut before flowering, because the flower decreases the visual quality and sometimes appear undesirable compounds. When plants are addressed to essential oil production, should be harvested in full bloom, since it is when the essential oil concentration is higher. In case of the seed this must be ripe, but considering the harvest before the seed falls down. And finally, roots are generally recommended to be harvested during vegetative rest, when all the active compounds translocate to roots for reserves during cold season, although sometimes it could be done in different seasons if other compounds are searched.

It must be taken into account that water and nutrients input, number of sunlight hours and sunlight intensity, temperatures and harvesting moment have influence both in the biomass production as in the quality of active ingredients.

To perform the harvesting there are specific **harvester machines** designed specifically for aromatic plants (e.g. *Lavandula* sp.). In other cases, grain or forage harvesters could be adapted. These type of machines can harvest 5-8 ha per day. Even a cutterbar could be added to a motorized plough for using in small fields.

***Figures 37, 38**. Specific harvester for Lavandula sp. (left) and cutterbar added to a motorized plough (right).*

***Figures 39, 40**. Forage harvester used for MAPs (left) and brushes adapted to a forage harvester (right) to lift the plant sides.*

The **harvesting rate** is always submitted to the processing speed of the fresh raw material. The working capacity of the harvester should be coordinated with the transformation capacity of the equipment or facilities, the available labour force and the optimal period for harvesting the species. A bad dimensioning of the transformation facilities or the feed rate of the processing line could be the failure origin of a MAPs production business.

In general, several aspects should be considered:

* The plant must be harvested when has the least moisture content, always after the dew.

* During harvesting, the manipulation of the plant should be avoided as possible, reducing the sun time exposition. There should not be piled too much, avoiding compaction of fresh material.

* Harvested material should be quickly processed, otherwise it could deteriorate if stored and be not useful for the market.

* Crop fields should not be far from the place of processing, maximum 15-20 km away.

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Post-harvesting

Several species need a special processing just after the harvesting and before their transformation (drying or distilling).

Species with large leafs (e.g. *Cynara scolymus*) or roots (e.g. *Cichorium intybus*) need to be chopped in order to ease their drying (increase the drying surface). Some species for essential oil benefit from remaining in the field for aerating during 2-3 days before starting the distillation.

If whole leafs are desired (for high quality herbal products), sometimes should be separated from stems previous to drying (e.g. *Aloysia triphylla*).

In other cases, harvested plants could be sieved to remove dust or stones before drying.

***Figure 41**. Cylinder with different sieve opening for remove soil from herbs.*

Processing

MAPs cultivation is always linked to a first transformation process done just after the harvest to preserve the herbal raw material quality.

When designing a MAPs production activity, the intended transformation and the necessary facilities and equipment should be planned according to the final raw material and its commercial destination.

Main processes are:

- Refrigeration (to preserve fresh herbs).
- Drying (to obtain dry herb).
- Distillation (to obtain essential oils).

Refrigeration

Refrigeration is mainly used for culinary herbs like basil (*Ocimum basilicum*), parsley (*Petroselinum crispum*), dill (*Anethum graveolens*), mint (*Mentha* sp.), etc.

In this case plants are harvested and, after water cleaning, washing away and chopping (if necessary), they are kept in a cold room. Packaging could be before or after refrigeration. Processing time has to be very fast in order to maintain the cold chain. Cooling temperatures range from 2 to 9ºC according to species, and are usually provided by refrigerators, cooling rooms, and even under controlled atmosphere.

Drying

The objective is to stabilize the drug (part of medicinal plant used), maintaining the same characteristics of the fresh herb, avoiding undesirable reactions during storage and assuring the visual aspect (colour and texture is important for herbal teas), flavour (good smell is important for seasonings and scented products) and properties (high content of active ingredients is important for pharmaceutical and cosmetic laboratories, thus for extracts manufacturers which are supplying them) are preserved.

The drying process is based in the loss of water content of the plant by evaporation, due to the moisture difference between the plant and the environment, until reaching a content level (about 12-13%) that allows to preserve the plant for a long time. Parameters to consider are: environmental temperature and humidity, airflow, drying time, plant water content and its chemical composition.

Main drying systems are two: natural drying and forced drying.

In **natural drying** facilities, plants are placed in an aerated room, in the shade to avoid colour loss. Fresh herb is usually spread in perforated shelves, to ease the air circulation, on in boxes or piles if they are woody plants. Drying rooms should be well ventilated, preferable in dry locations, easy to clean and protected from the entrance of rodents or other animals. Drying time will depend on external environmental conditions, so the process control will be difficult.

Figures 42, 43. Natural drying using perforated shelves.

Figure 44. Natural drying of Rosmarinus officinalis by piling.

Forced drying is referred to those systems that apply a heat source in order to heat the air which will circulate through the fresh herbal material with the objective of minimising and controlling the time of drying. A forced drying equipment comprises the following elements:

- **Heat generator.** It allows to increase the air temperature. Several energies could be used: fuel, electricity, gas, biomass or solar energy.

- **Ventilator and an air distribution system.** It accelerates the air movement, allowing entrance of dry air and exit of wet air from plants.
- **Closed structure** where placing and drying the plant, isolated from the outside.
- **Temperature and humidity control systems,** to manage the process at every stage.

Forced dryers could be also divided into two types: static and continuous.

- **Static dryers** are characterised by receiving plant batches, and stopping the process when plants are dried, discharging them and starting with a new batch. The closed structure could be drawers, boxes or chambers, of different sizes.
- **Continuous dryers** allow the entrance of fresh herb material in one side and the collection of dry material in the other side, because they are using a movable system like a conveyor or trolleys. These dryers can process more quantity of fresh plant in less time, but require high investments, only available for large surfaces.

***Figures 45, 46**. Static dryers, box (left) and chamber (right).*

***Figures 47, 48**. Continuous dryer by conveyor system*

In general, several aspects should be considered for drying:

* According to the plant material, could be piled more or less. Woody plants (e.g. *Rosmarinus officinals, Thymus vulgaris*) could be piled at higher heights, because they allow the air circulation. Herbaceous plants or flowers should be placed in thin layers.

* Initial water content of most MAPs species is between 60-80%, and the final admitted water content should be between 6-12%.

* Temperatures range used for drying MAPs in most species is around 30-40oC, with some exceptions (e.g. *Anethum graveolens* or *Petroselinum crispum* could be dried at 80-100oC, and Atropa belladonna should not exceed 20oC for not losing active ingredients).

* It is preferred a quick drying (6-8 hours) to a slow one (several days), but this is only achieved with forced drying systems.

After drying, several conditioning processes may be done in order to clean extraneous or foreign matter, to separate leaves from stems, to sieve to classify different particles sizes, to crush or to grind, etc. according to the final destination of the dry herbal material. This conditioning allows to obtain an added value, and sometimes if unavoidable if some end-products are produced (e.g. ground spices for condiments or crushed herbs for herbal teas sachets).

***Figures 49, 50**. Equipment for sieving dry herb material.*

Distillation

Distillation is the process to obtain essential oil from an aromatic plant. The essential oils are a mix of different compounds (constituents are usually terpenes or alcohols) with the property of being volatile. In a plant, they are responsible of its smell. They can be found in different plant parts (e.g. leaves of mint, flowers of lavender, fruits of anise, underground organs of iris, wood of sandalwood, peel of bergamot orange, etc.).

The main essential oil extraction methods used at industrial level are based in these compounds dragging with steam. According to the way of production of the steam and how it comes into contact with the plant, three types of distillation processes are defined:

- **Cohobation**. The herbal raw material is immersed into water and it's brought to the boil. The temperature uses to be 100oC. Care should be taken to avoid the plant material gets in contact with the boiling chamber walls, and the process time does not last to avoid oxidation reactions.

- **Hydrodistillation**. The steam is generated inside the boiling chamber, but plant material is not in contact with the water, being separated by a perforated grid. The distillation operating time is reduced, higher quality of essential oil is obtained and it is working at air pressure and 100oC.

- **Steam distillation**. The steam is produced in an annexed generator and is injected in the boiling chamber by different pipelines. It can work at higher pressures and temperatures than previous cited methods. The essential oil yield ratio and quality are higher.

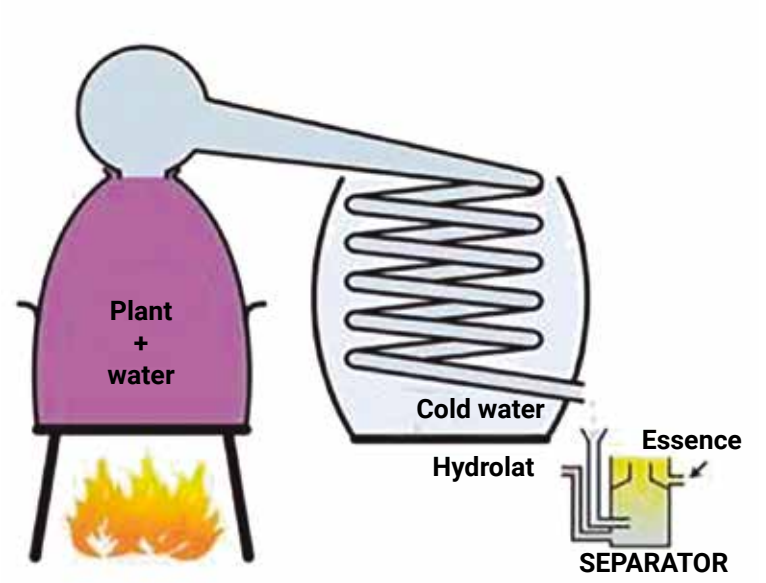

Figure 51.Cohobation system distillation[5].

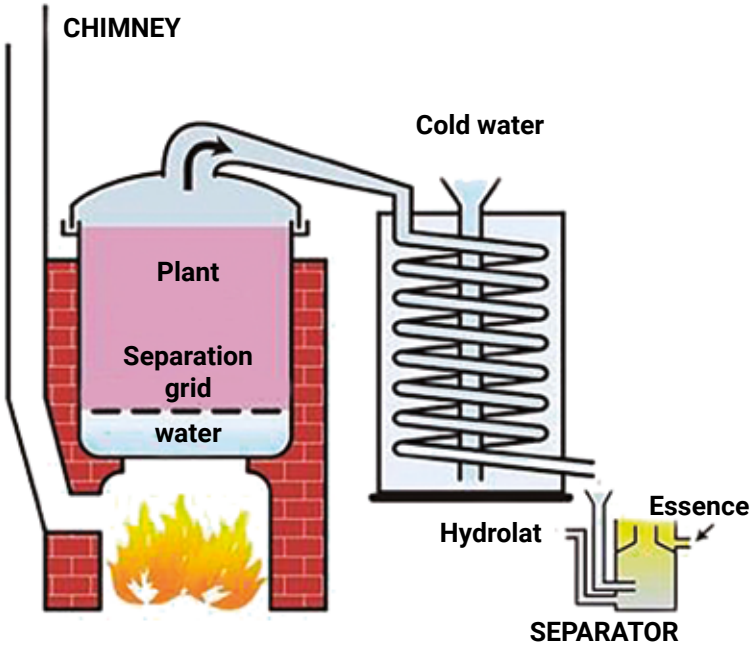

Figure 52. Hydrodistillation system[5].

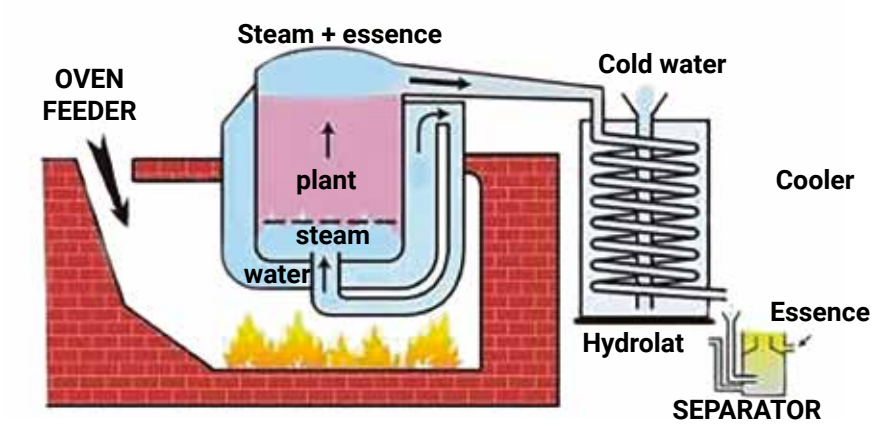

Figure 53. Steam distillation system[5].

Generally, a typical steam distillation facility comprises the following elements:

- **Steam generator.** The generator produces the steam necessary for the distillation process. This element will be preferable separated from the boiling chamber and connected by pipelines. The steam arrives at a pressure of 0.4-0.7 Mpa and a temperature of 150-170oC. The steam generator could be fed with different combustibles: gas, fuel, electricity, wood and distilled plant.

- **Boiling chamber.** It is an hermetic container containing the herbal material intended to be distilled. The space should be filled homogeneously with whole or chopped plant material, fresh or slightly dried. This container fits perfectly a basket containing the plant which facilitates the discharge of the herbal material once distilled. The container capacity could be different, up to 30 m^3. There is also mobile distillatory equipment, using the tractor trailer as boiling chamber. This method economises in labour force.

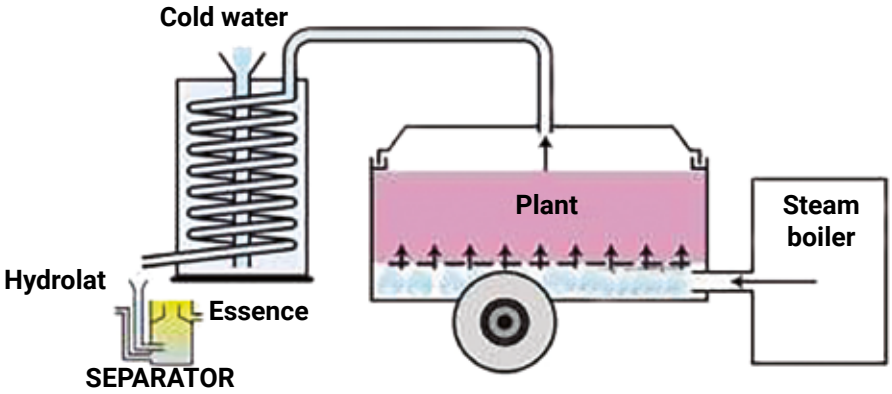

Figure 54. Mobile steam distillation system[5].

- **Cooler.** It has the function of condensing the mix of steam and volatile essential oil getting out from the boiling chamber. It is comprised by pipelines serpentine system in indirect contact with cold water.

- **Essential oil separator.** This is the end process container, where the mix of water (called hydrolyte) and essence is poured. It has the function of separating both liquids by density difference.

The yield in essential oil production depends on each species, the harvest period, the plant phenological stage, the age of the plant, the climate and soil conditions, and the distillation system.

***Figures 55, 56**. Steam distillator boiling chamber and discharging system.*

***Figures 57, 58**. Cooler and essential oil separator elements.*

To process plants with very low essential oil yield, but with a high commercial value, or because a specific active ingredient is searched, other extraction methods are used, but they require complex facilities and specific skills:

- **Solvent extraction.** The essential oil is extracted by dissolution in a solvent which has to be removed after with low pressure distillation.

- **Supercritical fluid extraction.** In this method, the solvent is a gas (usually CO_2) in specific conditions of temperature and pressure. It is very expensive.

- **Expression or peel scrapping.** It is mainly used for citrus, because the essential oils are contented in the fruit peel. Plant material is pressed, squeezed, compressed or scrapped to yield the essence.

At the end, the essential oil obtained should be clear, transparent, not coloured and clean. Essential oils have a wide range of applications: natural flavours source and preservatives (for food industry), fragrances (for perfumery and cosmetics), pharmaceutical ingredients and aromatherapy (for medicinal industry).

4. From sustainable collection to good agricultural and manufacturing practices: environment and quality

Sustainable collection is increasingly seen to be the most important conservation strategy for most wild-harvested species and their habitats, given their current and potential contributions to local economies and their greater value to harvesters over the long term. The basic idea is that non-destructive harvests and local benefits will maintain population, species and ecosystem diversity.

The major challenges for sustainable wild-collection include:

- **Lack of information on the wild resource.** Resource managers are always confronted with the lack of adequate information about the plants used, their distribution, the genetic diversity of wild populations and relatives and, above all, the annual sustained yield that can be harvested without damaging the populations. Research on the conservation and sustainable use of MAPs and their habitats has to be done for each species, which has unique ecological, socioeconomic, health and cultural associations that must be understood. Lasting solutions have to be tailored to local circumstances.

- **Undefined land use rights.** In many cases, access to the resource is open to everybody, rather than a limited access or private ownership. To make a living, commercial MAPs plants gatherers, therefore mine rather than manage these resources. Then, open-access schemes to harvestable plant populations prevent rational and cautious use and make it difficult to adhere to quotas and closed seasons.

- **Lack of legislative and policy guidance.** Information on trade in MAPs is scarce and data are rarely collected or published at a national level. Much production and consumption is at subsistence level and as a consequence the economic importance of these activities is largely under-estimated in government decision making regarding rural development, natural-resource management planning and in government budget allocations. Therefore, national legislation and policies mostly fail to provide frameworks for a rational and sustainable use of wild resources.

Limiting the harvest to a sustainable level requires an **effective management system** and sound scientific information. The management system must include:

- Annual harvest quotas;
- Seasonal or geographical restrictions;
- Restriction of harvest to particular plants parts or size classes;
- Clarification of the access and user rights to the resources.
- Continuous monitoring and evaluation of the success.

In many cases, harvesting techniques need to be improved as the extraction of the rots or bark is often negatively affecting the recovery of the species or may even kill it.

Given the fact that sustainable harvesting from the wild is difficult to achieve, **certification standards** can play a role to assure that a product meets certain standards of sustainability. Certification programmes related to natural-resource use have mainly been developed for timber and agricultural products, but they are presently being adapted for wild-harvest of non-timber plants. Various schemes focus on different areas along the supply chain: production, processing, trade, manufacturing and marketing. Four categories of certification schemes have been identified to be of relevance for MAPs products:

- Wild plant collection operations certification (e.g. FairWild).
- Forest management certification (e.g. Forest Stewardship Council – FSC)
- Social certification (e.g. Fair Trade Federation – FTF)
- Organic certification (e.g. International Federation of Organic Agriculture – IFOAM).
- Product quality certification. This include parameters such as product identity, purity, safety and efficacy. Correct identification of harvested MAPs is a basic requirement:

Sustainable collection practices

Recommended guidelines:

» FairWild Standard. http://www.fairwild.org/standard/

» International Standard for the Sustainable Wild Collection of Medicinal and Aromatic Plants (ISCC-MAP). http://www.floraweb.de/map-pro/

» Report conclusions need on MAPs sustainable wild harvesting training (Project Grundtvig PLANT WILD) - https://plantwild.files.wordpress.com/2013/04/3c-2ba-report-conclusions-need-on-maps-swh-training-grundtvig-plant-wild.pdf

Good agricultural and collection practices

Recommended guidelines:

» WHO Guidelines on Good Agricultural and Collection Practices (GACP) for Medicinal Plants – WHO. http://apps.who.int/medicinedocs/es/d/Js4928e/

» Guidelines for Good Agricultural and Wild Collection Practice (GACP) of Medicinal and Aromatic Plants – EUROPAM. http://www.europam.net/documents/gacp/EUROPAM_GACP_MAP_8.0.pdf

» Guideline on good agricultural and collection practice (GACP) for starting materials o herbal origin – EMEA. http://www.ema.europa.eu/docs/en_GB/document_library/Scientific_guideline/2009/09/WC500003362.pdf

Good manufacturing practices

Recommened guidelines:

» WHO Guidelines on good manufacturing practices (GMP) for herbal medicines - http://apps.who.int/medicinedocs/en/m/abstract/Js14215e/

» EudraLex The Rules Governing Medicinal Products in the European Union. Volume 4 - EU Guidelines to Good Manufacturing Practice Medicinal Products for Human and Veterinary Use. Annex 7- Manufacture of Herbal Medicinal Products. http://ec.europa.eu/health//sites/health/files/files/eudralex/vol-4/vol4_an7_2008_09_en.pdf

» Guidelines for Good Agricultural and Hygiene Practices for Raw materials used for Herbal and Fruit Infusions (GAHP) – THIE. http://www.thie-online.eu/fileadmin/inhalte/Publications/HFI/2_2014-06_PU_GAHP_Version_6.pdf

» General Guidelines for Good Agricultural Practices on Spices & Culinary Herbs – IOSTA. http://www.esa-spices.org/download/iosta-gap-final.pdf

5. From bulk to retail: marketing models and study cases[3]

Many aspects have to be taken into account when deciding the best business model for MAPs production:

- Available resources.
- Location
- Market needs
- Field surface

Available resources

Facilities

Wharehouses

If the farm has warehouses, they can be useful to install the dryer (natural or forced), processing room and storage room (for material, product or machinery). In case the producer does not have them, should be necessary to rent a space or built a new one.

For distillation, apart from small distillers, the distillation facilities size implies to build a new coverage.

Farm machinery

Each one of the cultivation stages (planting, maintenance, harvest) requires some mechanisation, but mainly according to the field surface.

In **small surfaces**, the planting could be done manually, otherwise a vegetables planting machine could be rented. For maintenance labours, there are different options: manual tools (hoes, rakes, etc.), bicycle with tillage implements (very used in organic agriculture), motorized plough, small tractor (e.g. *Pasquali*) with tillage implements, brushcutter, etc. In relation to harvest, if there are not too much plant, could be done manually with scissors or a sickle (mainly recommended for culinary fresh herb production). If larger quantities have to be harvested, then a mowing bar could be added to a motorized plough o to a brushcutter.

***Figures 59, 60**. Tillage bicycle "Ecoprac" (left) and small tractor "Pasquali".*

***Figures 61, 62**. Harvest with scissors (left) and with an adapted brushcutter (right).*

When having larger surfaces, the producer must consider a higher mechanisation of the farm labours, thus having: a vegetable planting machine, tractor with tillage implements, manure and pesticides applier, harvester, etc. Even the harvester will be different according to the plant part obtained:

- Uprooter (similar to those for potatoes or beetroots).
- Forage harvester (for herbaceous plants).
- Sunflower or cereal harvester (for grain plants).
- Aromatic special harvesters (e.g. *Clier* types for lavender).

Figure 63. Uprooter used for Echinacea sp. roots harvest.

In case of bush or tree species, the type of organ to collect should be considered. Most times should be done manually, but some harvest methods used for olive or nuts could be adapted.

Financial assets

The financial capacity will determine the investment to do, mainly referred to the seedling order, the machinery purchase and the new facilities. If the producer deals with a large surface, should need to expense more because will have larger requirements.

To face these expenses, the producer can count on own or family capital, bank credits, or subsidies. Own or familiar capital will have more time of investment return, while bank credit will ask for interest quotas. In relation to subsidies, the producer should take into account if these are non-repayable or soft credit, and also the percentage of grant, and how to face the co-financing and the advance payment of the expenses, because sometimes the grant is not received until the expense is done, and this involves cash capacity. The producer should check which specific subsidies exist in his country (e.g. grants for farm improvements, for disadvantaged areas, for young entrepreneurs, for hiring people with special needs, etc.).

Time availability

The time availability is an important factor to consider, thus to start producing MAPs demands an apprenticeship period, tests, reshaping and operations planning, until it can be considered a well-established business.

If the producer only has **weekends and holidays** for spending on the MAPs business,

therefore is advisable to deal with small surfaces and/or having automatized systems (e.g. irrigation) if possible. The farm work should be constant, mainly to maintain the field free of weeds, and in harvest season, to have more time or hire extra labour force. So, it is very important to do a correct planning of the available time.

Another possibility is when the producer has a **partial job or a job with flexible hours**, so having time during the day for the MAPs business. Nevertheless, if he is alone, only small fields could be managed and activities' schedule should be also well planned.

Generally, spring and summer season should be mainly devoted to planting, field maintenance, harvesting and drying, while autumn and winter to dry plant processing.

In case that the farmer is also **producing other agricultural outputs** which are complemented with MAPs, he must balance the work weight in each season (e.g. cereal sowing in winter and harvest in spring, olive harvest in autumn, trees pruning in winter, etc.). Then, the MAPs cultivation should not overlap with other traditional crops.

Professional experience

Several skills are envisaged for a MAPs producer, which will help him in the implementation of the different business activities.

The first one is **botanical knowledge**, thus it is important to know the plants with which he will deal: recognise them in all the phenological stages, know them by their scientific name (which is internationally known) and vernacular name in different languages (this will help in finding information), and the existing varieties, cultivars and chemotypes (to focus on the specific quality searched by the market).

In case that it is previewed to do wild collection it is also important to have information on norms and permits for doing the activity, to have also botanical knowledge and to know very well the territory in order to find the wild populations, and last but not least, to be aware of sustainable practices (in order to maintain the plant source in long term).

If someone is intending to start a MAPs business implying cultivation, it is necessary to have a minimum of **agriculture knowledge.** This means to know the production cycle, available techniques, the required farm machinery, etc. Then if this entrepreneur does not have previous agriculture skills, to engage to agriculture courses or to an official agriculture school is mandatory. The same if he is intended to produce organically, because involves specific techniques.

Also, MAPs production implies some agro-industrial activities (e.g. refrigeration, drying, distilling, processing, etc.). Therefore, some **industrial skills and good manufacturing** concepts should be acquired.

In addition to that, more related to the production stage, other important background is linked to the **business** (e.g. cost control, accountancy) and **marketing** (e.g. market infor-

mation, clients and competence knowledge, consumer needs, etc.).

Finally, and auxiliary to all the discussed aspects, there are the **language skills**, either for obtaining technical information on cultivation and processing (e.g. main scientific and technical books are written in English, or in French for aromatic plants or in German for medicinal crops), either for commercial contacts if exports are considered, mainly in Europe (e.g. English is considered the commercial language, but larger medicinal market is Germany, so German is good to know) and also USA and Japan. French could also be considered not only to access to markets in France, but also to countries with French influence (North Africa).

Location

Road communication

The proximity to large road communications will ease the transport of goods (both bulk or retail) to their final destination, which will be probable big cities or metropolitan areas (e.g. Istanbul, Ankara).

Being near a big city will be very convenient to speed the transport and administrative and commercial dealings. It is also very important if the producer is intending to sell culinary fresh herb, which need a fast distribution and a wide range of selling points. There will be also different vegetable distribution hubs which will collect the surrounding primary production. It is also interesting for trading end products (e.g. seasonings, herbal teas, etc.), because there will be more consumers than in rural areas.

At national level, the road is still the only means of transport capable to cover practically any type of demand. If the producer trades large amounts of products (e.g. containers of 20-40 tons), railway or sea transport could be also considered, but only with non-perishable products.

Industry network

The **local community** will be the starting point where a MAPs producer will trade his products, consequently this will be the first option. If few amounts are produced, therefore could be sold directly to the inhabitants, through local markets, shops, restaurants or hotels. But if the local market it is not enough to maintain the business (few consumers or higher offer), surrounding communities should be also covered, which means higher transport costs.

When having a larger production, both in bulk or retail products, the target client will be **wholesalers or industries**. It is very important to know where this industry is located in the country, so business directories should be consulted, or consuming focus (e.g. touristic places).

As the business scale is increasing, clients should be search abroad. Nevertheless, national clients are easier to deal with (better communications, common language and culture, same procedures, etc.).

If **export** is considered, it is advisable to outsource the services of an export agent or a reseller in the chosen country. It is very important to know the consuming demands but also the specific requirements in imports procedures, product quality certifications, transport and currency insurances, etc. Therefore the consultancy of a customs agent is recommended.

Market needs

When commercialising several considerations should be taken into account:

- To know the needs and requirements of the market.
- To plan the product availability: how many plants should be cultivated, how much product should be sold and how much could be stored. All this means to establish prices, transport and storage costs.
- To define where the product will be sold and how it will be consumed: processing, packaging, labelling and transport will be considered.
- To preview future needs of marketing: product brochure, company website and other social media (e.g. facebook, Instagram, etc.), advertising, etc..

Specifically, for MAPs species demand, it would mainly depend on the country consumption pattern, the industrial sector, and the price and volume level.

Demand according to the consumption pattern

Traditionally, people of a certain area will consume local species (e.g. Mediterranean species in Turkey) which are linked to the food or medicinal uses (e.g. *Laurus nobilis* or *Thymbra spicata*), but young people are very keen to find out new experiences, therefore plants coming from foreign cultures have a commercial opportunity (e.g. selling Mediterranean species in Asian markets).

Demand according to sector

The species demand will vary according to the industrial sector, although some of them are used in very different industries, with different applications and commercial forms. Hereafter are listed some of interest in Europe:

In the medicinal sector:

- **Pharmacy:** *Artemisia annua, Digitalis* sp., *Glycyrhiza glabra, Papaver somniferum.*

- **Herbal medicines and phytomedicines:** *Cassia* sp., *Crataegus* sp., *Equisetum* sp., *Ginkgo biloba, Hypericum perforatum, Linum usitatissimum, Matricaria chamomilla, Melissa officinalis, Olea europea, Passiflora incarnata, Silybum marianum, Taraxacum officinale, Thymus* sp., *Tilia* sp., *Urtica* sp., *Valeriana officinalis, Vitex agnus-castus,* etc.

- **Aromatherapy:** *Cupressus sempervirens, Juniperus* sp., *Lavandula angustifolia, Mentha* sp., *Rosmarinus officinalis, Salvia* sp., *Satureja montana, Thymus* sp.

- **Dermopharmacy:** *Prunus dulcis, Aloe* sp., *Calendula officinalis, Carthamus tinctorius, Curcuma longa, Arctostaphylos uva-ursi, Simmondsia chinensis, Citrus limón, Matricaria chamomilla, Rosa moschata*, etc.

In the food sector:

- **Spices and seasonings:** *Artemisia dracunculus, Capsicum* sp., *Coriandrum sativum, Crocus sativus, Laurus nobilis, Ocimum basilicum, Pimpinella anisum, Origanum* sp., *Petroselinum crispum, Rosmarinus officinalis, Satureja* sp., *Thymus* sp., etc.

- **Herbal teas:** *Aloysia triphylla, Camelia sinensis, Ilex paraguarensis,Matricaria chamomilla, Mentha* sp., *Tilia* sp., etc.

- **Fresh culinary herbs:** *Anethum graveolens, Allium schoenoprassum, Coriandrum sativum, Ocimum basilicum, Petroselinum crispum,* etc.

- **Dairy products:** *Allium schoenoprassum, Carum carvi, Cuminum cyminum, Rosmarinus officinalis, Satureja montana,* etc.

- **Beverages:** *Artemisia absinthium, Foeniculum vulgare, Gentiana lutea, Glycyrrhiza glabra, Humulus lupulus, Juniperus communis, Matricaria chamomilla, Mentha sp., Pimpinella anisum, Sideritis sp.,* etc.

- **Meat products:** *Cuminum cyminum, Origanum sp., Piper nigrum, Rosmarinus officinalis, Salvia officinalis, Sinapis alba, etc.*

In the perfumery sector:

- **Perfumes:** *Citrus bergamia, Cupressus sempervirens, Lavandula* sp., *Eucalyptus* sp., *Pelagornium* sp., *Cymbopogon citratus, Jasminum* sp., *Helichrysum* sp., *Narcissus* sp., *Rosa centifolia*, etc.

- **Toiletry:** *Aloe* sp., *Lavandula* sp., *Citrus limon, Rosa* sp., *Salvia sclarea*, etc.

Demand according to price

At the beginning, everybody pretends to know which are the species best paid in order to produce them, with the promise of better benefits. But sometimes **high prices** are due to some reasons:

- **Difficulties to obtain the plant material:** because it is grown in countries with political problems or armed conflicts (e.g. during 90s the trade of *Juniperus officinalis* berries stopped due to the Balkans conflict), its cultivation it is a monopoly in a specific country (e.g. *Panax ginseng* in Korea), or it only grows in specific areas or it is an endemism (e.g. *Origanum minutiflorum* in Mediterranean region of Turkey).

- **Difficulties to produce the plant:** it happens mainly with wild species intended to be cultivated, because mechanisation is not possible (e.g. low sized species like as *Spergularia rubra*), germination problems (e.g. *Gentiana lutea*) or specific habitats (e.g. *Drosera rotundifolia* only grows in peatlands).

- **High costs of transport:** because the species grows in isolated or far areas.

- **Complex processing:** e.g. extraction of essence from jasmine (*Jasminum grandiflorum*).

- **Low yield:** e.g. Melissa has a very low yield of essential oil, needing about 7 tons to produce 1 kg of essence.

- **Temporary price rising:** due to bad harvests in traditional producing areas, for flooding, drought, pests, etc.

- **Product recall from the market to cause price rising:** usual speculation in essential oils.

- **Appearance of new applications that bring a species into fashion:** this is very usual in the medicinal and cosmetic sector (e.g. *Stevia rebaudiana* as natural sweetener and to treat diabetes). This occurrence increases the consumer demand, thus the price, when there is not still offer at the beginning.

Therefore, sometimes high prices are synonymous of fluctuation, and it is rather common that after good years happens a **price drop**, either because problematic countries have solved their conflicts, or because a wild species have been successfully domesticated, or because the processing efficiency has been improved, or because the harvest yield has turned to be good, or because crops of new species have increased or because the wholesalers have decided to put product in the market.

There are certain species, mainly aromatic for food sector, that have more or less **stable prices** because they have been cultivated since many years ago and the consumption has been maintained at a certain level. These stable prices are not high prices, but allow to plan a MAPs production without many risks.

Sometimes, the reason why a species price is low, may be due to:

- Very mechanized crop with high yields (e.g. *Petroselinum crispum* or *Lavandula x intermedia*).
- Large surface of cultivation (e.g. *Salvia sclarea* in China).
- Species cultivated in developing countries where the labour force is cheap (e.g. *Matricaria chamomilla* in Egypt).
- A species abundant in the wild and easy to harvest (e.g. *Rosmarinus officinalis* in Morocco).
- By-product of other traditional crops (e.g. *Citrus* sp. essencial oil issued from peel after juices industry or *Olea europaea* leaf after olive oil production).

Producing these type of species only can stand out by reducing production costs and obtaining large amounts.

Demand according to volume

If a species is consumed in **large amounts** provides security to the producer at the moment of planning the crops, but it is probable that prices would not be too high, therefore forcing to cultivate large surface to produce large quantities.

However, it is necessary to know who is pulling this demand:

- **Wholesalers:** there are few and they are the sales funnel. They buy big quantities, almost the existing offer in a country, and after supply industries and herbal shops.
- **Extracts processors, beverages manufacturers and spices packagers:** they consume large amounts of specific species at prices not too high. Some of them have their own crops to avoid raw material supplying disruption.
- **Medicinal, food supplements and cosmetic laboratories:** they will buy not very high quantities and prices will vary, because there will be many buyers and offerors.
- **Herbal shops:** they use to buy to the wholesaler, but somehow they address directly to the producer. They ask for few quantities of a broad range of species.

Main species found in the market are those largely cultivated. Therefore, species consumed in few quantities are very difficult to find in the market, thus there islow supply. These are called **minority species**. They have not always a good price and sometimes are difficult to cultivate, but specialising in these species could be an interesting option, focusing in a reduced target market. Among these we can find the most part of medicinal plants coming from the wild: *Achillea millefolium, Agrimonia eupatoria, Arnica montana, Crataegus* sp., *Drosera rotundifolia, Lithospermum officinale, Malva sylvestris, Satureja fruticosa, Verbascum Thapsus*, etc.

Surface

The main aspect that will influence the marketing model of a MAPs production is the available field surface to cultivate. Three size ranges will be taken into account: small surfaces (up to 2 ha), medium surfaces (up to 50 ha) and large surfaces (from 50 ha).

***Small surfaces - SS** (up to 2 ha)*

Generally, this cultivation dimension will not allow to address a bulk market, but it is a very suitable option for intensive or handicraft cultivations, i.e. to use organic cultivation techniques that demand many labour force, mainly for weed control.

Different types of production could be implemented, but the limiting factor is the water availability. Therefore, if irrigation is possible, living plant and fresh herb cultivation can be professionally done; but if water is restricted, then is advisable to produce dry herb.

SS Living plant cultivation

NURSERY

A nursery is usually dealing with seedling production in greenhouse conditions.

It has several needs:

- To offer many different species and varieties.
- To have greenhouse facilities.
- To be located in temperate climate to avoid heating the greenhouse during cold seasons.
- To have water availability.
- To do plant distribution during all the year.
- To have vegetal propagation techniques knowledge.

A MAPs nursery can deal with two types of production:

- **Seedlings:** addressed to the sale to MAPs farmers. Varieties should be chosen according to the active ingredients content or essential oil richness, in relation to the food or medicinal industries requirements. But it has to be considered if there is enough farmers critical mass to justify a minimal production.
- **Pot plant:** addressed to the sale to end consumers through garden centres. In this case, varieties are selected mainly for ornamental features. It can be also produced culinary plants.

***Figures 64, 65**. Pot plant and seedling production at "Vivers Riera Villagrasa" in Catalonia, Spain.*

Examples of businesses in Catalonia (Spain):

- Aldufreu Associats http://www.aldrufeu-associats.com/
- Spice garden http://www.spicegarden.eu/
- Vivers Riera Villagrasa http://rieravillagrasa.com/
- Vivers tres turons http://www.vivertresturons.com/

In Turkey:

- WBT Tarım Ürünleri San.ve Tic. A.Ş. http://www.wbttarim.com/
- NU-KA İth. İhr. Paz.San. Tic. Ltd.Şti. http://www.nuka.com.tr
- Altes Alanya Tesisleri San. ve Tic.Ltd.Şti. https://www.altes-tr.com
- İnan Tarım Ticaret-Ecodab Gıda Tar. Koz. Yağ. San. ve Tic. Ltd. Şti. https://www.ecodab.com.tr

GARDEN

Living plants can take part of gardens with a different aim:

- **Visual garden:** it can be an attractive claim for rural tourism accommodations, hotels, etc. It is also usual to see aromatic plants (e.g. *Lavandula* sp., *Rosmarinus officinalis*) in roundabouts, city parks and road margins, because of their colourful flowering and their resistance to dry conditions.

- **Aromatic garden:** it can be useful to blind people, to teach kids the origin of the fragrances, to attract butterflies and other insects, as an image for a company producing herbal products, or to simply make more pleasant the environment of facilities intended for relax or recovering (e.g. spa resort, hospital, etc.).

- **Culinary garden:** as a part of a tourist accommodation or a restaurant's yard providing vegetables. MAPs are kept alive and only leaves, flowers of fruits required are harvested.

- **Educative garden:** MAPs allow to design a garden with different training objectives, e.g. botanical itinerary for identification of species, collection of local flora or plants with ethnobotany uses.

When receiving people, it would be also necessary to have facilities to attend visitors (toilets, parking, reception, etc.).

***Figures 66, 67**. "Ecoherbes Park" (left) and "Parc de les Olors del Serrat" (right) in Catalonia, Spain.*

Examples of businesses in Catalonia (Spain):

- Parc de les Olors http://parcdelesolors.com/
- Ecoherbes Park https://www.ecoherbes.com/jardin-botanico-ecoherbes-park/

- Associació Jardí Botànic Plantes Medicinals Gombrèn http://jardibotanic-gombren.cat/
- Botànic Cal Riera Moià http://botanicdecalrieramoia.blogspot.com.es/
- Hort de la Sínia http://www.hortdelasinia.com/el-jardi-dels-sentits/
- Vegetalia – El Turó dels sentits http://vegetalia.com/actualitat/noticia/3391/activitats-i-tallers-del-tur-dels-sentits-2016
- CosmeticsGiura-Tort http://www.cosmeticsgiura.com/es/visita-virtual-de-nuestra-casa/

In Turkey:

- Zeytinburnu Tıbbi Bitkiler Bahçesi http://ztbb.org/

ORGANIC ORCHARD

It can be also thought the use of living plants in organic orchards as plant protection, in an associated cultivation with vegetables, because MAPs have many protective or repellent properties (e.g. *Ocimum basilicum* with tomato, *Calendula officinalis* with eggplant or cucumber, *Tropaeolum majus* with celery, *Borago officinalis* with pumpkin, *Matricaria chamomilla* with cabbage or *Rosmarinus officinalis* with carrot).

FIELD CROP FOR BEEKEEPING

Melliferous aromatic plants could be cultivated in the field to be used by honey bees as nectar or pollen source, so the beehive could be placed next to the field. Many different species could be cultivated to have successive flowerings (e.g. *Thymus vulgaris* is flowering in Spring, *Lavandula* sp. in Summer, *Satureja montana* in autumn and *Rosmarinus officinalis* in winter), then obtaining different types of honey according to the season.

In France it is usual to bring the beehives to the lavender fields just before the plant is harvested.

***Figures 68, 69**. Lavandula sp. crop for beekeeping at "Can Caponet" in Catalonia, Spain.*

Examples of businesses in Catalonia (Spain):

- Can Caponet – kırsal konaklama http://www.cancaponet.com/
- El Raig d'Or https://es-es.facebook.com/raigdor/

In Turkey:

- Morlab Biotechnology http://www.morlab.com.tr

SS - Taze bitki yetiştiriciliği

ORCHARD

It can be implemented a MAPs cultivation in a small surface with fresh culinary herbs or aromatic plants for herbal teas. It can be useful to supply a house (like a garden), a local market or to some restaurants.

Water availability is necessary, as this is like a vegetable orchard. In general, it does not require many mechanisation and many labours could be done manually. However, during cold season there is no production.

It can also be established an educational orchard and use the plant as herbal material for implementing gardening activities and workshops for manufacturing herbal products. In this case, it would be also necessary to have facilities to do these activities (small dryer, processing room) and to attend visitors (toilets, parking, reception, etc.).

***Figures 70, 71**. Petroselinum crispum crop at Sínia Pujadas (left) and fresh herb production at "Les Herbes de Can Riera" (right) in Catalonia, Spain.*

Examples of businesses in Catalonia (Spain):

- Les Herbes de Can Riera http://www.lesherbesdecanriera.com
- L'hort de la Sínia http://www.hortdelasinia.com/
- El Vergel de las Hadas https://vergeldelashadas.com/
- Riuverd http://www.riuverd.cat/es
- Sínia Pujadas http://www.eixdiari.cat/guia/ca/mercat-del-centre-pujadas-ortuno.html
- Aurora del Camp, SCP http://www.auroradelcamp.com

In Turkey:

- Erüst TarımÜr.Paz. Ve Tic.Ltd.Şti http://www.erusttarim.com.tr

PROTECTED CULTIVATION

Protected cultivation is referred to the cultivation technique using shade nets or greenhouses, with the objective of enlarging the production period. It is very used for fresh herbs production and it is mainly done by nurseries.

In general, it is necessary to produce many different species and varieties and offer plant during all the year. It is mandatory to have irrigation and it is recommended to place the production facilities in temperate areas to avoid heating the greenhouse during cold seasons.

Two types of MAPs production could be done:

- **Cut fresh herbs:** in this case the herb is cut and packed according to the orders, because the product is highly sensitive and deteriorates in a week once harvested. It requires many manual work, cold rooms and isolated transport.

- **Pot plant:** the culinary plant is cultivated in small pots which are later sold to super-markets and allow the fresh plant to be reachable during a longer time. The type of pot is designed for maintaining the plant during the time the consumer is cutting the plant for its use in the kitchen. The production needs are similar to the nurseries producing ornamental pot plants.

***Şekil 72, 73**. Pot plant and fresh cut herb production at "Vivers Riera Villagrasa" (left) and fresh cut herb production at "Pàmies Hortícoles" (right) in Catalonia, Spain.*

Examples of businesses in Catalonia (Spain):

- ViversRieraVillagrasa http://rieravillagrasa.com/ - http://www.lesherbes-decanriera.com
- Pàmies horticoles http://www.pamieshorticoles.com
- Bioplanta Can Tria http://agrobotigacantria.blogspot.com.es/p/6.html

SS - Dry herb cultivation

For small surfaces and dry herb production, different commercial strategies (bulk sale / retail sale) are required according to the number of species cultivated.

FEW DIFFERENT SPECIES: BULK SALE

If the producer only cultivates one or few species in a small surface, he can think of different alternatives for trading dry herb in bulk:

- **Association with other producers:** a group of nearby MAPs producers can be created, with the legal status that better suits (e.g. farm cooperative, working cooperative, agrarian transformation company, etc.). Members can share either the product processing facilities or the commercialisation. Should be very strict in producers' batches classification according to the quality, because each different quality will have different destinations and prices. It is also very important to do a good planning of the species to cultivate in order to organise the use of the dryer according its capacity, to face the market demand and to diversify clients (to avoid market fluctuations). Furthermore, it is interesting to encourage crop rotation among producers.

- **Sale to other producers:** if producers are quite isolated, it is difficult to associate with each other, so they can try to sell the dry herb to other producers who have more experience in the market, and who must offer a wider range of species, which sometimes they cannot produce. Agreements could be done with these producers, being a good way for star producing because entrepreneurs could take advantage of elderly producers knowledge.

- **Production of minoritory species:** a possibility is to cultivate those species for herbal medicines which are not demanded in large by the market and usually come from wild collection and are difficult to cultivate (e.g. *Artemisia absinthium, Papaver rhoeas, Spergularia rubra, Arnica montana, Drosera rotundifolia, Malva sylvestris, Lithospermum officinale*, etc.). In this case, it is necessary to have knowledge in plant domestication and good contacts with buyers to obtain information about demanded species.

***Figures 74, 75**. Saffron cultivation at "Aromis" (left) and Arnica montana cultivation at "Taüllorgànics" (right) in Catalonia, Spain.*

Examples of businesses in Catalonia (Spain):

Associations:

- Safracat (safran birliği) https://twitter.com/catsafra
- Safrà de les Garrigues (safran birliği) https://es-es.facebook.com/Safr%-C3%A0-de-les-Garrigues-198567036955887/
- Parc de les Olors Network http://parcdelesolors.com/xarxa/
- Les Herbes del món https://lesherbesdelmon.wordpress.com/

Minority production :

- Taüllorgànics (Arnica montana, Leontopodium alpinum, Rhodiola rosea) http://www.taullorganics.com/
- Arnica i Flora, S.C. (Arnica montana) http://www.arnicaiflora.es

MANY DIFFERENT SPECIES: RETAIL SALE

With a small surface but having a wide range of different cultivated species, it is possible to manufacture different handicraft herbal products:

- **Seasonings and herbal teas:** elaborated from dry plants, and under the food legislation rules. In Europe:
  - Tea and Herbal Infusions Europe - http://www.thie-online.eu/
  - European Spice Association - https://www.esa-spices.org/
- **Medicinal herbal teas:** elaborated with dry plants. These type of herbal teas are under the herbal medicines for human use rules. In Europe:
  - European Medicines Agency – Herbal medicinal products: http://www.ema.europa.eu/ema/index.jsp?curl=pages/regulation/general/general_content_000208.jsp
- **Scented products:** potpourris, sachets, bundles, etc. Combining dry plant and essential oils. These products do not have a clear regulation under EU.
- **Value added products:** In the case of saffron (*Crocus sativus*) and other value added products, a small surface could be devoted to its cultivation, when end-products are manufactured.

In general, these small productions need few mechanization (many activities could be manual or allow the use of small machines). It is enough to have a natural dryer in a warehouse (if there is not too much plant to dry and is well scheduled), but it is necessary to have a processing room. Sometimes, some manufacturing processes or specific packaging (e.g. tea sachets) could be subcontracted. Packaging, taxes, distribution and marketing costs should be also taken into account.

***Figures 76, 77**. Different MAPs cultivation and dryer of "Sambucus" in Catalonia, Spain.*

***Figures 78, 79**. Herbal teas and seasonings of "Sambucus" (left) and food products made of saffron of "Concaromis" (right).*

Examples of businesses in Catalonia (Spain):

Seasonings and herbal teas:

- Agrícola Fortuny, SC – Aromàtiques Ecològiques el Drac Verd http://www.eldracverd.com
- Aromik https://es-la.facebook.com/AROMIK-458262067715561/
- E.I. Sambucus, SCCL http://www.sambucus.cat
- Ecoherbes https://www.ecoherbes.com/infusiones-hierbas-aromaticas-ecologicas/
- Herboristeria Nogué https://www.herbesdossera.com/
- Natural Subirats http://naturalsubirats.com/
- Les Herbes de l'Alt Pirineu http://parcdelesolors.com/parc-daraos/
- Cal Portalé http://parcdelesolors.com/parc-de-les-olors-de-claverol-pallars-jussa/

Scented products :

- Aromes.cat http://www.aromedi.es/
- Parc de les olors del Serrat http://parcdelesolors.com/parc-del-serrat/
- Cal Forner http://parcdelesolors.com/parc-de-les-olors-de-cal-forner-bergueda/

Value added products (saffron):

- Concaromis, SL - Aromis http://www.aromis.cat
- Naturges-Ponent, SCP http://www.naturges.com
- El Tossal de les Garrigues http://www.eltossaldelesgarrigues.com

In Turkey:

- Arhan Medikal Özel Sağ. Tarım Ür. Ltd .Şti. http://www.arhanmed.com
- Kamaş Kuruyemiş Gıdave Tem. Mad. Tar. Ürn. Tur. İnş. Teks. İml. İh. İt. San. Tic. Ltd.Şti. http://kamasbaharat.com/tr/
- Çalışkan Tarım Ürünleri http://herbsandspices.caliskantarim.com

SS - Essential plants cultivation

This type of plant productions imply the installing of a steam distillation system for obtaining essential oils. The main limiting factor a producer may find when cultivating this type of species is that a large amount of plant material has to be produced (because the essential oil yield is very low).

FEW DIFFERENT SPECIES: RETAIL SALE

In case of small surfaces, low quantity of essential oils or other extracts are obtained, and therefore it will be difficult to sell in bulk, thus the only commercial output will be the manufacturing of end-products and the retail sale. Natural products are more and more demanding for high quality extracts and essential oil, and the percentage used in an end-product is quite small:

- **Aromatherapy:** uses a wide range of pure and chemotyped essential oils. No specific regulation exists in the EU.

- **Natural cosmetics:** involves the production of extracts and essential oils coming from plant source. In the EU, there is a specific regulation on cosmetics: https://ec.europa.eu/growth/sectors/cosmetics/legislation_en

- **Natural perfumes:** segment of perfumery industry using natural essential oils. They are also under cosmetics regulation.

It would be necessary to have a small distillatory (sized according to the maximum expected fresh plant material production). It is advisable to pack the essential oil in small containers and distribute them to different clients (masseurs, naturopaths, specialised shops, handicraft perfumes or cosmetics manufacturers, etc.). Therefore, it would be recommended to address marketing strategies to these type of professionals.

Organic production of essential oils is very interesting, because they are very valued in the market, and the organic cultivation in medium surfaces in easier to handle.

***Figures 80, 81**. Natural perfumes elaborated by "Fragàncies del Montseny" (left) and Lavander distilling at "Les Feixes de Cal Margarit" (right) in Catalonia, Spain.*

Examples of businesses in Catalonia (Spain):

- Taüllorgànics (extracts for cosmetics) http://www.taullorganics.com/
- Les Feixes de Cal Margarit (essential oils for cosmetics and perfumes) http://www.feixescalmargarit.com/es/
- Fragàncies del Montseny (Natural perfumes) http://www.fragancies-montseny.es/

In Turkey:

- NBT Eterik Yağ İmalatı Ticaret Ltd. Şti. nbt@nb.t.com
- Defne Şifalı Bitkiler Ltd. Şti. https://www.gmdu.net/corp-

Medium surface - MS (up to 50 ha)

MS - Dry herb cultivation

It would be more or less similar to the *SS-dry herb cultivation*, but on a large scale, so it is necessary to correctly sizing the labour force, the machinery, the facilities and the commercialisation, to face the increase of production. Therefore, it is recommended to mechanise the crop (planting machine, tractor, harvester, etc.), provide a forced dryer which allows to process greater amounts of plant material and larger equipment for processing the dry herbal material (crusher, sieving system, miller, etc.).

FEW DIFFERENT SPECIES: BULK SALE

This type of business consists in producing large quantities of few species (usually just one) to sell to botanical wholesalers or to companies consuming large amounts of dry herbal material (extracts manufacturers, beverages manufacturers, spices packagers, etc.).

The forced dryer and the processing equipment should be sized according to the plant production, because the quantity of harvested plant of a single species will be very high at a specific period.

The advantage is that producing few species is easier and the processing is simple, but clients demand always high quantities at a low price. One exception is with *Humulus lupulus* which some producers are producing in bulk and selling to handicraft breweries at higher prices.

***Figures 82, 83**. Melissa officinalis crop at "L'Armengol" and Humulus lupulus crop at "Lupulina.cat" in Catalonia, Spain.*

***Figure 84**. . Industrial continuous dryer for bulk processing at "L'Armengol" in Catalonia, Spain.*

Examples of businesses in Catalonia (Spain):

Sale to wholesalers:

- L'Armengol SCP (8 ha of Melissa officinalis) https://sites.google.com/site/larmengolscp/
- Naturhemp (10 ha of Cannabis sativa) https://www.linkedin.com/in/marcel-estudillo-91423a60/

Humulus lupulus for handicraft breweries:

- Lupulina.cat http://www.lupulina.com/
- Vivers tres turons http://www.vivertresturons.com/lupulus-num-3
- Catalana del llúpol https://es-es.facebook.com/Catalana-de-Ll%C3%-BApol-1610945805836968/

MANY DIFFERENT SPECIES: BULK SALE

In this case, dry herbal material could be sold to small companies (small wholesalers, laboratories, manufacturers for third parties, purchasing centres, packagers, etc.).

In general, producers should have processing equipment for facing specific client requirements (e.g. to grind the plant at a specific grading) and have a wide range of species, because most of this buying companies demand many species in small quantities.

The main advantage is that the price paid is higher than wholesalers, but the final product requirements and quality are higher, and sometimes are asking for active ingredients analyses.

Examples of businesses in Catalonia (Spain):

- Parc de les Olors network is selling the members production to Tegust http://www.tegust.com/es/(herbal teas packager)
- Herbocat is a small wholesaler and packager that is buying to small producers http://www.manantial-salud.com/

MANY DIFFERENT SPECIES: RETAIL SALE

When many species are cultivated in medium surfaces, it is important to consider that will be necessary to mechanically manipulate each type of herb once dried, in order to have the adequate dried raw material for manufacturing the end-products.

Costs of manufacturing room, packaging, distribution and advertising will be higher than those described for *SS dry herb cultivation*, because it would be necessary to process larger amounts of herbal raw material, thus needing more space and equipment (unless

part of the manufacturing processes are subcontracted). In addition, end-products will require the fulfilment of norms and procedures, and the payment of taxes. It must be also considered that would be necessary to commercialise to a bigger geographical scope.

Manufactured products could be similar to those previously mentioned, but at an industrial level: seasonings and herbal teas for food sector, medicinal herbal teas, etc.

***Figures 85, 86**. Different MAPs cultivation and processing room of "Herbes de la Conca" in Catalonia, Spain.*

***Figures 87, 88, 89**. Herbal teas and seasonings of "Herbes de la Conca" (left) and "Bernau Herbes" (right) in Catalonia, Spain.*

Examples of businesses in Catalonia (Spain):

- Bernau Herbes (up to 6 ha) http://www.bernauherbes.com/
- Herbes de la Conca (up to 5 ha) http://www.herbesdelaconca.com

Large surface – LS (more than 50 ha)

LS - Dry herb cultivation

FEW DIFFERENT SPECIES: BULK SALE

This will be the same explained before for MS dry herb cultivation, but huge cultivated surfaces are only available for large agricultural cooperatives, which have a high investment in processing machineries and commercialisation. Producers use to have around 15 ha each and must do the drying by themselves.

***Figure 90**. Origanum sp. field of a member of "Aromates de Provence" in France.*

There is not this size of business in Catalonia, but can be found in France:

- Aromates de Provence http://www.lesaromatesdeprovence.fr/
- L'Herbier du Diois http://www.herbier-du-diois.com

LS - Essential plants cultivation

FEW DIFFERENT SPECIES: BULK SALE

Large productions of essential oil species will allow to face wholesalers' essences demands which sometimes ask for minimum orders of 200 kg (a barrel). A large capacity distiller will be needed (more than 1000 l) sized according to the previewed production, and somehow a storage room with stable temperature.

Main advantages are that the essential oil, in low temperature conditions and with no light, can be stored during many years (up to 10) and this allows to face market prices fluctuations, and furthermore the distillation is an easier processing comparing to drying.

Inconveniences are due the high international competition and the market fluctuations, with some occasional low prices. It is also difficult to manage large surfaces with organic techniques, implying an important mechanisation.

An aspect to be considered with essential oils production is the Eureopean regulation on chemicals REACH, which also affects essential oil manufacturers and sellers (when quantities are higher than 1 ton/year).

***Figure 100**. Lavander field of "Pablo Grande" in Burgos, Spain.*

There is not this size of business in Catalonia, but can be found in other Spanish regions:

- Cooperativa de Peñafiel – COCOPE https://es-es.facebook.com/COCOPE-SCoop-240506182651298/
- Alcarria Flora http://www.alcaflora.com/
- Esencias Martínez Lozano http://www.esenciaslozano.com/
- Peñarrubia del Alto Guadiana http://www.guadianaecologico.com
- Pablo Grande http://www.anipam.es/menu/asociados/id42-francisco-pablo-grande-rojo.html
- Hoya de Juan Fernández http://www.anipam.es/menu/asociados/id58-hoya-de-juan-fernandez-s.-l.html
- José Manuel González de Lucas http://www.anipam.es/menu/asociados/id23-jose-manuel-gonzalez-de-lucas.html

It can be summarized like this:

***Table 2.** Different business models of medicinal and aromatic plants' production*

Field surface	Number of different species	Living plant	Fresh plant	Dry herb	Essential oil
Small surface	Few species	*Organic orchard: Plant protection* Field crop: *Beekeeping*		*Field crop: Bulk sale*	*Field crop: Retail sale*
	Many species	Nursery: *Retail sale* Garden: *Tourism*	Orchard: *Retail sale* Protected cultivation: *Retail sale*		
Medium surface	Few species			*Field crop: Bulk sale*	
	Many species			*Field crop: Retail sale*	
Large surface	Few species			*Field crop: Bulk sale*	*Field crop: Bulk sale*

6. Crop information sheets: main marketable species in Turkey.

Once seen the most marketable species and possible business models, specific requirements of the cultivation of the species, yields and production costs have to be considered. The balance of these factors will give us a first idea of which species are more profitable.

As general rule, a MAPs crop profitability depends on several factors:

- **Water availability** (rainfed/irrigation): with irrigation there is possibility of water costs and irrigation system investment, but better harvests are envisaged.
- **Cultivation techniques** (conventional/organic): conventional cultivation has pesticides and herbicides costs, and organic cultivation, labour force costs mainly from weeds control.
- **Machinery** (own/rented): if own, the purchasing cost should be amortized during several years; if rented, a periodic use price should be paid.
- **Investments** (private / communal): if expenses are shared with other partners will be more economic. Facilities investments should be amortized and credit quotes paid.
- **Crop surface:** as more surface, more maintenance costs, but machinery is better amortized.
- **Length of cultivation:** short cycle crops involve more planting costs.
- **Planting density:** as higher density, more seedling costs but more production yield per hectare.
- **Cost of seed or seedling:** sowing have lower cost than seedling production, but more losses risk.
- **Planting, maintenance, harvesting** (manual/mechanised): If production activities are done by hand have more labour force costs.
- **Number of cuts per year:** according to the species and the area of cultivation (temperate climate, water availability), it is possible to obtain more than one harvest per year, thus more production yield.
- **Plant material yield:** Raw material to be sold should be taken into account (e.g. dry leaf of thyme), not the fresh plant harvested in the field.
- **Processing:** drying (natural/forced), dry material processing (sieving, cutting, milling), distilling, etc. There are different systems in the market, as more automatized

more expensive, but save labour costs.

- **Packaging** (bulk/retail): To manufacture end-products to retail selling implies having packaging costs, but a more added value and higher sale prices.
- **Distribution** (own transport / client transport): Distance to the delivery point should be considered.
- **Demand and price:** a good profitability is obtained when costs are reduced, there is a high demand and paid prices are good.

Calculation of cost per hectare

FIRST YEAR COSTS (per ha)	
Field preparation costs	
Planting costs	**Sowing costs**
Seed cost Seedling cost Establishment cost	Seed cost Establishment cost
ALL THE YEARS COSTS (per ha)	
Irrigation costs	
Maintenance costs	
Weeding Fertilising Pesticides applications Ploughing	
Harvesting costs	
Processing costs	
Drying Dry material processing	Distilling
End-product manufacturing costs	
TOTAL ANNUAL COSTS (per ha) + Contingency + Updated price cost	

Calculation of profit per hectare

ANNUAL GROSS PROFIT (per ha)
Yield of commercial plant material x sale price
ANNUAL NET PROFIT without amortization (per ha)
Annual gross profit – Total annual costs
AVERAGE ANNUAL NET PROFIT without amortization of all the crop cycle (per ha)
SUM of annual net profits w.a. / NUMBER of years of crop cycle
AVERAGE ANNUAL NET PROFIT OF A FARM BUSINESS
(NUMBER of total hectares x Average annual net profit w.a.) – SUM of annual amortizations

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Figures

All photos belong to the Group of Aromatic and Medicinal Plants of the Forest Research Centre of Catalonia (CTFC) with the exception of:

Figure 11

http://www.escapado.fr/IMG/jpg/truffiere_et_lavande.jpg

Figures. 51, 52, 53, 54

http://www.futura-sciences.com/planete/dossiers/geographie-region-paca-decouverte-lavande-261/page/6/

Figure 59

http://3.bp.blogspot.com/-PdFlZSsjPTI/VTd1sT2u2_I/AAAAAAAAALY/bOedhxGcMGk/s1600/IMG_20150412_194957.jpg

Figure 60

http://i58.tinypic.com/2qwctib.jpg

Figure 80

http://www.fraganciesmontseny.es/sites/default/files/products/eau_toilette_wild_forest_secrets_8451.jpg

Figure 81

http://www.feixescalmargarit.com/es/img/cms/LAVANDA/Equipo%20Destilaci%C3%B3n%20Web.jpg

Figure 83

http://www.lupulina.com/wp-content/uploads/2016/01/IMG_20160815_095453_B-1-767x1024.jpg

Figure 88

http://www.bernauherbes.com/img/productes/condimentaries/foto-condimentaries.jpg

Figure 89

http://www.bernauherbes.com/img/productes/infusions/foto-infu.jpg

Figure 100

http://zetaestaticos.com/valladolid/img/noticias/0/067/67492_1.jpg

Please find hereafter technical cultivation sheets of a group of selected species whose cultivation could be interesting in Turkey:

a. **Local species**

i. *Origanum* sp. *(O. onites; O. minutiflorum).*
ii. *Salvia fruticosa.*
iii. *Sideritis* sp. *(S. stricra; S. congesta).*
iv. *Nigella sativa.*
v. *Thymbra spicata var. spicata L.*

b. **b.** **Other Mediterranean species**

vi. *Origanum* sp. *(O. vulgare; O. virens).*
vii. *Salvia officinalis.*
viii. *Lavandula* sp. *(L. latifolia; L. angustifolia; L. x hybrida).*
ix. *Mentha x piperita.*
x. *Rosmarinus officinalis.*

i. *Origanum* spp. (*O.onites; O.minutiflorum* [e])

LAMİACEAE

INTRODUCTION

DESCRIPTION OF THE SPECIES


Figure 1 i.1. *Origanum onites*


Figure i.2. *Origanum minutiflorum*[e]

- **Botanical description:**
    - ***Origanum onites* L.** (Tur. Bilyalı kekik, İzmir kekiği, Spa. Orégano turco, Eng. Turkish oregano): Perennial herb up to 65 cm, hirsute. Branches up to 10 pairs per stem, up to 13 cm. Leaves petiolate to subsessile (petiole to 6 mm), cordate, ovate or elliptic, 3-22x2-19 mm, ± acute or acuminate, remotely serrulate or entire, veins ± raised on lower surface. Spic-

ules in corymbiform inflorescence, c. 3-17x4 mm, erect. Bracts enclosing calyx marginally, herbaceous, greenish, hairy, obovate or elliptic, 2-5x1.5-4 mm obtuse to acuminate, entire or denticulate. Verticillasters 2-flowered; flowers hermaphrodite, very small. Calyx 1-lipped, flattened, bractlike, 2-3 mm. Corolla white, 3-7 mm, flattened. Stamens unequal, shortly exserted from corolla. Styles up to 10 mm long. Nutlets small, brownish, ovoid, Flowering period: April-August.

- ***Origanum minutiflorum* O. Schwarz et P.H. Davis** (Endemic)(Tur. Sütçüler kekiği, Spa. --, Eng. Sweet marjoram) Perenial herbs to 35 cm, hirtello-pubescent. Branches to 10 pairs per stem, 4 cm long. Leaves petiolate to subsessile (petiole to 6 mm), ovate or elliptic, 3-16x1-12 mm, ± acute. Spicules very small (c. 2-8x3 mm), erect. Bracts herbaceous, greyish, hairy, ovate or elliptic, 1-3x0.5-1.5 mm, ± obtuse. Verticillasters 2-flowered; flowers hermaphrodite, very small. Calyx c. 2 mm; upper and lower lips often with small lobes.

  Corollas white, 2.5-4 mm with 2-lipped. Stamens subequal, straight, ± included in corolla.

- **Used parts:** leaves and flowering tops. Turkish oregano is an important culinary herb, used for the flavour of its leaves, which can be more flavourful when dried than fresh. Turkish oregano essential oil is extracted from the leaves of the plant.

ORIGIN AND HABITAT

Figure i.3. *Natural distribution of Origanum onites; Antalya, Balikesir, Isparta, İzmir, Manisa, Muğla, Uşak, Turkey.*

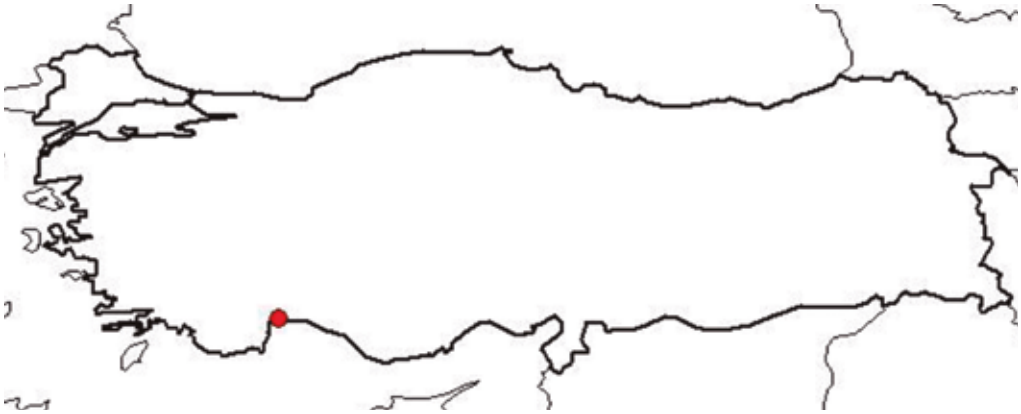

Figure i.4. Natural distribution of Origanum minutiflorum e;Antalya, Turkey

- **Origin and geographical description:**
    - ***Origanum onites* L.** Phytogeographic region: East Mediterranean element. Conservation status: Cultivating.
    - ***Origanum minutiflo*rum O. Schwarz ve P.H. Davis.** Phytogeographic region: Endemic. East Mediterranean element. Conservation status: Rare, vulnerable for collecting.
- **Habitat:**
    - ***Origanum onites* L.** Stony hills and rocky slopes, usually on limestone, sometimes in partial shade, s.l.-1500 m.
    - ***Origanum minutiflorum* O. Schwarz ve P.H. Davis.** Rocky limestone slopes, 900-1800 m.

USES AND MARKET

- **Uses:** Leaves as a spice and flavoring agent, the flowering tops are used in medicinal sector (antibiotic and antioxidant qualities and activity against cramps and in diabetes). It is used for manufacturing herbal medicines, liquors, perfumes, soaps, cosmetics.
- **Market:**
    - Medicinal sector: It has antifungal, antimicrobial, insecticidal and antioxidant activities Diversified effects such as antispasmodic, antibacterial and antifungal (have been attributed to this plant by modern pharmacological study. It is used against common cold, as spasmolytic and as an antirheumatic.
    - Food sector: It is also used in flavouring Turkish delight candy (and is also used in tea, salads and meat dishes. Dried leaves and flowering tips of this species are used in formulation of vermouths and bitters. It is also used in herbal vinegars and tea can be made

from its leaves.

- Other sectors: Consumption of *O. onites* distillate has beneficial effects on lipid profiles, antioxidant status and endothelial functions in patients with mild hyperlipidaemia. The essential oil is used for flavouring sauces, condiments and other products.

- Ornamental. It is a decorative plant in the port, shrub and flower, often cultivated in flower pots;

- Honey. These species are good honey plants.

TECHNICAL DATA ON CULTIVATION

Figure i.5 *Field of Origanum onites in Turkey.*

- **Commercial varieties:**

  - ***Origanum onites* L., Ceylan-2002** and **Tayşi- 2002**

  - ***Origanum minutiflorum e*, --**

- **Multiplication:**

  - Sexual: Oregano seeds can be planted indoors to produce transplants or direct seeded. When direct seeding, seeds should be sown in rows spaced 50–60 cm (19–24 in) apart with seedlings thinned to allow 20 cm between plants. Seeds will germinate in 4 days at a temperature of 21°C.

  - Asexual: cuttings are best taken in late Spring when plant growth is at a maximum. Sof-

twood cuttings taken from the new plant growth are quickest to root. Remove portions of stem 7.6–12.7 cm in length using a sharp knife. Cut the stem at a 45° angle. Plant the cuttings in a light potting medium such as peat moss and vermiculite and keep moist until rooted.

- **Length of cultivation:** from 5 to 6 years.

- **Crop conditions:** *Origanum onites L.* and *Origanum minutiflorum* O. Schwarz et P.H. Davis (Endemic) are related to the herb marjoram, sometimes being referred to as wild marjoram. Oregano has purple flowers and spade-shaped, olive-green leaves. It is a perennial, although it is grown as an annual in colder climates, as it often does not survive the winter. Oregano will grow in a pH range between 6.0 (mildly acidic) and 9.0 (strongly alkaline), with a preferred range between 6.0 and 8.0. It prefers a hot, relatively dry climate, but does well in other environments.

- **Cultivation establishment:** Oregano is planted in early spring, the plants being spaced 30 cm apart in fairly dry soil, with full sun.

- **Crop maintenance:**

    - Irrigation: During crop establishment in the first year irrigation is required, but in subsequent years, winter rain is usually sufficient to get a single cutting in summer. But to get a second cutting in autumn, irrigation is required after the first cut. Spring irrigation is only required if the winter rains are inadequate.

    - Fertilisation: A typical fertilization regime is to apply 100 kg/ha of P_2O_5 and 100 kg/ha of K_2O to oregano.

    - Pests and diseases: Insect, *Myzus persicae, Agrotis* spp., *Frankliniella occidentalis. Fungus, Puccinia menthae*, Arachnid, *Tetranychus urticae*.

- Harvest: Turkish oregano is best harvested just before flowering. The entire plant can be harvested by clipping the branches to leave only the lowest set of leaves. The leaves can be used fresh or they can be dried for longer storage. The clipped plant will begin to set out new growth within 2 weeks of harvest.

Figure i.6. *Harvest of Origanum onites with adapted motorized plough in Turkey.*

Figure i.7. *Harvest of Origanum onites with harvester in Turkey.*

PROCESSING

- **Drying:** There are several methods used to harvest oregano and dry it for preservation. It may be pull off the tiny leaves and dry them separately or dry the entire stem and then crumble off the crisp leaves. Bundle the stems together and hang them to dry oregano in a dark, dry spot. It may be also dry the stems on food dehydrator trays in single layer or for a low-tech solution, place them on trays for several days in a warm room. Turn the stems several times during the drying process to expose the leaves evenly to air and heat. Once the leaves are dry and the stems are stiff, you can remove the leaves for storage. The best way to do this is to pinch the stem at the bottom and pull up. The leaves will fall off easily.

- ***Figure i.8.*** *Drying of Origanum onites at field and open area in Turkey.*

- ***Figure i.9.*** *Dry leaves of Origanum onites.*

- **Distillation:** Currently, the most common methods used for the isolation of essential oils from natural products are steam distillation and solvent extraction. However, the loss of some volatile compounds, low extraction efficiency, degradation of unsaturated compounds through thermal or hydrolytic effects and toxic solvent residue in the extract may be encountered with these extraction methods. Superheated (or subcritical) water extraction (SWE) has been used as a technique for extraction from solid samples in a number of recent studies . The term 'superheated water' is used to denote the region of the condensed phase which occurs between 100°C and the critical point (374°C).

- **Dry herb conditioning:** After drying oregano and harvesting the leaves, you need to store them

in a dark, dry location to preserve the most flavor. Use paper sack or airtight plastic containers. Light and air will degrade the flavor of the herb. Dry oregano will last for up to six months with best flavor and quality.

YIELDS

Table i.1. Plant height (cm), branch number (number/plant), fresh, dry herb and essential oil yield (kg/ha) of Origanum onites and Origanum minutiflorum at field conditions.

Species	Plant height (cm)	Branch Number (number/ plant)	Fresh herb Yield (kg/ ha)	Dry Herb Yield (kg/ ha)	Essential Oil Yield (l/ ha)
Origanum onites	40.87	6.33	292.00	133.67	7.6
Origanum minutiflorum [e]	44.47	6.40	324.67	142.00	7.1

Table i.2. Essential oil rates (%) of Origanum onites and Origanum minutiflorum from wild and at field conditions.

Species	From wild essential oil rate (%)			At field conditions essential oil rate (%)		
	B.F.	F.	A.F.	B.F.	F.	A.F.
Origanum onites	1,6	4.2	2.7	2.2	5.7	1.6
Origanum minutiflorum	3.3	5.3	4.1	2.6	4.0	5.3

QUALITY

- **Main constituent:**
  - ***Origanum onites:*** Essential oil; thymol, carvacrol and cedrol.
  - ***Origanum minutiflorum*** [e]***:*** Essential oil; carvacrol.

Table i.3. *Essential oil components (%) of Origanum onites and Origanum minutiflorum grown in the field conditions and in the wild at flowering stage.*

Essential Oil Components	*Origanum onites* in the wild	*Origanum onites* İn the field conditions	*Origanum minutiflorum* in the wild	*Origanum minutiflorum* İn the field conditions
β-Pinen	0.10	-	0.40	0.50
α-Pinen	0.40	0.10	0.40	3.60
Camphor	0.20	-	0.02	0.02
Borneol	1.20	1.00	2.0	1.50
β-Myrcene	1.70	0.50	1.60	1.70
Thymol	9.40	-	1.10	1.60
Terpineol	1.70	1.50	0.30	0.20
Carvacrol	28.20	19.20	86.50	83.80
Linalool	31.80	70.40	0.03	0.02
Thujone	0.60	0.80	0.30	-
p-Cymene	-	-	2.7	0.01
Transcaryophyllene	0.10	2.00	0.10	-
α-Terpinen	0.10	-	0.60	-
γ-Terpinen	5.10	0.80	3.70	1.70
Citronelal	0.10	-	0.90	0.03
Cineole	2.80	1.40	-	-
Linalaly acetate	3.60	-	0.40	-
Geranaly acetate	0.10	-	0.03	0.10

- **Legislation:**
    - Manufacturing, Hygiene and Safety, Trade Number : 27676
    - PRINCIPLES AND IMPLEMENTATION OF ORGANIC FARMING-Protection of ecological balance, the implementation of organic agricultural activities, regulation of organic agricultural production and marketing, development, to determine the procedures and principles for dissemination. http://www.resmigazete.gov.tr/eskiler/2010/08/20100818-4.htm
    - Regulation on the Protection and Utilization of Plant Genetic Resources - to protect and improve the Turkey plant genetic resources, survey, collection, collected material storage, production, regeneration, characterization, evaluation, is designed to establish rules concerning the documentation and exchange. http://www.tarim.gov.tr/TAGEM/Belgeler/yayin/Bitki.pdf

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ii. *Salvia fruticosa* Mill.
LAMİACEAE

INTRODUCTION

DESCRIPTION OF THE SPECIES

Figure ii.1. *Salvia fruticosa Mill.*

- **Botanical description**
    - ***Salvia fruticosa Mill.*** (Tur. Elma çayı , Spa. salvia mayor, Eng. Greek sage,). Greek sage grows 0.61 m high and wide, with the flower stalks rising 0.30 m or more above the foliage. The entire plant is covered with hairs, with numerous leaves of various sizes growing in clusters, giving it a silvery and bushy appearance. The flowers are pinkish-lavender, about 1.3 cm long, growing in whorls along the inflorescence, and held in a small oxblood-red five-pointed hairy calyx.
- **Used parts:** leaves and flowering tops. They can be found as dry raw material, as essential oil or even as fresh or frozen herbs.

ORIGIN AND HABITAT

- **Origin and geographical description:** Native Flora of the greater Mediterranean Basin Region - of southern Europe, western Asia-Middle East and northern Africa. The flora of Turkey includes 88 species and 93 taxa of which 45 are endemic. Its wide variation in leaf shape, there has been a great deal of taxonomic confusion over the years, with many of the leaf variations of *Salvia fruticosa* being named as distinct species. These include *S. libanotica, S. triloba, S. lobryana*, and *S. cypria,* which are now considered to be *Salvia fruticosa*.

- **Habitat:** In its native environment it grows as part of the maquis shrubland and several other open plant communities, but populations composed entirely of *Salvia fruticosa* are not uncommon.

Figure ii.2. *Natural distribution of Salvia fruticosa; Antalya, Aydin, Balikesir, İzmir, Muğla, Tekirdağ, Turkey***.**

USES AND MARKET

- **Uses:** It has a long tradition of use in Greece, where it is valued for its beauty, medicinal value, and culinary use, along with its sweet nectar and pollen. *Salvia fruticosa* was depicted in a Minoan fresco circa 1400 BCE at Knossos on the island of Crete. The ancient Phoenicians and Greeks likely introduced the plant for cultivation to the Iberian peninsula, with remnant populations of these introduced plants still found in some coastal areas. Greek sage accounts for 50–95% of the dried sage sold in North America, and is grown commercially for its essential oil.It also has a long tradition of use in various Muslim rituals—for newborn children, at weddings, in funerals, and burnt as incense. A cross between *S. fruticosa* and *Salvia officinalis* developed in the middle east is called "silver leaf sage" or Salvia" Newe Ya'ar', and is used in cooking.

  In its native habitat, it frequently develops woolly galls about 1 inch in diameter which are called 'apples'. These 'apples' are peeled and eaten when they are soft, and are described as being fragrant, juicy, and tasty. The formation of galls was originally thought to be limited to *Salvia pomifera*, which led to the misidentification of many gall-bearing *Salvia fruticosa* plants. In 2001 it was discovered that the galls on *Salvia fruticosa* were caused by a previously undiscovered genus of Cynipid gall wasp.

- **Market:**

  - Medicinal sector: The leaves are antihydrotic, antiseptic, antispasmodic, astringent, carminative, cholagogue, depurative, expectorant, febrifuge, stimulant, tonic and vasodilator. They are used internally in the treatment of digestive and respiratory complaints, menstrual problems, infertility, nervous tension and depression. This remedy should not

be prescribed to pregnant women. The leaves can be harvested as required and used fresh, or they can be harvested before the flowers open and dried or distilled for their essential oil.

- Food sector: The leaves are used as a spice or as an adulterant of sage (*S. officinalis*). Somewhat inferior in quality to sage but it is easier to grow indoors. The leaves make up 50 - 95% of commercially dried sage leaves. A fragrant tea, called "fascomiglia" is made by infusing the leaves.

- Perfumery sector: An essential oil obtained from the leaves is used to adulterate spike lavender oil (obtained from *Lavandula latifolia*).

TECHNICAL DATA ON CULTIVATION

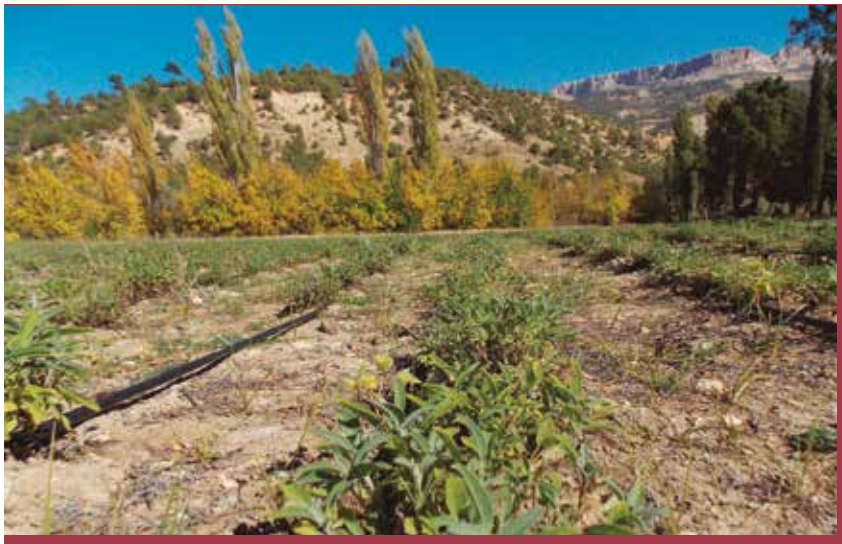

Figure ii.3. *Salvia fruticosa* **crop.**

- **Commercial varieties:** The fresh yields, the essential oil content, and the quality of a sage hybrid (*Salvia officinalis x Salvia fruticosa*, cv. Newe Ya'ar No. 4, Lamiaceae) as affected by development and harvest time were determined.

- **Multiplication:**

  - Sexual: the seeds have a high germination rate (more than 80%), thus they germinate easily. The most common method to obtain commercial seedling of Greek salvia is from seeds. Seed - sow March/April in a greenhouse. Germination usually takes place within 2 weeks. Prick out the seedlings into individual pots when they are large enough to handle and plant them out in early summer. In areas where the plant is towards the limits of its hardiness, it is best to grow the plants on in a greenhouse for their first winter and plant them out in late spring of the following year.

- Asexual: it can also be propagated by division of plants from old plantations. This is done in spring o autumn. This method is not used to the high cost of labour. Cuttings of half-ripe wood succeed at almost any time in the growing season.

- **Length of cultivation:** from 3 to 5 years.

- **Crop conditions: I**t is also grown as an ornamental flowering shrub, preferring full sun, well-draining soil, and good air circulation. Hardy to 20 degrees F., it is very drought resistant.

- **Cultivation establishment:** The main aim of land preparation in transplanted crops is weed control. Soil surface is not necessary to be finely ground. Accordingly, one or two ploughings at a depth of 20 to 25 cm followed by one harrowing are usually enough. In the case of drilled crops, however, more than one surface cultivations (harrowing/rotavating) are necessary in order to make the seedbed fine and friable. Planting is carried out in autumn (October-November) or early spring (end of February-March). Autumn planting is more preferable, since a better plant establishment is promoted, except in areas with very cold winters. The choice of the most appropriate plant spacing strongly depends on local conditions (soil fertility, climatic conditions, weeds) and varies from 50 to 60x25 to 40 cm. Denser crops (35x15 cm) have also been successful (*Putievski et al., 1986a*). On the other hand, wider spacings have been reported (100 cm-apart rows) for seed propagating crops (*Macchia et al., 1988*). Denser stands reduce the numbers of primary and secondary stems as well as plant dry matter production.

- **Crop maintenance:**

  - Irrigation: It is recommended that sage crops can be irrigated in spring to induce a rapid plant growth. Spring irrigation could also be used for incorporating surface fertilizers. A second irrigation after the first cutting considerably helps regrowth and makes possible a second cut in autumn (*Marzi, 1987*). More than two irrigations are usually not necessary, although irrigations at weekly intervals from spring to autumn have also been reported (*Putievsky et al, 1986*).

  - Fertilisation: In practice, fertilizers have to be applied before planting (basic application) to help a quick and efficient crop establishment as well as during growth (surface application) in order to meet the seasonal crop demands. The recommended rates for the basic application depend on the levels of the available macronutrients in soil: 40 to 100 kg N (as ammonium sulfate), 30 to 80 kg P_2O_5, and 30 to 100 kg K_2O per hectare. Fertilizers are mechanically incorporated into the soil. Surface application must be carried out in early spring, 10-15 days before flowering when the maximum uptake rates are observed. Nitrogenous fertilizers are used (usually ammonium nitrate) at rates of 40 to 80 kg N/ha. Incorporation can be done either mechanically between the rows or by means of a light irrigation.

  - Weed control: it is possible to use herbicides effectively, especially in the first year of

plant establishment, depending on the local weed flora. In view of the relatively narrow range of the affected weeds, a combination of chemical with mechanical weed control is recommended in most cases in order to avoid weed competition.

- **Harvest:** The timing of harvest strongly depends on the expected quantity and quality of the product. Fresh matter yield is highest in spring while dry matter yield is highest in summer (*Putievski et al., 1986b)*. Essential oil concentration is lowest in spring (0.72.2%), highest in early autumn (2.0-3.4%), and intermediate in winter (1.7-2.5%) (*Putievski et al., 1986a*).

PROCESSING

- **Drying:** The harvested biomass is air-dried under shade. Exposure to direct sunlight has to be avoided in order to prevent evaporation of the volatile compounds of the essential oil. Artificial drying of the essential oil can also be applied at 40 °C for 48 h. Whole plants or plant parts can be used for infusions. Leaves can be mechanically separated from the stems using special equipment, if required, bearing in mind that leaf oil is richer in 1, 8-cineole and myrcene and poorer in a-pinene and camphor than that of stems and inflorescences (Putievski et al., 1986b).

- **Dry herb conditioning;** to separate the leaves and the bracts from the stems, a vibrating machine is used. The final product is a mix of leaves, flowers and bracts, representing the 30-40% of the dry plant. Storage of the dried plant material in darkness for about two years was found to reduce essential oil concentration by 15 to 25% (Paillard, 1994b). Low temperatures during storage (-2 and -18°C) do not offer any advantage in comparison with normal temperatures (20 °C) (ibid.).

Figure ii.4. *Dry leaves of Salvia fruticosa.*

- **Distillation**: In the case of extraction for essential oil, fresh/dry material (flowering stems) has to be used.

YIELDS

Herbage yields vary from 3 to 12 t/ha of dry matter, depending on crop density, soil fertility and water availability (*Putievski et al., 1986a & b; Aiello & Clementell, 1987; Bezzi, 1987*). Yields from the first year crop are significantly lower (less than half in some cases: *Karamanos, 1995*) than those from the second year onwards. Leaves are the main yield components (more than 50% in total DW) followed by stems, and flowers (34 and 14% respectively; ibid.). Essential oil yields also vary between 110 and 200 kg/ha. Increased leafiness brings about higher oil yields, in view of the highest oil concentration observed in leaves.

Table ii.1. *Plant height (cm), branch number (number/plant), green, dry herbage and essential oil yield (kg/ha) of Salvia fruticosa at field conditions.*

Species	Plant height (cm)	Branch Number (number/ plant)	Fresh herb Yield (kg/ ha)	Dry Herb Yield (kg/ ha)	Essential Oil Yield (l/ha)
Salvia fruticosa	72.4	9.3	3046.7	1163.3	31.0

Table.ii.2. *Essential oil rates (%) of Salvia fruticosa from wild and at field conditions.*

Species	From wild essential oil rate (%)			At field conditions essential oil rate (%)		
	B.F.	F.	A.F.	B.F.	F.	A.F.
Salvia fruticosa	0.7	1.2	0.9	0.8	2.7	0.8

QUALITY

- **Main constituents:** The leaves have a high oil content, with some of the same chemicals as lavender.
    - Essential oil. 1,8-cineole,α-Pinene, Camphor.
    - Diterpenoids. Carnosol, carnosic acid, carnosic acid 12-methyl ether, rosmadial, isorosmanol, ferruginol, and manool.
    - Triterpenoids. α-amyryltetracosanoate, oleanolic acid, ursolic acid, and erythrodiol
    - a steroid (3-acetylsitosterol).
    - Flavone. Salvigenin.
    - Fatty acids: oleic acid, palmitoleic acid and stearic acid.

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Tablo ii.3. Essential oil components (%) of Salvia fruticosa grown in the field conditions and in the wild at flowering stage.

Essential Oil Components	*Salvia fruticosa* in the wild	*Salvia fruticosa* İn the field conditions
β-Pinen	0.20	25.6
α-Pinen	2.10	6.1
Camphor	0.20	2.6
Borneol	1.20	2.8
β-Myrcene	4.10	7.5
Thymol	0.90	0.1
Terpineol	-	0.4
Carvacrol	43.20	1.9
Linalool	0.10	0.8
Thujone	0.90	1.9
o-Cymene	-	0.1
Transcaryophyllene	0.05	3.7
α-Terpinen	0.90	12.6
γ-Terpinen	11.30	2.1
Citronelal	0.10	0.1
Cineole	14.40	1.1
Linalaly acetate	-	3.4
Geranaly acetate	0.10	3.7

- **Legislation:**
    - Manufacturing, Hygiene and Safety, Trade Number : 27676.
    - Principles and Implementation of Organic Farming-Protection of ecological balance, the implementation of organic agricultural activities, regulation of organic agricultural production and marketing, development, to determine the procedures and principles for dissemination. http://www.resmigazete.gov.tr/eskiler/2010/08/20100818-4.htm
    - Regulation on the Protection and Utilization of Plant Genetic Resources - to protect and improve the Turkey plant genetic resources, survey, collection, collected material storage, production, regeneration, characterization, evaluation, is designed to establish rules concerning the documentation and exchange. http://www.tarim.gov.tr/TAGEM/Belgeler/yayin/Bitki.pdf

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iii. *Sideritis* spp.
(*Sideritis congesta*[e]-*Sideritis stricta*[e])
LAMİACEAE

INTRODUCTION

DESCRIPTION OF THE SPECIES

Figure e iii.1. *Sideritis congesta*[e]

Figure iii.2. *Sideritis stricta*[e]

- **Botanical description**: ***Sideritis spp.*** (Tur. Dağ çayı. Spa. Rabo de gato. Eng. Mountain Tea).

  Sideritis congesta **Boiss. Et Heldr. Apud Bentham** (Endemic). Perennial, herbaceous, woody at base. Stem erect, 20-75 cm, simple or rarely branched, with dense flattened

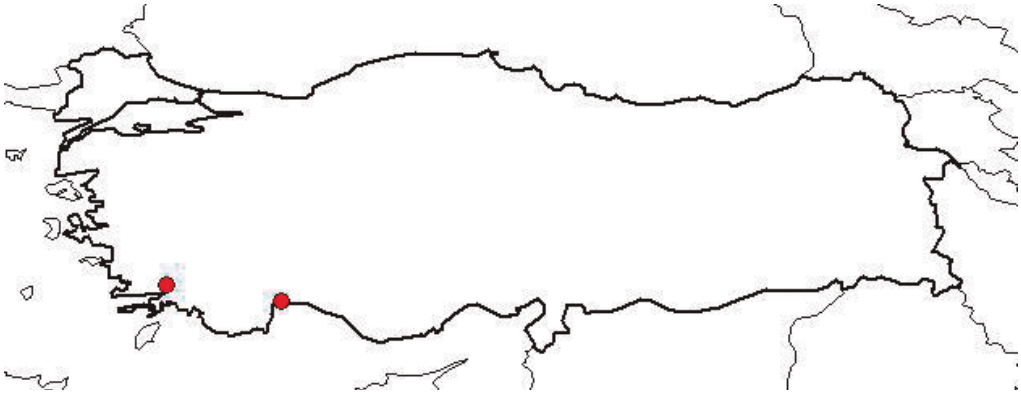
white tomentose pile at the bottom, sparse at the top. All leaves are oblong, oblong-lanceolate, both sides are dense hairy, distinctive vein, 1.5-5x0.5-2-1.5 cm, no stalks, attenuate, Superficial pronounced subamplexicaul, crenate-denticulate, serrate thread, acute or mucronate. Interds are spaced 2-6 cm apart. Flowering, 5-20 cm, simple or 2-3 branches. Verticillas are density, 1-4 cm apart at the bottom, 5-12, 6 flowers. Bracts are entire ovate-orbicular, 1-2 x 1-2 cm (including 2-7 mm acuminate), lower bracings serrulate-serrate gear, tops generally flat, contracted, long pile, dense short glandular pile. Calyx 8-11 mm, long hairy and dense glandular hair, teeth linear-lanseolate, 3,5-5 mm. Corolla yellow, 12-18 mm, calyx passes, inside and outside hairy, sparsely glandular hairy, lips 2-4 mm with distinctive brown stripe. Hazelnuts 1-2 mm, triangular brown, hairless, slightly rugose, rounded. Flowering period: May-Agust.

- ***Sideritis stricta* P. H. Davis Et Hub.-Mor**. (Endemic); Perennial, herbaceous, woody at base. Stem erect, 55-90(-110) cm, simple,yellowish green, rarely branched, densely long adpressed white eglandular below, ±dense spreading eglandular and short glandular above. Leaves long adpressed white eglandular hairy above, sparsely short glandular and eglandular hairy along nerves below, reticulate; Inflorescence simple or branched. Verticillasters 8-20, 6-flowered, 1 -3 cm distant below, forming a dense spike above. Bracts entire, distinctly ciliate, outer sparsely adpressed white eglandular and short glandular, inner glabrescent, sparsely glandular, reticulate; Calyx 9-11mm; tube 6-7 mm, Corolla yellow, 12-15 mm; longer than calyx.

- **Used parts:** dried aerial parts, essential oil.

ORIGIN AND HABITAT

Figure iii.3. *Natural distribution of Sideritis congesta e; Antalya, İçel, Turkey*



Şekil iii.4. *Natural distribution of Sideritis stricta e; Antalya, Muğla, Turkey*

- **Origin and geographical description:** *Sideritis* genus is a genus of flowering plants well known for their use as herbal medicine, commonly as an herbal tea. They are abundant in Mediterranean regions, the Balkans, the Iberian Peninsula and Macaronesia, but can also be found in Central Europe and temperate Asia. *Sideritis congesta* e and *Sideritis stricta* e includes approximately 150 species of annual and perennial plants distributed mainly in the Mediterranean region, 44 species (55 taxa),39 taxa being endemic (78.2%), are native in the flora of Turkey.

- **Habitat**: Open *Pinus brutia* forest, calcareous rocks, limestone slopes, 600-1400 m. Sideritis species grow optimally in full sun and are well suited to drought conditions. They are found on rocky slopes and pastures, from a few meters above the sea level to more than 3000 m, and require moderately nutrient-rich soils and slightly alkaline.

    - ***Sideritis congesta*** **Boiss. Et Heldr. Apud Bentham**: growing on the open *Pinus brutia* forest and oak scrub of Antalya, at altitudes up to 1000 m.

USES AND MARKET

- **Uses:** Used for medicinal, aromatic and ornamental purposes. They have been traditionally consumed as herbal tea, furthermore, essential oils obtained from *Sideritis* species have been used for tonic, carminative, antispasmodic, diuretic, antiinflamatory, analgesicr.

- **Market:**

    - Medicinal sector: For centuries, Turkish people were used it as a medicinal plant for the treatment of daily diseases. Also it was used as soothing the nervous system, antiflamate the antispazmatik, carminative, analgezik, sedatives, cough, stomach pain prevention, anticonvulsant and digestive complaints in folk medicine. According to some research in recent years, extracts that obtained from *Sideritis* species have effect as antistress, antiulcer, analgesic, antioxidant, antibacterial, anti-inflammatory and insecticidal effects.

- Food sector: *Sideritis* spp. is used as a herb either for the preparation of herbal teas, or for its aromatic properties in local cuisines. The herbal tea is commonly prepared by decoction, by boiling the stems, leaves and flowers in a pot of water, then often serving with honey and lemon.

TECHNICAL DATA ON CULTIVATION

Figure iii.5. *Field of Sideritis stricta e in Turkey*

- **Commercial varieties:** --

- **Multiplication:**

  - Sexual: Sideritis seed use a freely draining seed mix placed in plastic containers or punnets. Acacia seeds need to be treated before sowing to enable moisture to penetrate the normally hard seed coat. One method is to place seeds in a container, cover with near boiling water and soak overnight. Seeds which swell are ready for sowing, the remainder may be re-treated. Another method is to scarify the seed. This is done by rubbing the seeds between two pieces of sandpaper thus thinning the seed coat to allow water to penetrate. If few seeds are to be sown it is possible (but normally difficult on account of the very hard seed coat) to nick the top of the seed away from the seed stalk with a sharp blade or needle without damaging the soft part of the seed. Seeds should be sown about 5 mm apart in prepared soil mix, lightly covered with mix to the depth of the seed or a little more, lightly pressed flat, watered and the containers placed in a semi-shaded site and kept above ground level or placed in a propagation unit. Soil should be kept moist but not wet. Germination can occur between a few days and a few weeks. Remember to label all pots with plant names and date of planting.

  - Asexual: Specially, from those with smaller phyllodes (leaf like structures). It is usually recommended that cuttings be taken from half hardened wood and be about 5-15 cm long. Material taken from lateral growth and stem material hardening after flowering

can be used for cuttings. The cutting should be cut below a node with sharp secateurs and the lower two thirds of the 'leaves' removed without tearing the bark. Reduce any large 'leaves' to about half their size or less to reduce water loss and stress. Remove any flowers or buds. Dip the base of the cutting in a rooting hormone, either liquid or powder and place cutting in plastic containers filled with cutting mix which has been lightly flattened. Make a hole with stick or pencil to take each cutting. Firm, water the pots before placing them under plastic, in a propagator or glass or 'poly' house. To strike cuttings of bipinnate (fern-like) foliaged Acacias is more difficult as the tiny leaflets tend to hold water and fall very quickly, thus spoiling the cutting. More experiments and trials need to be undertaken with this type of cutting to be consistently successful.

- **Length of cultivation:** from 3 to 5 years.

- **Crop conditions:**

- **Cultivation establishment:** The main aim of land preparation in transplanted crops is weed control. Soil surface is not necessary to be finely ground. Accordingly, one or two ploughings at a depth of 20 to 25 cm followed by one harrowing are usually enough. In the case of drilled crops, however, more than one surface cultivations (harrowing/rotavating) are necessary in order to make the seedbed fine and friable. Planting is carried out in autumn (October-November) or early spring (end of February-March). Autumn planting is more preferable, since a better plant establishment is promoted, except in areas with very cold winters. The choice of the most appropriate plant spacing strongly depends on local conditions (soil fertility, climatic conditions, weeds) and varies from 50 to 60x25 to 40 cm. Denser crops (35x15 cm) have also been successful. On the other hand, wider spacings have been reported (100 cm-apart rows) for seed propagating crops. Denser stands reduce the numbers of primary and secondary stems as well as plant dry matter production. The seedlings, which were ready to plant at june, were planted and irrigated regularly. Plant density was 60x40 cm.

- **Crop maintenance:**

    - Irrigation: Yield crop is increasing for any specie under irrigated condition, although it should be taken into account that *Sideritis* don't tolerate excess of moisture in soil or damp condition. It may be difficult to cultivate without irrigation. The most recommended is localized irrigation by dripper, sprayer or micro-sprinkler because a small discharge of water is applied for each plant. However, it is the most demanding in management. Irrigation; 15.000 -35.000 pl /ha.

    - Fertilisation: MAPs are not very nutrients and demanding but it is very important to carry out a fertilizing program. A peak in production plant has been illustrated after winter fertilization. Fertilization is very helpful after plant coppicing, because plant springs stronger and healthier. Phosphorus 80-90 kg /ha recommended as superphosphate, nitrogen 50-70 kg / ha, hard soluble nitrogen fertilizer, potassium 40–60 kg/ha, manure 40-50 t/ha, well fermented.

    - Weed control: Weeds can be removed mechanically in row cultivation by using rod weeder, disking whereas weeds should be removed by hand pulling, hoeing within the

row, especially if it is organic agriculture. If it is conventional agriculture it can be applied some authorized standard herbicides, carrying out the stipulated dose and frequency. During the first year of cultivation and until rows are not closed, weed control is necessary. During the second year of cultivation, weeds control may reduce until third part. It is used straw cover or bark for reducing weeds control. *Mulching* is successfully applied for the creation and cultivation of perennial plantations of slowly sprouting medicinal plants because it delays the development of the weed until the culture sprouts.In little farming explotation, it may be interesting:

- *Plastic blankets:* is made up of black polyethylene, polyester they are very similar to garden weed Guard Ground. They are used between the rows or covering all the field. They are used to be combined with a trickle irrigation (13- 16 mm diameter line or integral dripperline) especially recommended in dry areas.

- *Organic blankets:* is made up of biodegradable material, which are common nearby our field; for example coarse straw, leaves, pine bark, distillation-processed plant drugs. They provide carbon to the soil. An example is also the green manure.

- *Inorganic blanket:* it gets to used materials like sand for example is a method very common in Almeria.

- Pests: Yellow vein mosaic virus *Pythium* spp., *Phytophthora* spp., *Fusarium* spp., *Rhizoctonia solani, Alternaria, Colletotrichum gloeosporioides, Erysiphe cichoracearum* infestation was observed in *Sideritis stricta*.

- **Harvest:** The shrub can be harvested once in the second year of vegetation and generally twice in the following productive years. The plant should be harvested at the start of flowering in sunny weather. The cut plants should be transported at once to dry.

PROCESSING

- **Post-harvest:** It is kept cleaning the plants from left weeds, always following the traditional drying methods. Local tradition requires to get the mountain tea dry keeping it into dark and worm environment for about 5 to 10 days. Immediately after the previously described procedure, the gathered dried tea is packed in uncut bundles of 35 cm. Packages with broken bundles are easier to be used in some occasions.

- **Drying:** Drying should be done in shady, airy places. Artificial dryers, which dry the plant at 40-50°C, results in better quality drug. The drying ratio is 2.5%.

Figure iii.6.Dry Sideritis stricta e.

- **Dry herb conditioning:** The final product is flowers with buds, representing the 10% of the dry plant.
- **Distillation:** In the case of extraction for essential oil, dry material (flowering stems) has to be used.

YIELDS

Table iii.1. *Plant height (cm), branch number (number/plant), fresh and dry herb, Fresh flower, and dry Flower (kg/ha) of Sideritis congesta e and Sideritis stricta e at field conditions.*

Species	Plant height (cm)	Branch Number (number/ plant)	Fresh herb yield (kg/da)	Dry herb yield (kg/da)	Fresh flower Yield (kg/da)	Dry Flower Yield (kg/da)
Sideritis congesta [e]	18.7	8.0b	355.0	210.0	143.5	78.0
Sideritis stricta [e]	95.0	10.0	782.0	347.0	298.0	124.0

Table iii.2. *Essential oil rates (%) of Sideritis species from wild and at field conditions.*

Species	From wild essential oil rate (%)			At field conditaions essential oil rate (%)		
	B.F.	F.	A.F.	B.F.	F.	A.F.
Sideritis congesta [e]	1.00	0.30	0.55	1.19	0.46	1.34
Sideritis stricta [e]	0.10	0.16	0.05	**1.21**	0.30	**1.71**

QUALITY

- **Main constituents:** *Sideritis* genus such as terpenes, flavonoids, essential oil, iridoids, coumarins, lignanes, and sterols. Diterpenes, flavonoids and essential oil occur in almost every species; in fact they are the main responsible for the pharmacological activity. The main essential oil constituent are:
    - monoterpene hydrocarbon
    - oxygenated monoterpene
    - sesquiterpene hydrocarbon
    - oxygenated sesquiterpene
    - diterpene
    - monoterpene hydrocarbons
    - α-pinene, β-pinene, β -phellandrene, sabinene, myrcene

Table iii.3*. Essential oil components (%) of Sideritis congesta e and Sideritis stricta e grown in the field conditions and in the wild at flowering stage.*

Essential Oil Components	*Sideritis congesta* in the wild	*Sideritis congesta* in the field conditions	*Sideritis stricta* in the wild	*Sideritis stricta* in the field conditions
alpha-pinene	20,72	14,63	2,58	9,52
beta-pinene	29,11	21,48	0,26	27,33
myrtenol	-	1,58	17,61	-
limonene	1,53	1,33	-	1,88
beta-caryophyllene	0,85	1,14	9,04	0,26
cis-Muurol-5-en-4-alpha-ol	8,86	26,46	-	16,52
cis-Muurol-5-en-4-beta-ol	3,54	-	-	0,33
caryophyllene oxide	-	-	13,01	0,51
delta-cadinene	5,20	0,11	0,91	1,75
manool oxide	-	3,13	2,89	-
nuciferolacetate	0,36	0,36	-	0,35
germacrene D	2,59	-	4,39	-

- **Legislation:**
    - Manufacturing, Hygiene and Safety, Trade Number : 27676
    - PRINCIPLES AND IMPLEMENTATION OF ORGANIC FARMING-Protection of ecological balance, the implementation of organic agricultural activities, regulation of organic agricultural production and marketing, development, to determine the procedures and principles for dissemination. http://www.resmigazete.gov.tr/eskiler/2010/08/20100818-4.htm
    - Regulation on the Protection and Utilization of Plant Genetic Resources - to protect and improve the Turkey plant genetic resources, survey, collection, collected material storage, production, regeneration, characterization, evaluation, is designed to establish rules concerning the documentation and exchange. http://www.tarim.gov.tr/TAGEM/Belgeler/yayin/Bitki.pdf

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- http://medplanet.dbioro.eu/doc/Courses_EN.pdf

- http://ocw.upm.es/ingenieria-agroforestal/industrial-utilization-of-medicinal-and-aromatic-plants/contenidos/temario/Unit-2/topic_3_cultivation_of_MAPs.pdf
- http://www.orgchm.bas.bg/~seephyto/downloads/2012_May_meeting/Sofia_2012_S_Kulevanova.pdf
- http://www.tubives.com/index.php?sayfa=1&tax_id=7663
- http://www.tubives.com/index.php?sayfa=1&tax_id=7663

iv. *Nigella sativa* L.

RANUNCULACEAE

INTRODUCTION

DESCRIPTION OF THE SPECIES

Figure iv.1. Nigella sativa L.

- **Botanical description**:
    - ***Nigella sativa* L.** (Tur. Çörek Out. Spa. Neguilla. Eng. Black-cumin). Annual flowering plant in the family Ranunculaceae, native to south and southwest Asia. Nigella sativa grows to 20–30 cm tall, with finely divided, 2-5 cm in length , linearly lanceolate segments leaves. They are pinnately arranged The flowers are delicate, and usually colored pale blue and white, with 5 to 10 petals. The black caraway fruit is a large and inflated capsule composed of three to seven united follicles, each containing numerous seeds. It is in flower in July, and the seeds ripen in September. The flowers are hermaphrodite (have both male and female organs) and are pollinated by Bees.
- **Used parts**: Seed, oil.

ORIGIN AND HABITAT

- **Origin and geographical description:** *Nigella sativa* L. is native to southern Europe, northern Africa, and southern Asia. It is widely grown for its flavorful seeds and leaves, used as a culinary spice in Asian and Middle Eastern cuisines.

- **Habitat**: *Nigella sativa* is an annual growing to 0.4 m by 0.2 m. It is not frost tender.

Şekil iv.2. *NNatural distribution of Nigella sativa L.; Gaziantep, İstanbul, Iğdir, Siirt, Amasya, İçel, Kocaeli, Kahramanmaraş, Turkey.*

USES AND MARKET

- **Uses:** Seed - raw or cooked. Normally used as a flavouring on bread, cakes, curries, pickles, etc. There is a belief that eating the seed will make a woman's breasts plumper. The seed is a very popular spice from in the Mediterranean. It has a pungent flavour according to one report whilst another says that it has a spicy fruity taste and a third that the scent is somewhat like nutmeg. The immature seed is bitter, but when fully ripe it is aromatic. It is also used as a pepper substitute. The aromatic seed contains about 1.5% essential oil. It is placed amongst clothes to repel moths. The seeds can also be put in muslin bags and hung near a fire when they will fill the room with their delicious scent. They need to be changed about every three weeks. Its oil is used as parasiticide and repellent. The seed contains 35% of a fatty oil.

- **Market:**

    - Medicinal sector: *N. sativa* has a long history of use as medicine. Modern clinical trials have begun to investigate its efficacy, mainly using the seed oil extract, volatile oil, and isolated constituent thymoquinone. The most trials, and those of the best quality to date, provide preliminary support for its use in asthma (for both prevention and treatment of acute attacks), allergic rhinitis, and atopic dermatitis. Smaller and less rigorous studies suggest it might help people with functional dyspepsia, respiratory problems due to mustard gas poisoning, seizure disorders, diabetes mellitus and the metabolic syndrome, and opioid addiction. One meta-analysis of clinical trials concluded that N. sativa has a short-term benefit on lowering systolic and diastolic blood pressure, and another found that various extracts of black seed can reduce triglyercides, LDL and total cholesterol

while raising HDL cholesterol

- Food sector: The seeds of *Nigella sativa* are used as a spice in Indian and Middle Eastern cuisines. The black seeds taste like a combination of onions, black pepper and oregano. They have a pungent bitter taste and smell. The dry-roasted nigella seeds flavor curries, vegetables and pulses. It can be used as a "pepper" in recipes with pod fruit, vegetables, salads and poultry. In some cultures, the black seeds are used to flavor bread products.

- Cosmetic sector: uses in perfumery sector.

TECHNICAL DATA ON CULTIVATION

Figure iv.3. Field of Nigella sativa.

- **Commercial varieties:** populations.

- **Multiplication:** The rows should be 30 cm apart and the ground must be saturated deep with water. After about two weeks you should see the seeds germinate. If you want to grow them inside in peat pots do this prior to the autumn or spring and transplant them outside in your garden area 25 cm apart. Inside peat pots take around 7 weeks to germinate and grow big enough to transplant.

- **Length of cultivation:** half of year, half hardy annual (hardy annual).

- **Crop conditions:** Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and prefers well-drained soil. Suitable pH: acid, neutral and basic (alkaline) soils (pH 6 to 7). It cannot grow in the shade, full sunlight. It prefers dry or moist soil. Regular watering during prolonged dry periods, Cultivated Beds.

- **Cultivation establishment:** *Nigella sativa* is most suitable to come after anchor plants. The

soil must be well prepared before sowing and should be planted as early as possible in the spring. It is recommended to use 20 cm seedlings and 1.5-2 kg seed in the field**.**

- **Crop maintenance:**
    - Irrigation: the increase in yield with water use in black cumin production is limited. Finally, the results of the research showed that black cumin is tolerant to water deficit.
    - Fertilisation: *Nigella sativa* is sensitive to farmyard ferret. Good burnt animal must be used. Chemical fertilizers should fertilize in moderate doses (5kg/da N, 4 kg/da P_2O_5, 3 kg/da K_2O) as they increase fertility.
    - Weed control: Anchor must be made to fight with weed in the *Nigella sativa* field.
    - Diseases: Diseases of the black stain and powdery mildew are observed.
- **Harvest:** When fruit skin starts blackening, black cumin is harvested. Do not be late in harvesting since the grain is poured, also harvest must be done early in the morning. Harvesting can be done with sickle. It can also be done with mower or harvester. After the form, the bundles are dried up by stacking them vertically. After drying, the blend is done. The seeds must be dried again after the harvest.

PROCESSING

- **Drying:** Drying characteristics of Black cumin seeds (BCs) (*Nigella sativa*) with initial moisture content 58.14% was investigated in microwave assisted drying system. When using Nigella seeds for cooking the seeds can be harvested by placing the pods in a paper bag; allow to dry out completely, then rub the paper bag in your hands to release the black cumin seeds. Next cut the corner of the bag and retrieve the seeds with use of a sieve. This is the start of the preservation process, which for most spice crops requires drying that will enable the long-term crop storage and the opportunity for further processing. There are four main types of drying. The most basic method of drying is to spread the crop on a surface exposed to the sun. An improved method, speeding up the drying, is to use a fuel source (wood, oil/diesel, gas or electricity) to heat the drying room.
- **Dry herb conditioning:** Ensure that the black cumin seeds are completely dry then store in an airtight container.
- **Extraction:** *Nigella sativa* seeds are exposed to the extraction process to obtain the fat oil. The temperature for the extraction process is maintained at 100 oC and 1 bar for the pressure.

Figure iv.4. Dry capsule and seeds of Nigella sativa.

YIELDS

Table v.1. *Plant height (cm), branch number (number/plant), green, Seed yields (kg ha) and 1000 seed weight (g) of Nigella sativa L.at field conditions.*

Species	Plant height (cm)	Branch Number (number/ plant)	Number of capsule (capsule/ plant)	Seed yields (kg /ha)	1000 seed weight (g)
***Nigella sativa* L.**	31.40	4.5	5.00	57.6	2.51

Table iv.2. *Essential oil rates (%) and fixed oil rate (%) of Nigella sativa L. at field conditions.*

Species	Essential oil rate (%)	Fixed oil rate (%)
***Nigella sativa* L.**	**0.23**	**28.4**

Table iv.3. *Solvent-extracted oil-yields (%) of Nigella sativa L. seeds in Turkey.*

Species	Oil-yields (%)	Fixed oil rate (%)
***Nigella sativa* L.**	**29.4–29.7**	**32**
Reference	**Üstun et al. (1990)**	**Nergiz and Ötles (1993)**

QUALITY

- **Main constituents:**

  Nigella sativa oil contains mainly;

  - conjugated linoleic acid
  - thymoquinone
  - nigellone (dithymoquinone)
  - melanthin, nigilline
  - trans-anethole
  - Chemical constituents essential oils with: Carvone, d-limonene, cyamine, nigellone,

Table iv.4. *Fatty acid and sterol composition of Nigella sativa L. seeds (as percentages).*

Fatty acids (%)	
Myristic	1.2
Palmitic	11.4
Stearic	2.9
Oleic	21.9
Linoleic	60.8
Arachidic	trace
Eicosadienoic	1.7
Sterols	
Campesterol	11.9
Stigmasterol	18.6
β-Sitosterol	69.4

Table iv.5. Proximate and mineral composition of N. sativa L. seeds.

Proximate composition (%)	
Moisture	**6.4**
Fat	**32.0**
Ash	**4.0**
Crude protein	**20.2**
Crude fibre	**6.6**
Carbohydrate	**37.4**
Minerals (mg per 100 g)	
Calcium	**188**
Iron	**57.5**
Sodium	**85.3**
Potassium	**1 180**

- **Legislation :**
    - Manufacturing, Hygiene and Safety, Trade Number : 27676.

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- https://en.wikipedia.org/wiki/Nigella_sativa
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v. *Thymbra spicata* L. var. *spicata* L.

LAMİACEAE

INTRODUCTION

DESCRIPTION OF THE SPECIES

Figure v.1. *Thymbra spicata L. var. spicata L.*

- ***Thymbra spicata* L. var. *spicata* L.** (Tür. Zahter, Spa.--, İng. Black thyme) : is a genus of plants in the family Lamiaceae. *Thymbra spicata* L. var. spicata L is an evergreen shrub growing to 0.5 m. It is in leaf 12-Jan. The flowers are hermaphrodite (have both male and female organs) and are pollinated by Insects. It is noted for attracting wildlife. The plants are known with purple white flowers, 6-7 month.

- **Used parts**: fresh-dry aerial parts, buds and leaves, essential oil.

ORIGIN AND HABITAT

- **Origin and geographical description:** *Thymbra spicata* L. var. *spicata* L. is native to the Mediterranean region of southern Europe, North Africa, and the Middle East.

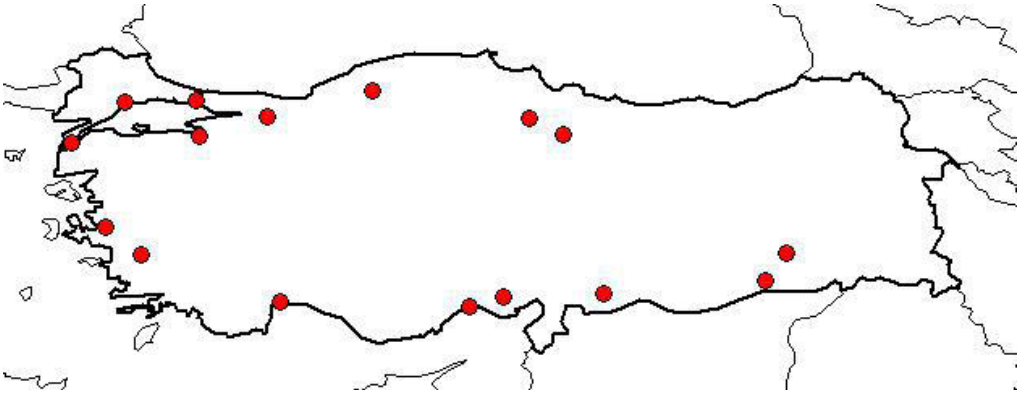

Figure v.2. *Natural distribution of Thymbra spicata L. var. spicata L.; Adana, Gaziantep, İstanbul, Mardin, Batman, Karabük, Amasya, Antalya, Aydin, Bursa, Çanakkale, İçel, İzmir, Sakarya, Tekirdağ, Tokat, Turkey.*

- **Habitat**: grows on calcareous, hillsides and open sunny places from 121 to 1249 m both under Mediterranean and Semi-arid climatic condition of Turkey. Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and prefers well-drained soil. Suitable pH: acid, neutral and basic (alkaline) soils. It cannot grow in the shade. It prefers dry or moist soil. Woodland garden sunny edge.

USES AND MARKET

- **Uses:** The dry herb is used for medicinal and culinary purposes. The essential oils of this plant have wide industrial applications. A good bee plant.

- **Properties:** Biological effects of this plant consist of antioxidant properties, antibacterial, anti-mycolitic, antiseptic has been reported that this plant has mostly antimicrobial effects.

- **Market:**

    - Medicinal sector: as a drug, the leaves have recently gained much popularity as a remedy to combat hypercholesterolemia. Besides, the dried plant, softened in boiled water used to be applied to wounds as a drug.

    - Food sector: is used as a spice in meals, for flavouring and preservation.

    - Cosmetic sector: it is used for elaborating perfumes.

TECHNICAL DATA ON CULTIVATION

Figure v.3. *Plant and field of Thymbra spicata in Portugal.*

- **Commercial varieties:** --
- **Multiplication:**
    - Sexual: Seed - sow during spring in a greenhouse. When they are large enough to handle, prick the seedlings out into individual pots and grow them on in the greenhouse for at least their first winter. Plant them out into their permanent positions in late spring or early summer, after the last expected frosts.
    - Asexual: Cuttings of half-ripe wood, July/August in a frame. Division in spring. Larger divisions can be planted out direct into their permanent positions. It is found that it is best

to pot up smaller divisions and grow them on in light shade in a greenhouse or cold frame until they are growing away well. Plant them out in the summer or the following spring.

- **Length of cultivation:** from 4 to 6 years.

- **Crop conditions**: *Thymbra* will grow in a pH range between 6.5 (neutral) and 8.5 (alkaline) with a preferred pH range between 6.5 and 7.0. Succeeds in a sunny position in most well-drained soils. This species is not hardy in the colder areas of the country, it tolerates temperatures down to between -5 and -10°C. *Thymbra* grown outdoors prefers full sun. Drought resistant and ideal for xeriscaping. Suitable for containers and indoor cultivation. Attracts butterflies, birds, or bees.

- **Cultivation establishment**: about planting density, *Thymbra* plants should be spaced 45 – 60 cm apart. • Cultivation establishment: about planting density, Thymbra plants should be spaced 45 – 60 cm apart.

- **Crop maintenance:**
  - Fertilisation: *Thymbra* requires minimal fertilization unless the soil quality is of extremely poor quality, or when grown via the hydroponic method.
  - Irrigation: Average water needs. Water on a regular schedule. Allow soil to go completely dry between watering, then soak thoroughly.
  - Weed control: Since it grows slowly, especially early in its life, weed-control is essential. Mulching with straw is helpful.
  - Pests and diseases: *Thymbra* can be susceptible to whitefly and spider mites, but has minimal disease issues.

- **Harvest:** *Thymbra* is harvested in mid-summer, just prior to flowering. Secondary growth will occur for the balance of the year, and this growth should be left to grow, or winter hardiness will be sacrificed. Knowing when and how to harvest black thyme will garner the best results when drying. Woody stemmed herbs are best harvested just before blooming for peak flavor. Cut the stems for drying fresh black thyme, just before a growth node. This will increase bushing and ensure a constant supply of the tasty leaves. Morning is the best time of day for harvesting *Thymbra*.

PROCESSING

- **Post-harvest:** After harvesting Thymbra, wash it and shake off the excess water. You can choose to dry the entire stem or remove the tiny leaves. The leaves will dry more quickly off the stem but they will remove more easily from an already dried piece of the herb. To remove the leaves by hand, pinch the end of the stem with your thumb and forefinger and pull up the stalk. The leaves will fall off. Remove any of the peripheral twigs and proceed with drying fresh thyme.

- **Drying:** There are several ways you can dry your herbs. Drying fresh black thyme in a food dehydrator is fast and protects against possible mold. The moisture in herbs that are drying in the necessary warm conditions may cause the formation of mold if too much humidity is in the area. To dry *Thymbra* in a dehydrator, lay the stems in a single layer on the racks that come with the unit. The stems will dry in under two days and can be stripped of the leaves. Traditionally, many herbs were dried by hanging. This is still a useful practice today and requires no special equipment. Take stems and bundle them together. Tie the bundles and hang them where the temperatures are at least 10 °C and humidity is low. Stems may take a week or more to dry. Drying the leaves is the quickest method of preserving the herb. Once

the leaves are separated from the stem, you can just lay them on a cookie sheet. Stir them up after half a day. The leaves will be completely dry in just a couple of days.

- **Dry herb conditioning:** The final products are leaves, flowers and buds, representing the 30-40% of the dry plant. Storing Thymbra correctly will preserve its essence and flavor. Put the dried herb in an airtight container in a dim to dark area. Light and moisture will degrade the herb's flavor.

- **Distillation:** In the case of extraction for essential oil, fresh/dry material (flowering stems) has to be used.

YIELDS

Table v.1. *Plant height (cm), branch number (number/plant), green, dry herbage and essential oil yield (kg/ha) of Thymbra spicata L. var. spicata L. at field conditions.*

Species	Plant height (cm)	Canopy diameter(cm)	Dry leaf yield(kg/ha)	Green Herb-age Yield (kg/ha)	Dry Herb-age Yield (kg/ha)	Flower spike length (cm)
Thymbra spicata L. var. spicata L	**35.1**	**54.3**	**2176.8**	**7633.8**	**3134.3**	**3.49**

Table v.2. *Essential oil rates (%) of Thymbra spicata L. var. spicata L. in the field conditions at flowering stage.*

Species	Essential oil rate (%)
***Thymbra spicata L. var. spicata* L.**	**3.60**

QUALITY

- **Main constituents:**
  - Essential oil, rich in carvacrol thymol, γ-terpinene and p-cymene.
  - Monoterpene hydrocarbons
  - Sesquiterpene hydrocarbons
  - Oxygenated monoterpenes
  - Polyphenolic compounds

Table v.3. *Essential oil components (%) of Thymbra spicata L. var. spicata L. grown in the field conditions at flowering stage.*

Essential Oil Components	*Thymbra spicata L. var. spicata* L.
β-pinene	0.21
myrecene	1.18
γ-terpinene	12.23
p-cymene	9.83
E-caryophyllene	1.22
Thymol	2.26
Caryophyllene oxide	0.95
Carvacrol	67.08

- **Legislation:**

  - Manufacturing, Hygiene and Safety, Trade Number : 27676

  - Principles and Implementation of Organic Farming-Protection of ecological balance, the implementation of organic agricultural activities, regulation of organic agricultural production and marketing, development, to determine the procedures and principles for dissemination.

    http://www.resmigazete.gov.tr/eskiler/2010/08/20100818-4.htm

  - Regulation on the Protection and Utilization of Plant Genetic Resources - to protect and improve the Turkey plant genetic resources, survey, collection, collected material storage, production, regeneration, characterization, evaluation, is designed to establish rules concerning the documentation and exchange.

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» http://www.pfaf.org/user/Plant.aspx?LatinName=Thymbra+spicata

» https://www.gardeningknowhow.com/edible/herbs/thyme/harvesting-thyme.htm

vi. *Origanum vulgare* L. (subsp. *vulgare* and *virens*)
LAMIACEAE

INTRODUCTION

DESCRIPTION OF THE SPECIES[1,2]

Figure vi.1. *Origanum vulgare L. subsp. vulgare L. (left) ve subsp. virens (right).*

- **Botanical description:**
    - ***Origanum vulgare* L. subsp. *vulgare*** (Tk. Keklik Otu, Sp. Orégano, En. Oregano): is a vivacious herbaceous plant about 80 cm high. The stems have quadrangular section, and are reddish coloured covered by a slight pilosity. The leaves are opposite, heart-shaped and have whole margin. The flowers are bundled in the branching vertex forming terminal inflorescences. The bracts are violet-purple and the flowers pink.
    - ***Origanum vulgare* L. subsp. *virens* (Hoffmanns & Link) letsw.** (Tk. -, Sp. Orégano verde, En. -): is a similar species or subspecies to the previous one, but the inflorescence is laxer, the bracts are pale green and the flowers usually white.
- **Used parts:** leaves and flowering tops. They can be found as dry raw material, as essential oil or even as fresh or frozen herbs.

ORIGIN AND HABİTAT[1,3,4, 13]

- **Origin and geographical description:** *O.vulgare* is found naturally in Europe, North Africa, temperate Asia (Iran, Siberia, Central Asia, China, etc.); naturalized in parts of North America, New Zealand. In the Iberian Peninsula, Origanum vulgare L. subsp. vulgare is distributed basically in the northern area, while *Origanum vulgare* L. subsp. *virens* in the South-western area. *O.vulgare* subsp. *vulgare* is present in Turkey, but not subsp. *virens*.

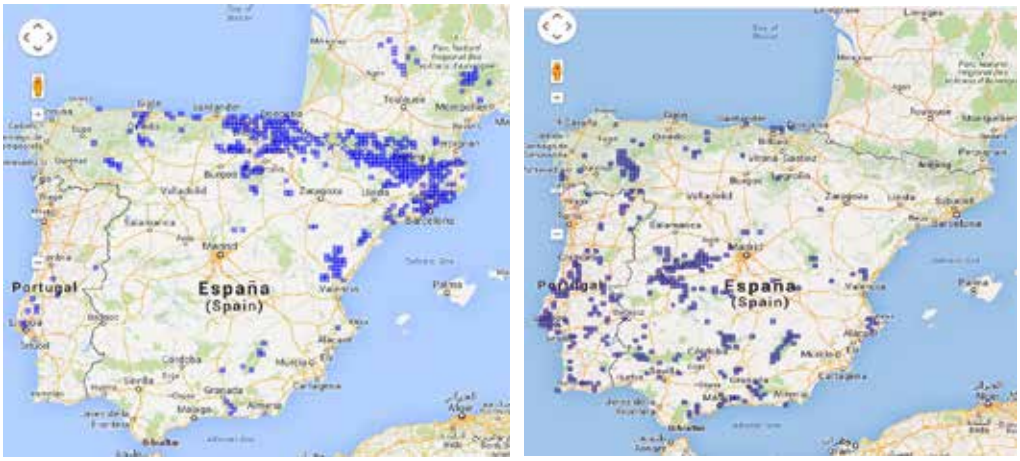

Figure vi.2. *Natural distribution of Origanum vulgare L. in Iberian Peninsula, subsp. vulgare (left map) and subsp. virens (right map). Source: SIVIM – Sistema de información de la vegetación ibérica y macaronésica.*

- **Habitat:** *O. vulgare* subsp. *vulgare*, grows well from 0 to 1,700 m above sea level. Its natural habitat is low humid areas of deciduous forest. *O.vulgare* subs. *virens* can be found between 100 to 1,000 m above sea level and its natural habitat is the oak forests. Both subspecies can grow in almost all type of soils, preferably calcareous. Regarding climatic requirements, they grow well in temperate and warm conditions. Their annual water needs range from 400 to 600 mm. Both species are also frost resistant.

USES AND MARKET[1,5,7]

- **Uses:** the flowering tops are used in medicinal sector (powdered, infusions, fluid and dry extracts, tinctures) while the leaves in food sector. It is used for manufacturing herbal medicines, liquors, perfumes, soaps, cosmetics. Antioxidants source.

- **Properties:**

    - Internally: Aperitif, digestive, carminative, choleretic; spasmolytic, expectorant, antiseptic airway; general tonic and diuretic.

    - Externally: Analgesic, antiseptic, healing, antifungal.

- **Market:**
    - Medicinal sector: it is traded as dry leave (in bags, poaches or cans), essential oil (in essences, tablets, capsules or blisters) and extract (in syrups, capsules or fluid complexes). Existing pharmaceutical formulations: antiseptic-expectorant capsules, antiseptic ear drops, genital antiseptic ovules, antiseptic infusion.
    - Food sector: it is mainly traded the powdered dry leave as condiment (in dispenser containers, jars, boxes or bags), for seasoning pasta, pizza and meat dishes (part of the "Provence herbs" mix). It is also used for aromatising liquors and vinegar. It has interest as preservative in the sausage industry.
    - Cosmetic sector: according to the Cosmetic Ingredients Database, *O.vulgare* leaf and extract are used as skin conditioning, and the leaf oil as masking and refreshing. The *O.vulgare* flower extract have the functions of antiseborreic, masking, oral care and refreshing, and the flower/leaf/stem water of masking and perfuming.
    - Gardening: in aromatic plants gardens, rocky designs and vivacious groupings.

TECHNICAL DATA ON CULTIVATION[1,6, 14]

Figure vi.3. *Origanum vulgare subsp. virens crop in Catalonia (Spain)*

- **Comercial varieties[14]:**
    - *Origanum vulgare* subspecies:
        - subsp. *gracile*
        - subsp. *prismaticum*
        - subsp. *hirtum*

        - subsp. *viridulum*
    - *Origanum vulgare* varieties:
        - *var. album: "Aureum Album"*.
        - *var. formosanum*
    - *Origanum vulgare* ornamental cultivars: "Acorn Bank", "Aromata", "Aureum", "Aureum Crispum", "Bristol cross", "Bury Hill", "Compactum", "Compactum Album", "Corinne Tremaine", "Country cream", "Curly Gold", "Gold Tip", "Golden Shine", "Heirloom/heritage", "Kleiner italienen", "Nanum", "Nyamba", "Pink mist", "Polyphant", "Thumble's Variety", "Tomintoul", "Tracy's Yellow", "Variegatum", "Vulkan", "Webb's White" "White charm".
    - The favorite oregano in the seasoning market is the Chilean, who is believed to be a hybrid of oregano (*Origanum vulgare x Origanum majorana)*.

- **Multiplicaion:**
    - Sexual: the seeds have a high germination rate (more than 80%), thus they germinate easily. The most common method to obtain commercial seedling of oregano is from seeds.
    - Asexual: it can also be propagated by division of plants from old plantations. This is done in spring o autumn. This method is not used to the high cost of labour.
- **Length of cultivation:** from 3 to 5 years.
- **Crop conditions:** oregano is a species that can be grown optimally in fresh dry conditions (600 mm per year), producing even more than in irrigation conditions. Note that this does not mean that watering is not recommended, but dry conditions are better because the plants are prone to pests and diseases in wet conditions.
- **Cultivation establishment:** planting is done in spring, usually with seedlings propagated from seeds. Planting density ranges between 30,000 and 40,000 plants per hectare, depending on soil fertility and machinery available for the maintenance of the crop. The most common distances between plants are from 40 to 60 cm. It is recommended to add about 30-40 t/ha of mature manure when preparing the field for plantation.
- **Crop maintenance:**
    - Irrigation: both *O.vulgare* subsp. *vulgare* and subsp. *virens* can be grown in dry land, although it is advisable to have support irrigation to ensure intake of water after planting and first harvest. No data is available on the amounts of irrigation applied.
    - Fertilisation[6]: taking into account the nutrient content of the soil, they can be suggested the following annual fertilisation: N 120-150 UF (divided into two times, once after the start of the growing season and again after the first harvest), P_2O_5 80-120 UF, K_2O 100-120.
    - Weed control: the most important problems will appear the first year of cultivation, when the plant is small; after it makes a rosette plant that prevents the proliferation of auxiliary plants. It is recommended a mechanical weed control between rows, and in the row can be done manually or by using a mulching system. Also with herbicides: ITEIPMAI (1992) recommended *Bentazona, Clorprofam, Metazaclor, Napropamida* and *Propizamida* for post plantation treatment (first year), and *Terbacil* for pre-emergence treatment (the following years). Please, check authorised herbicides in your country.

- Diseases:

    - *Caused by fungi: Phytophthora cyptogea* (affects the whole plant, causing shoot and root rot, drying branches and yellow, brown or black spots appear in the leaves; avoid excessive moisture in the soil and protect wounds with copper), oidium-*Erysiphe glaeopsidis* (causes whitish spots with dusty appearance in the leaves; usually well controlled with sulphur)*, Botrytis cinerea* (the rot affects the stems and the shoots and is covered with grey or whitish micelles; recommended aeration, thus avoiding high densities planting, and protect wounds with copper), rust-*Puccinia rubsaameni* (causes redish or orange spots in the stems and the underside of the leaves; it is hardly controlled with sulphur), and *Colletotrichum* spp. (causes leaf necrosis that depreciate the quality of the product. The first symptoms are small and brown spots on the leaves and stems. Over time, these spots are becoming larger and cause the leaves fall and dry buds).

    - *Caused by nematodes:* The nematodes attack the roots, forming galls or deformation, and cause the drying and dying of the entire. *Nacobbus aberrans* is the most common in oregano. *O.vulgare* subsp. *vulgare* is resistant to *Meloidogyne incognita, M. arenaria and M. javanica,* which are the most common nematodes in vegetable crops, being useful to plant oregano in orchard crop rotations.

    - *Caused by virus:* alfalfa mosaic virus (AMV) has been isolated in oregano, which causes yellow and whitish spots, deformation and yellowing on the leaves and stunting of the plant.

- Pests:

    - Red spider mite (*Tetranychus urticae*): lives in the underside of the leaves, and sucks cellular contents and causing green colour lose. Then yellow spots like small spots appear in the upper surface of the leaves and, over time, cause the leaves to dry.

    - Leafhopper (*Eupteryx decemnotata*): insect that sucks the contentscellular oregano leaves.

- **Harvest:** the time of harvest varies according to the final destination of oregano. To produce essential oil is harvested when the plants are in full bloom (July, August in Spain). For fresh or dried herb is harvested in beginning of flowering, when the plant has more leaves. During the first year you can make a harvest, and from the second year up to two harvests. It can be used a forage harvester.

PROCESSING[6]

- **Drying:** it is necessary to dry the harvest as soon as possible, indoors, in a ventilated place and at a temperature range of 30 to 40ºC. The density of the fresh plant is about 60-80 kg/m^3.

- **Dry herb conditioning:** to separate the leaves and the bracts from the stems, a vibrating machine is used. The final product is a mix of leaves, flowers and bracts, representing the 40-60% of the dry plant.

- **Distillation:** to obtain essential oil, the fresh plant is distilled by steam distillation system.

Figure vi.4. *Dry herb of Origanum vulgare subsp. virens.*

Figure vi.5. *Dry leaves of Origanum vulgare subsp. vulgare.*

YIELDS[9-12]

Table vi.1. *Theoretical yields of Origanum sp.*

Type of material	First year of cultivation	Following years of cultivation	Source
Fresh plant (50.000 plants/ha)	3 t/ha	15-20 t/ha	ITEIPMAI, 1992
Fresh plant	5-7 t/ha	12-22 t/ha	Marzi, 1996
Fresh plant	3-9 t/ha	12-16 t/ha	Fernández-Pola, 1996
Fresh plant	1-6 t/ha	6-16 t/ha	McGimpsey, 1993
Dry leaves and flowers (50.000 plants/ha)	0,5 t/ha	3-4 t/ha	ITEIPMAI, 1992
Dry leaves and flowers		2-5-3,5 t/ha	Hornok, 1992
Essential oil	0,07-0,3 % of fresh plant 0,2-0,7% of leaves and flowering tops (subsp.vulgare) 0,5-2,3% of leaves and flowering tops (subs. virens)		ITEIPMAI, 1992
Essential oil	0,2-0,25% of fresh plant		Fernández-Pola, 1996

Table vi.2. Average yield of Origanum sp. (subsp. vulgare and virens) in rainfed and irrigated production conditions during 3 years of cultivation in Catalonia, Spain[1].

		Rainfed	Irrigated land
Dry plant yield (t/ha)			
Annual yield		**5,61**	**3,31**
Harvest yield	Summer	4,86	2,66
	Autumn	0,75	0,65
Dry leaves yield (t/ha)			
Annual yield		**2,68**	**1,88**
Harvest yield	Summer	2,13	1,37
	Autumn	0,54	0,51
Relation dry:fresh		**40:100**	**42:100**
Relation leaves:plant		**53:100**	**62:100**
Essential oil yield (ml/kg of leaves)			
Annual content		**10,31**	**10,81**
Harvest content	Summer	12,57	13,57
	Autumn	7,30	6,52

Rainfed and irrigated production differs mainly in relation leaves: plant. In rainfed conditions, plants are woody and therefore there is a higher proportion of non-commercial material. Irrigated plants are smaller with higher proportion of leaves, thus facilitating subsequent handling of the plant.

***Table vi.3**. Average yield response in rainfed farming comparing vulgare and virens subspecies (origin Spain) during 6 years of cultivation in Catalonia, Spain.*

		Origanum vulgare L. subsp. *vulgare*	*Origanum vulgare* L. subsp. *virens*
Dry plant yield (t/ha)			
Annual yield		**4,18**	**4,59**
Harvest yield	Summer	3,98	4,03
	Autumn	0,19	0,58
Dry leaves yield (t/ha)			
Annual yield		**1,91**	**2,36**
Harvest yield	Summer	1,82	1,91
	Autumn	0,09	0,45
Relation dry:fresh		**47:100**	**41:100**
Relation leaves:plant		**48:100**	**59:100**
Essential oil yield (ml/kg of leaves)			
Annual content		**9,13**	**9,95**
Harvest yield	Summer	8,96	9,95
	Autumn	10,00	5,95

It seems that *Origanum vulgare* L. subsp. *virens* is more productive than subsp. *vulgare*.

QUALITY[7,8]

Origanum vulgare L. subsp. *virens* is more productive than subsp. *vulgare*.

- **Main constituents of *Origanum vulgare* L.:**
    - Essential oil (0,1-1,0%) rich in thymol, carvacrol (up to 90%), β-bisabolene, cariophyllene, ρ-cymene, borneol, linalool, linalyl acetate, α i β pinenes, α-terpinene.
    - Phenolcarboxylic acids: caffeic, chlorogenic, rosmarinic.
    - Flavonoids: apigenol, luteolol, kempferol, diosmetol derivatives.
    - Tannins
    - Bitter compounds.
    - Triterpenes: ursolic acid and oleanolic acid derivatives.
- **Legislation:**
    - Real Decreto 2242/1984, de 26 de septiembre de 1984, por el que se aprueba la Reglamentación Técnico-Sanitaria para la elaboración, circulación y comercio de condimen-

tos y especias (Spanish regulation on seasonings and spices):

- Orégano (Origanum vulgare L.; Origanum virens L.), leaves and flowering tops.

- **Standards:**

  - ISO 7925:1999 – Dried oregano (Origanum vulgare L.) – whole or ground leaves – Specification.

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vii. *Salvia officinalis* L.
LAMİACEAE

INTRODUCTION

DESCRIPTION OF THE SPECIES[1]

Figure vii.1. *Plant (left) and flowering top (right) of Salvia officinalis L.*

- **Botanical description**:

  - ***Salvia officinalis* L**. (Tk. Adaçayi, Sp. Salvia, En. Sage): woody shrub, reaching up to 60 cm high. The stems are quadrangular, very branched, white and hairy. The leaves are opposite, lower leaf petiolate and upper leaf without petiole, elliptical shaped, with toothed margin, whitish the lower side with very marked nerves. The flowering top in cluster form, with violet flowers. There are 5 subspecies: *officinalis, lavandulifolia, multiflora, gallica* and *oxyodon*.

Figure vii.2. *Detail of Salvia officinalis L. leaf.*

- **Used parts:** aerial part, mainly leaves for obtaining dry herbal material (*Salviae folium*) and also extracts (water, fresh, dry, fluid, glycolic, hydroglycolic, tincture, etc.). For obtaining essential oil (*Salvia aetheroleum*), whole plant is harvested during flowering.

ORİGİN AND HABİTAT[1,2]

- **Origin and geographical description:** sage's origin is in eastern Mediterranean (Greece and Balkans), but have been spread its cultivation to western Mediterranean (Italy, France, Spain, Morocco, etc.), even in temperate areas of America and Asia minor. In Iberian Peninsula there exist endemic subspecies: *Salvia officinalis* subsp. *lavandulifolia* (Vahl) Gams and subsp. *oxyodon*. In Turkey, there is not present in the flora.

Figure vii.3. *Spanish sage (Salvia officinalis subsp. lavandulifolia).*

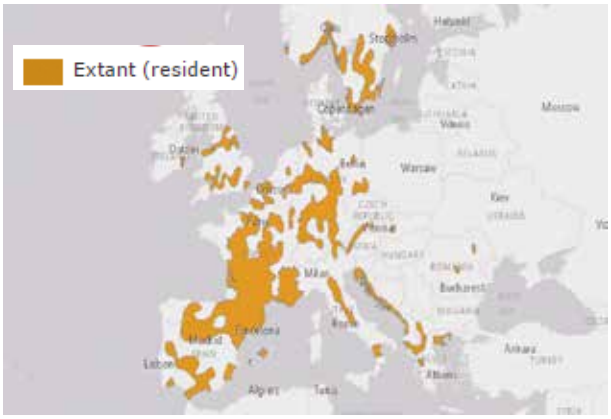

Figure vii.4. *Current distribution of Salvia officinalis L. (http://maps.iucnredlist.org).*

Habitat: it grows very good with 450 mm of annual rainfall, but bigger water quantities yield more production. It withstands low temperatures and frost, since it needs winter cold to form the flower. It grows in full sunlight. Naturally, it develops in calcareous and stony ground, relatively shallow and nutrient poor soils. It prefers a slight texture, since it do not support root asphyxia. It occurs between 200 and 1800 m above sea level.

USES AND MARKET[1,4,5]

- **Uses:** phytotherapy (oral, oromucosal and cutaneous use), perfumery (fixing), dermopharmacy, cosmetics, soaps, liquors, culinary. Antioxidants source.

- **Properties:**

    - Comminuted herbal substance and extracts: *Internally:* relief of excessive sweating, symptomatic treatment of mild dyspeptic complaints, such as heartburn and bloating. *Externally*: inflammations in the mouth and the throat, minor skin inflammations.

    - Essential oil: spasmolytic activity. Antibacterial and antiviral. ATTENTION: α-thujone, which is more toxic than *β-thujone* and is present as a higher proportion of the essential oil, is a convulsant. Could have toxic effect in high doses (due to *thujone* and c*amphor content*). *Internal*: Digestive complaints, excessive perspiration. *External*: Inflammations of the oral and pharyngeal mucosa, mucous membranes of nose and throat.

- **Market:**

    - Medicinal sector: herbal substance, for tea preparation and for capsules (oral, oromucosal and cutaneous use). Dry extract (4-7:1), extraction solvent water, for capsules (oral and oromucosal use). Liquid extract 1:1, extraction solvent ethanol 70% (oromucosal gel); liquid extract 1:1, extraction solvent ethanol 20% (cutaneous use); liquid extract 1:7.2, extraction solvent ethanol 96% (oral and oromucosal use); liquid extract 1:3.5-5, extraction solvent ethanol 31.5%; liquid extract 1:4-5, extraction solvent ethanol 50%. Tinctura salviae (1:5), extraction solvent ethanol 70% (oromucosal use). Salviae unguentum – salvia folii extractum (cutaneous use) (Specified products on the market in European Member States)[4].

    - Food sector: bundles of fresh herb (in bags and plastic trays) and dried leaves, cut and ground as a condiment (in bags and dispenser containers, glass and plastic jars) and herbal teas (in sachets). Also the oleoresin is traded.

    - Cosmetic sector: according to Cosmetics ingredients database, *Salvia officinalis* leaf is used as masking, skin protecting and tonic; the extract as antidandruff, cleansing, oral care, skin conditioning and tonic, and the root extract as skin conditioning; the water (steam distillate) as skin conditioning and the leaf water also as masking; the essential oil as masking and tonic.

    - Gardening: it is commercially propagated in the gardens of all Europe. There are several ornamental varieties with different leaf colours.

TECHNICAL DATA ON CULTIVATION[1, 6, 10]

Figure vii.5. *Salvia officinalis L crop in Catalonia (Spain), in spring (left) and autumn (right).*

- **Commercial varieties[10]**:
    - High essential oil content cultivars: "Regula", "Extrakta", "Phasa", "Ceres".
    - Ornamental cultivars: "Alba", "Albiflora" (white flowers), "Albiflora nana", "All Gold", "Aurea" (golden sage), "Banba", "Bergbright", "Berggarten", "Bicolor", "Blackcurrant", "Cedric", "Crispa", "Giant", "Ginger", "Goldblatt", "Grandiflora", "Grete Stolze", "Grower's Friend", "Heirlom/Heritage" (Dalmatian sage), "Holt's Mammoth", "Icterina", "Kew Gold", "Minor", "Minor Alba", "Nazaret", "Pink Splash", "Purpurascens", "Purpurascens Variegata", "Purpurea", "Robin Hill", "Rosea, "Selsley Splash", "Sperling's allerlei", "Tricolor", "Variegata", "Würzburg".
- **Crop conditions:** sage could be cultivated in rainfed conditions, with a minimum precipitation of 300-400 mm per year, but the contribution of extra water can improve the growing and the yield.
- **Length of cultivation:** from 3 to 5 years, although in good conditions could last 10 years due to its resprouting capacity.
- **Multiplication:**
    - Sexual: the seeds have a high germination rate in greenhouse conditions (80-90%, at 20°C in 20 days). Weight of 1000 seeds=6.3g. The usual method to obtain commercial seedlings of sage is by seeds.
    - Asexual: it can also be propagated by division of plants (when the plant is in dormancy period) or by cuttings (done at end winter, length of 12 cm with minimum 4 buds, no need of hormones; can be planted in spring). The recommended season is in Spring, with good rooting success.
- **Cultivation establishment:** It is recommended to add about 20 t/ha of mature manure when preparing the field for plantation. The plantation could be done in spring or in autumn (if the winter is mild), usually with seedlings obtained by seed. The plantlets could be planted when

have about 10 cm height and 4-5 pairs of leaves, so 8-10 weeks after sowing. Direct sowing could also be done, as germination rate in the field is about 61-65%, 3-4 weeks after sowing, using a pneumatic precision seed drill with a shallow sowing (1 cm). The optimal plantation density is from 40,000 to 50,000 plants per hectare. The distances between plants are from 30 to 50 cm.

- **Crop maintenance:**
  - Irrigation: A support irrigation after the plantation helps in the establishment of the crop, and an irrigation after the first annual harvest foster the resprouting and facilitates the second and even third harvest.
  - Fertilisation[6]: taking into account the nutrient content of the soil, they can be suggested the following annual fertilisation: N 70-80 UF (30 UF after first harvest), P_2O_5 80-100 UF, K_2O 80-150 UF. The fertilisation takes place at the end of winter, before sprouting.
  - Weed control: It is recommended a mechanical weed control between rows, and in the row can be done manually or by using a mulching system. Also with herbicides: ITEIPMAI (1992) recommended *Cloridazona, Lenacil* and *Metamitrona* in pre-emergence treatment (when doing direct sowing), *Clorizadona* and *Napropamida* in post-emergence treatment (first year) and *Diuron, Linuron, Terbaci*l (the following years). Please, check authorised herbicides in your country.
  - Diseases:
    - *Caused by fungi*: *Phytium* sp. and *Phytophthora cryptogea* (affects the whole plant, causing shoot and root rot, drying branches and yellow, brown or black spots appear in the leaves; avoid excessive moisture in the soil and protect wounds with copper). *Fusarium* sp. (affects the stems and causes withering; has difficult control and it better apply preventive measures, as eliminating affected plants). *Erysiphe galeopsidis* (causes whitish spots with dusty appearance in the leaves; usually well controlled with sulphur).
  - Pests: sage have few problems, since it has insect repellent properties. *Cicadella viridis* is cited as a leafhopper causing damages in adult leaves.
- **Harvest:** for obtaining dry leaf, it could be done two harvests per year: the first before flowering in spring, and the second at the end of summer. If the conditions are good, a third harvest could be done in autumn. In spring, flowering sometimes appears suddenly, and then the harvest for the leaf have not enough quality. In this case, it is recommended to cut the plant and wait for the second harvest. On the other hand, for obtaining essential oil, it is advisable to harvest during flowering; first year, the sage does not flower, then it is better to obtain dry herb. The cut could be done with a mower harvester, establishing the cut height at 10-15 cm from the soil to allow resprouting.

PROCESSING[1, 6]

- **Post-harvest:** after harvesting, the fresh plant could be cut in small fragments before drying (but this not allow to obtain whole leaves).
- **Drying:** could be using natural air or heated air. Natural drying should be done indoors, with shadow and aerated conditions; it is necessary to mix from time to time and not pile the crop. Heated drying: temperature should range from 40-45ºC, until the plant material reach 13% of humidity. The density of the sage leaves is about 130 kg/m^3 fresh and 90 kg/m^3 dry.

- **Dry herb conditioning:** sometimes it is difficult to separate the whole leaves from the stems by mechanical systems, thus they are brittle. Many small stems remain, then it is necessary to separate by sieving.
- **Distillation:** to obtain essential oil, the fresh plant is distilled by steam distillation system.

Figure vii.6.*Dry whole leaves of Salvia officinalis L.*

Figure vii.7. *Cut dry leaves of Salvia officinalis L.*

YIELDS[1,6,7,8,9]

***Table vii.1**. Theoretical yields of Salvia officinalis L.*

Type of material	First year of cultivation	Following years of cultivation		Source
		First harvest	Second harvest	
Fresh plant (50.000 plants/ ha)	8 t/ha	4 t/ha	20 t/ha	ITEIPMAI, 1992
Fresh plant		10-12 t/ha	8-9 t/ha	Catizone, 1986
Fresh plant	-	5-8 t/ha		Hornok, 1992
Fresh plant	6-12 t/ha	18-22 t/ha		Fernández-Pola, 1996
Fresh leaves		2.5-3 t/ha		Hornok, 1992
Dry plant (50.000 plants/ ha)	2 t/ha			ITEIPMAI, 1992
Dry leaves (50.000 plants/ ha)	1 t/ha	0.5 t/ha	3.5 t/ha	ITEIPMAI, 1992
Essential oil	35-75 kg /ha (15-17 t/ha of fresh plant)			ITEIPMAI, 1992
Essential oil	21-34 kg /ha			Fernández-Pola, 1996
Essential oil	8-10 kg/ha			Hornok, 1992
Essential oil	0.2-0.3 % of fresh plant			Catizone, 1986

Table vii.2. Average yield of Salvia officinalis L. in rainfed and irrigated production conditions during 3 years of cultivation in Catalonia, Spain[1].

		Rainfed	Irrigated land
Dry plant yield (t/ha)			
Annual yield		**3.43**	**3.24**
Harvest yield	Spring	1.29	1.79
	Summer	1.16	1.10
	Autumn	0.98	0.35
Dry leaves yield (t/ha)			
Annual yield		**2.43**	**2.44**
Harvest yield	Spring	0.77	1.22
	Summer	0.86	0.91
	Autumn	0.80	0.30
Relation dry:fresh		**33:100**	**32:100**
Relation leaves:plant		**73:100**	**77:100**
Essential oil yield (ml/kg of leaves)			
Annual content		**20.59**	**17.61**
Harvest content	Spring	20.02	19.00
	Summer	21.32	15.87
	Autumn	20.42	16.75

Sage is a species with low requirements of water, since there were not observed differences of dry leave production between rainfed and irrigation conditions. But the yield obtained in the dry conditions of Catalonia, is hardly lower than other wet areas in Europe.

QUALITY[4]

- **Herbal substances:**
    - *Sage leaf*: consists of the whole or cut dried leaves of *Salvia officinalis* L. It contains not less than 15 ml/kg of essential oil for the whole drug and minimum 10 ml/kg of essential oil for the cut drug, both calculated with reference to the anhydrous drug.
    - *Sage tincture*: produced from 1 part of comminuted sage leaf and 10 parts of ethanol (70% V/V) is a separate monograph in the European Pharmacopoeia. The tincture produced from sage leaf should contain minimum 0.1% m/m essential oil.
    - *Sage essential oil*: has a very variable composition depending on the source, time of harvesting and other factors.

- **Main constituents:**

  - Essential oil (up to 3%). Monoterpenoids: *α-thujone* (10-60%), *β-thujone* (4-36%), *camphor* (5-20%), 1,8-*cineole* (1-15%). Sesquiterpenes: *α-humelene, β-caryophyllene, viridiflorol*.

  - Hydroxycinnamic acid derivatives (about 3,5%). Caffeic acid dimer: *rosmarinic acid* (up to 3,3%). Caffeic acid trimers: *metrilic acid A, methyl melitrate A, sagecoumarin, salvianolic acid K*. Caffeic acid tetramer: s*agerinic acid. 6-feruloyl-glucose. A polyalcohol* derivate of 6-feruloyl-glucose. Hydrozycinnamic esters of disaccharides: *1-caffeoyl-(6'-apiosyl)-glucoside, free caffeic acid*.

  - Phenolic diterpenes. Tricyclic diterpene (*carnosid acid*) which readily auto-oxidises to lactones (*carnosol*, 3,5%). Phenolic diterpenes with lactone structures: rosmanol, epirosmanol, 7-methoxy-*rosmanol, galdosol, safficinolide, sagequinone methide A*. Sageone. Methyl carnosate.

  - Triterpenes. Pentacyclic triterpene acids: *ursolic acid* (up to 3,5%) and *oleanolic acid (*up to 4%). Triterpene alcohols: *α-amyrin* (0.18%), *β-amyrin* (0.10%).

  - Flavonoids (about 1,1%). Flavones and their glycosides: *luteolin, 6-hydroxiluteolin, 6 methoxyluteolin, apigenin, 6-methoxy-apigenin, vicenin-2, 5-methoxy-salvigenin.*

  - Phenolic glycosides. A diverse range.

  - Polysaccharides. Arabinogalactans, high-MW pectin. Glucuronoxylan-related polysaccharides.

  - Other constituents. Benzoic acid derivatives: *ρ-hydroxibenzoic acid, gentisic acid, syringic acid. Phytosterols: β-sitosterol, stigmasterol* (0.001%).

- **Legislation:**

  - Real Decreto 2242/1984, de 26 de septiembre de 1984, por el que se aprueba la Reglamentación Técnico-Sanitaria para la elaboración, circulación y comercio de condimentos y especias (Spanish regulation on seasonings and spices).

    - Salvia– Healthy, clean, fresh or dried plants of «*Salvia officinalis*», Linneo, and «*Salvia lavandulaefolia*», Walp.

  - Real Decreto 3176/1983, de 16 de Noviembre, por el que se aprueba la Reglamentación Técnico-Sanitaria para la Elaboración, Circulación y Comercio de Especias Vegetales para Infusiones de uso en Alimentación (Spanish regulation on food herbal teas.

    - Salvia - *Salvia officinalis*, leaf.

- **Standards:**

    - ISO 11165:1995 – Dried sage (*Salvia officinalis* L.) – Specification.

    - ISO 9909:1997 – Oil of Daltamian sage (*Salvia officinalis* L.).

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viii. *Lavandula* sp. *(L. angustifola, L. latifolia, L. x intermedia)*

LAMIACEAE

INTRODUCTION

DESCRIPTION OF THE SPECIES [1, 6]

Figure viii.1. *Lavandula angustifolia, Lavandula x intermedia, Lavandula latifolia (from left to right).*

Şekil viii.2. *Details of the flowering spike (L. angustifolia, L. x intermedia, L. latifolia (from left to right).*

- **Botanical description:**

    - ***Lavandula angustifolia* Miller** (Tk. Lavantasi , Sp. Lavanda/Espliego , En. Lavender): woody shrub up to 50 cm height, of erect branches. The leaves are linear (from 20 to 50 mm long and 1 to 3 mm wide), of intense green colour and not hairy. The floral peduncle reaches 10 to 30 cm length and it is not usually branched. The flowers, of blue-purple colour, are grouped in an inflorescence stalk, with floral bracts widely oval and sharp.

    - ***Lavandula latifolia* Medik.** (Tk. -, Sp. Espliego/Alhucema, En. Spike lavender): woody shrub up to 80 cm height, with a short stem and with the leaves grouped in the base of the plant. Its leaves have lanceolate shape (from 30 to 60 mm long and 5 to 8 mm wide), of greyish green colour and hairy. The floral peduncle reaches 20 to 50 cm length and it is branched. The flowers, of pale purple colour, are grouped in an inflorescence stalk, with linear floral bracts.

    - ***Lavandula x intermedia* Emeric ex Loisel** (Tk. -, Sp. Lavandín, En. Lavandin). It is also known as *Lavandula x hybrida*, but this is an illegitimate name. It is the sterile hybrid of *Lavandula latifolia* (brings the seed) and *Lavandula angustifolia* (brings the pollen), being more vigorous and productive that the parents. The plant shape is a bigger ball, and more homogenous. The floral peduncles are larger (60-80 cm) and the inflorescence stalk is bigger, sharper and have violet colour; it is characterising by two small inflorescence spikes at the main one's base. The leaves are linear with oblong shape with a blunt tip.

- **Used parts**: the inflorescence stalk, mainly addressed for the essential oil extraction. It is also used for manufacturing dry bouquets and scented decorations. The lavender flower is also used in herbal teas.

ORIGİN AND HABİTAT [1,2,3 6]

- **Origin and geographical description[2,3]:**

    - ***Lavandula angustifolia*** is endemic to France, Italy and Spain, where it is found in mountain ranges from 0-1,800 m asl (Italy), 500-1,500 m (France) and 500-1,700 m (Spain). It has been widely introduced outside this area and is frequently found in cultivation all over Europe, where it has escaped and become naturalized in many areas. It is widespread across eastern Spain, but elsewhere is only known from the southeastern corner of France and just over the border in Italy, plus one locality Italy near Bologna. *L. angustifolia* Miller subsp. *pyrenaica* is a variety endemic to the east Pyrenees and NE Spain (Lis-Balchin 2002).

    - ***Lavandula latifolia***, is endemic to France, Spain and Italy and is found at elevations from 0-2,050 metres asl. It has been introduced to Sicily and to the Balkan Peninsula, in former Yugoslavia. It is widespread across eastern Spain, but is more restricted in France, where it is found scattered across eleven departments in the south west, plus one small population in southern Indre-et-Loire (Inventaire National du Patrimoine Naturel 2012. In Spain, the Extent of Occurrence EOO is estimated to be over 270,000 km² in the northeast alone.

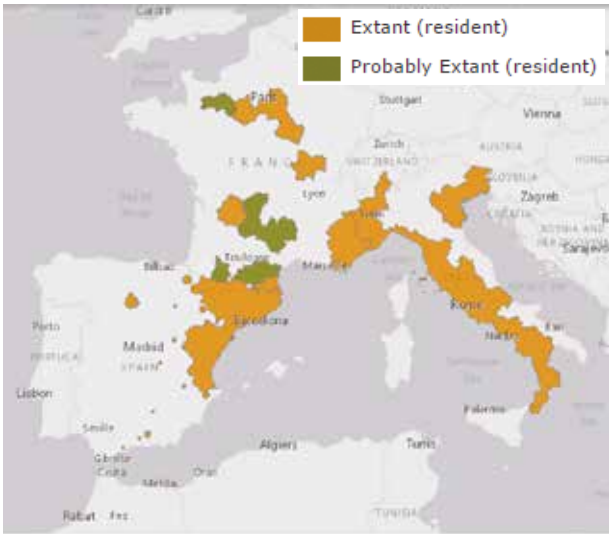

Figure viii.3. *Current distribution of Lavandula angustifolia Miller (http://maps.iucnredlist.org)*

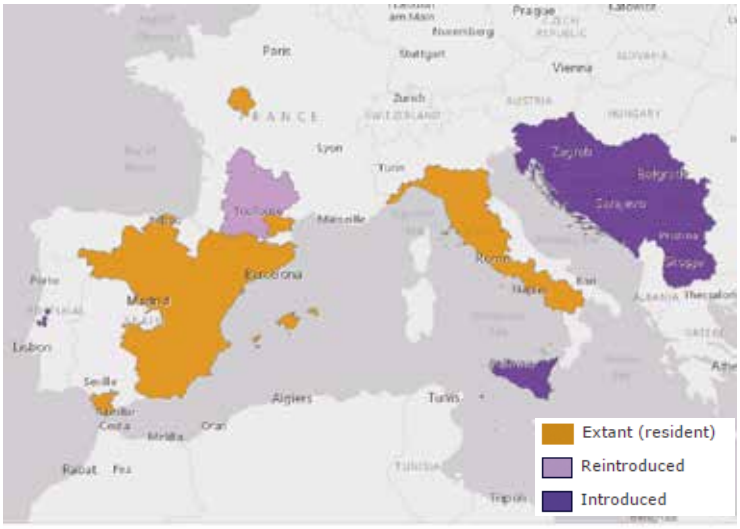

Figure viii.4. *Current distribution of Lavandula latifolia Medik. (http://maps.iucnredlist.org)*

Lavandula x intermedia could be seldom found in the nature, at 800-1,000 m of altitude, in the areas where *L. angustifolia* and *L. latifolia* could live together.

Habitat[1,6]: Both *Lavandula angustifolia* and *lavandula latifolia* are few demanding in nutrients. They are found in dry grassy slopes amongst rocks, in exposed (usually parched), hot rocky environments, with low organic matter. *Lavandula angustifolia* is often on calcareous soils, while *L. latifolia* and *L. x intermedia* can grow in acidic ones. *Lavandula latifolia* is salt wind exposure tolerant, and highly drought tolerant once established; plants are not long-lived. In its native habitat they are found in montane areas, making it a hardy species ideal for cultivation. They constitute a prime nectar source for honey bees.

USES AND MARKET[1,2, 4,5]

- **Uses**[2]**:** phytotherapy (oral use and bath additive), perfumery, soaps and cosmetics, air fresherners, flavouring, apiculture and gardening.

o *Lavandula latifolia*, produces up to three times as much essential oil as the more popular *Lavandula angustifolia*, but it is of lower quality. The most produced species is the hybrid *Lavandula x intermedia*, which is widely cultivated in France and Spain. Nevertheless, it is preferred the essential oil of *Lavandula angustifolia*.

- **Properties**[4,5]**:** Traditional herbal medicinal product for relief of mild symptoms of mental stress and exhaustion and to aid sleep.

Lavandulae flos: flowers of *Lavandula angustifolia* Miller. Herbal substance or comminuted herbal substance as herbal tea for oral use, and Herbal preparations in liquid dosage form for oral use.

Lavandula aetheroleum: Essential oil obtained by steam distillation from the flowering tops of *Lavandula angustifolia* Miller. Liquid dosage form for oral use and as a bath additive.

Lavandula latifolia is very popular and is believed to be antibacterial, antifungal, sedative, antidepressive and a muscle relaxant, and is also effective for burns and insect bites, although these are not clinically proven.

- **Market**[1,4,5]**:**

o Medicinal sector: *Lavandula angustifolia* It is used in herbal preparations using the essential oil, comminuted herbal substance or tincture. The essential oil of both species is used in aromatherapy.

o Food sector: both species are used to flavour food, but dry flowers are also traded to manufacture herbal teas and condiments.

o Perfumery sector: Both species are widely used in the perfumery and fragrance industry. It is commercialised the essential oil or the derivative essences to elaborate different cosmetic products.

o Cosmetic sektor: according to Cosmetics ingredients database,

- ***Lavandula angustifolia:*** herb (inflorescences) extract and the essential oil is used as perfuming; the flower, the flower water and the whole plant extract as skin conditioning; the flower powder and water as masking; the flower wax as emollient and skin conditioning; the flower extract as cleansing, deodorant, masking, refreshing and tonic; the flower/leaf/stem extract and juice as flavouring, masking, oral care, perfuming and skin conditioning; and the flower/leaf/stem essential oil and water as flavouring, humectant and masking.

- ***Lavandula x intermedia:*** leaf extract an essential oil is used as masking; the herb (inflorescences) extract and oil as perfuming; the flower/leaf/stem extract as flavouring, masking, oral care and perfuming, the water as masking and perfuming, but its essential oil only as perfuming. There is also indicated specification of *Lavandula x hybrida* var. *abrial*, var. *barreme*, var. *grosso* herb (inflorescences) extract and essential oil, used as perfuming.

- ***Lavandula latifolia:*** *Lavandula spica* flower essential oil is used as masking; the flower/leaf/stem extract as skin conditioning; the herb (inflorescence) extract and essential oil as perfuming.

- Gardening: Both species are used as ornamental, but preferring the hybrid (*Lavandula x intermedia*) because it is more productive.

- Other uses: the dry flowers are used to manufacture scented decorations (sachets, potpourris, bouquets, etc.). It is preferred *Lavandula angustifolia* due to its fragrance and flower colour.

TECHNICAL DATA ON CULTIVATION[1, 2, 6, 7, 8, 9, 10, 11, 16]

Figure viii.5.*Crop of Lavandula angustifolia in France.*

Figure viii.6. *Crop of Lavandula x hybrida in Catalonia, Spain.*

Figure viii.7. *Crop of Lavandula angustifolia in Turkey.*

Lavandula angustifolia is mainly cultivated in Bulgaria with 3.700 ha (2012) increasing to 6.700 ha (2014). In France there are about 4,280 ha in 2016 (FranceAgrimer data). Ukraine (Crimea) it is also an important producer with about 1,000 ha. China have around 1.500 ha (mainly for inner market). In Romania it is cultivated over an area of 750 ha. In Serbia it is cultivated over an area of 20 ha. It is also cultivated in India, Greece, Lithuania, Latvia, Finland, Croatia, and Hungary but there are no data available on the production quantities, and the importance of lavender plantations has decreased in recent decades. Breeding of cultivars is carried out in Romania out by the Central Research Station Fundulea and in the former Yugoslavia there is 1 domestic or improved cultivar (Baričevič et al. 2004, Lipman 2009)..

Lavandula latifolia, is commercially harvested and cultivated in Spain, being the only producer of this species (less than 10 tonnes).

Lavandula x intermedia, is widely cultivated in France (Provence region) with 18.130 ha in 2006 (FranceAgrimer data) with a global harvest of 1.365 tonnes. Spain is the second global producer of lavandin, with 2.045 ha in 2013 (Anuario de Estadística Agraria, 2016). Morocco (region Oulmès) has about 1,000 ha, mainly for dried flower.

Italy have only about 150 ha of lavender and lavandin. *Lavandula angustifolia* and *L. latifolia* are regulated by the Royal Decree no 772 of 1932, where only 10 kg of flowered tips are allowed to be harvested form the nature.

In United States of America and in United Kingdom there several hectares but have mainly tourist objectives.

- **Commercial varieties**[2,6,7]:
    - French (for essential oil production):
        - *Lavandula x intermedia* (var. *Grosso, Abrial, Super, Sumian*); the most cultivated one is *Grosso* (15,380 ha in 2016), due to the market demand and the yield production; in Spain is found mainly Super, but *Grosso* is increasing. .
        - *Lavandula angustifola* (var. Maillette, Population, Clonal). Population lavender is the most cultivated in France (2,180 ha), followed by Clonal variety (2,100 ha).

- Greek: A new variety *L. angustifolia* var. *Etherio* with improved essential oil yield, rich flower production and adaptability to local conditions is cultivated in Greece (Hassiotis et al. 2010).

- Bulgarian: *L. angustifolia* var. *Druzhba*, for bouquets, and var. Ubyleyna for essential oil.

- Other (ornamental): Alba, Alexis, Anniversary Bouquet, Arabian Night, Badsey Blue,Barbara Joan, Bogong, Burgoldeen, Castel, Cavershan Blue, Chaix, Dutch, Cigalou, Edelweiss, Enigma, Ferréol, Fifrelin, Foxe-amphoux, Fragrant memories, Fred Boutin, Futura, Giono, Grappenhall, Grey Hedge, Gros Bleu, Grosse Séguret, Heavenly Angel, Heavenly Night, Heavenly Scent, Hidcote Giant, Impress Purple, Jaubert, Julien, Lullingstone Castle, Maime Epis Tête, Margaret, Mitcham Blue, Nicolei, Niko, Nizza, Old English, Olympiad, Pale Pretender, Pigifra, Provence, Riverina Alan, Riverina Thomas, Seal, Spike, Standard, Sussex, Trio, Twickel Purple, Walvera, Waterford Giant, Yuulong.

- **Length of cultivation** [1,6]: the duration of the crop is about 8 to 10 years. When the Lavandula sp. are planted for first time in a field could last up to 15 years, but the optimal yields up to 10 years. When they are planted in a field where some Lavandula sp. have been previously planted, the length of the cultivation is reduced to the half, due to the soil depletion, being recommended crop rotations with cereals (oat, wheat, barley), *Papilonaceae* or *Coriandrum sativum* or *Pimpinella anisum*.

- **Crop conditions**[1,6]: The three species are adapted to dry land conditions, but a prolonged dryness can reduce considerable the yield, needing a minimum precipitation of 300 mm per year. In areas of high precipitation (up to 1,000 mm per year), waterlogging should be avoided, because these are species susceptible to root asphyxia. Despite the support the cold temperatures, the plantations are always established in areas where cold is not accumulated, and the fields are recommended to have south or south-east orientation, thus light is a clue key in the plant development. The dry wind, so long as it is not very strong, enhances the quality of the essence, because it enables the evaporation of certain undesirable volatile compounds.

- **Multiplication**[1] **:**

  - Sexual**:** generally, the *Lavandula* sp. seeds have bad germination (20-30%, so pre-treatments are recommended to improve it. The best ones are freezing, cooling or application of gibberellic acid.

  - Asexual**:** the cuttings could be done from semi-hard woody stems (summer) or hard ones (winter). These are species with bad rooting capacity, therefore rooting hormones are prescribed. The seedling is usually obtained from cuttings. *Lavandula x intermedia* only can be propagated by cuttings.

- **Cultivation establishment**[1,8,9]**:** Few months previous to the plantation, the soil should be plough at about 50 cm deep (*Lavandula* sp. have a long root), and fertilise with 30-40 tonnes/ha of manure. Before planting, the soil must have worked with the cultivator. The plantation could be done at beginning of spring or in autumn, with seedling or bare rooted plantlets; *Lavandula angustifolia* could be also planted by seed. In areas of severe winter, it is recommended to plant in spring, so that plants could resist the cold weather. The plantation density varies from 7,500 to 12,000 plants per hectare, depending on the soil characteristics and rainfall regime. If some irrigation support could be provided, the plantation density could be increased up to 18,000 plants per hectare. The usual distances between plants are between 50 and 80 cm.

- **Crop mainteinance [1,8,9] :**

  - Irrigation: lavender species could be grown in rainfed conditions, because their water requirements are low. Nevertheless, the production increases if occasionally support watering is applied.

  - Fertilisation: there are crops few demanding in nutrients, thus naturally they grow in poor soils. Then, the annual fertilisation should be balanced and the doses should not be very high. The most adequate fertilisation in dry land is about: 45 UF/ha of N, 30 UF/ha of P_2O_5 and 70 UF/ha of K_2O. It is better to bring phosphorous and potassium in autumn, to allow the rain drain the fertilizer to the roots. Other fertilisation programmes establish the use of 150 kg/ha of complex 15 NPK (15-15-15) mixed with other 150 kg of calcium ammonium nitrate (27%) from the 3rd – 4th year of cultivation.

  - Weed control: the most important problems appear during the first years, when the plant is still small and weed are very competitive. The main weeds appearing in France cultivation conditions are gramineae (*Elytrigia* sp., *Poaceae* sp., *Alopecurus* sp., ray-grass, *Avena loca*) and dycotiledoneae (*Gallium aparine*, Thistles, *Convolvulus* sp., *Polygonum* sp., *Rubus* sp., *Brassicaceae*, etc.). There are 2 types of weed control: position weeding (it the most important one; it is done in winter, when the plant is resting; it allows the destruction of most weeds), catching up weeding (done at vegetative stage, when it is necessary; it could be specific to the type of weeds). It is recommended a mechanical control, keeping in mind that the species are sensible to uprooting. This mechanical control could be combined with herbicides control in the row (the localisation of the spraying allows the herbicide doses decreasing). ITEIPMAI (1992) recommended in the first year of plantation: *Bromacil, Dichlobenil, Hexazinone* and *Metamitron* in plantations established from woody cuttings, and Isoxaben and *Prometrine* in plantations established with herbaceous cuttings, and the following years *Bromacil, Dichlobenil, Hexazinone*. Please, check authorised herbicides in your country. In organic production, weed control should be done manually when required

  - Diseases:

    - *Caused by fungi*: root rot (*Armillaria mellea, Septoria lavandulae, Phoma lavandulae*). To avoid them it is necessary a good drainage of the soil, and remove and burn all the infected plants.

    - *Caused by virus*: the most important is the alfalfa mosaic virus, causing the yellow mosaic and atrophying leaves and stems.

    - *Decay disease ("déperissement")*: cause by a phytoplasme (bacterium) spread by a leafhopper. The methods to fight against is to control the vegetal propagation by plant certification and by selection of tolerant clones, and adopt agronomic techniques more favourable, like rotations.

  - Pests:

    - *Thomasiniana lavandulae* larvae: causes necrosis, dehydration and death of the sprouts. They are hiding tin the bark to the plants buds, making them difficult to control. The most efficient way of controlling this pest is fighting against the adult (small fly) that gets out from the soil in spring. *Sophronia humerella larvae*: eat the young sprouts in spring.*Meligethes subfunatus beatle*: eats the propagating organs of the flowers and can destroy the flowering stalks entirely. *Moths caterpillars eat both leaves and flowers*. Aphids, locusts, mealy bugs, etc..

- **Harvest** [1, 6]: the lavandin (*Lavandula x intermedia*) harvesting is done during flowering, when the most of the plants have between 60 and 80% of the flowers open, while lavender (*Lavandula angustifolia*) harvesting when 50% to 60% of the flowers are open. If they are harvested too late, the plants start producing seeds and the essence contents decreases. The first year of cultivation there is not harvested, because the yield is very low; the following years, it is obtained a harvest per year. The flowering period is different for each specie. In Catalonia (Spain) conditions:

    - *Lavandula angustifolia*: June - July.
    - *Lavandula x intermedia*: July – August (during 40-50 days).
    - *Lavandula x latifolia*: August – September.

The harvest consists in cutting the inflorescence stalks from the woody plant base. It could be done manually (for obtaining lavender bouquets) or mechanically when addressed to distillation. The lavandin could be harvested in different ways: in bulk or, seldom, in bundles. The most common technique is the called "vert broyé" (the spike is cut and chopped when harvested by a harvester, throwing it in the tractor trailer that is directly transported to the distillation facility). For lavender, the most usual technique is in bulk, and the cut flowers are aerated 2-3 days before distillation (for lavender clonal is it preferred the "vert broyé" system).

Figure viii.8. *Lavender harvester (Clier) for "vert broyé" system.*

PROCESSING[6,12]

Figure viii.9. *Distillation of lavender for obtaining essential oil, in Turkey.*

Figure viii.10. *Flowers of lavender could be dried for scented decorations.*

- **Essential oil:** the traditional method is base in a steam distillation during 30-40 minutes.
    - Before distilling: it is recommended to aerate the harvest in the field during 1-2 days to allow the loss of moisture, then increasing the distillation capacity and facilitating the essential oil extraction.

Figure viii.11. *Lavander aerating in the field.*

    - Steam distillation: plant is introduced in a boiler and steam is introduced, dragging the essential oil with the steam flow, which is subsequently refrigerated and condensed, and finally the essential oil can be separated by difference of density with the water .

- "Vert broyé" distillation: meaning "green crushed", because when harvested the inflorescence stalks are crushed by the harvester and left in the same tractor trailer, which is used as a boiler for distilling. The quality of the essential oils differs a little due to the higher water content, and have a slight "green note".

- **Dry flowers**: for obtaining the dry flowers the inflorescence stalks are harvested and dried as fast as possible. The drying could be naturally, but it big amount of plants have to be processed then it is recommended to used heat air drying systems up to 35oC. The stalks should be place vertically to avoid the flowers loss and should be dried shaded for avoid colour loss. Once dried, the flowers are separated from the stalks by beating them, and after are sieved for cleaning and selecting.

YIELDS[1]

The lavender and spike lavender start the production the second year, they reach full production at 4th year and starts decreasing gradually at the 7th year reaching at the 9th year the same yield of the 2nd year.

Dry flower yield[1]

The yield of fresh flowering spikes, of lavender and spike lavender, is varying according to the year of cultivation:

Table viii.1. *Yield of Lavandula sp. in Spanish conditions.*

Year of cultivation	Fresh spikes yield (kg/ha)
First	200-300
Second	1,000-1,500
Third	2,000
Forth	3,000-4,000

Source: Muñoz (1987)

The average annual yield of dry flowers in full production is about 500 kg/ha.

Table viii.2. *Average yield of Lavandula angustifolia and Lavandula latifolia L. in rainfed production conditions during 6 years of cultivation in Catalonia, Spain1*

	L.angustifolia	***L.latifolia***
Dry plant yield (t/ha)		
Annual yield	**1.21**	**0.58**
Dry leaves yield (t/ha)		
Annual yield	**0.44**	**0.14**
Relation dry:fresh	**40:100**	**44:100**
Relation flowers:spike	**37:100**	**26:100**
Essential oil yield (ml/kg of leaves)		
Annual content	**55.45**	**58.47**

Table viii.3. *Average yield of lavandin (Lavandula x intermedia) varieties for essential oil.*

Lavandin variety	Essential oil yield (kg/ha)		Source
	Average	Maximum value	
Abrial	80-120	200	Meunier, 1992
	50-60		Spanish producer
Grosso	100	240	Meunier, 1992
Super	60-70	80-90	Meunier, 1992 Muñoz, 1987
	40-50		Spanish producer

QUALITY[1, 8, 16]

- **Herbal substances:**
  - Lavender flower: Spanish Pharmacopeia specifies that *Lavandula angustifolia* flower should have more than 13 ml/kg of essential oil, but the usual values are between 10 and 30 ml/kg. No reference exists for *Lavandula latifolia*.
- **Main constituents:**
  - *Lavandula latifolia*: Essential oil: camphor, cineol, linalool, borneol.
  - *Lavandula angustifolia*: Essential oil: linalool, linalyl acetate, borneol, cineol. Tannins, coumarins, flavonoids, ursolic acid.
  - *Lavandula x intermedia*: Essential oils: lynalil acetate and linalool. The lavandin essential oils have more quality at higher altitude, with more lynalil acetate and less camphor content. In relation to the varieties, the "Super" have more fragrant quality because is more similar to lavender essential oil.
- **Legislation:**
  - Real Decreto 2242/1984, de 26 de septiembre de 1984, por el que se aprueba la Reglamentación Técnico-Sanitaria para la elaboración, circulación y comercio de condimentos y especias (Spanish regulation on seasonings and spices).
    - Espliego– leaves and flowering tips of «Lavandula latifolia L or L. spica».
- **Standards:**
  - ISO 3054:2017 – Essential oil of lavandin Abrial (*Lavandula angustifolia* Mill. x *Lavandula latifolia* Medik.), French type.
  - ISO 4719:2012 – Essential oil of spike lavender (*Lavandula latifoli* Medikus), Spanish type.
  - ISO 8902:2009 – Oil of lavandin Grosso (*Lavandula angustifolia* Mill. x *Lavandula latifolia* Medik.), French type.

- ISO 3515:2002 – Oil of lavender (*Lavandula angustifolia* Mill.)

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ix. *Mentha x piperita* L.
LAMIACEAE

INTRODUCTION

DESCRIPTION OF THE SPECIES[5]

Figure ix.1. *Plant of Mentha x piperita L. (flowering top at right).*

- **Botanical description:**
    - ***Mentha x piperita* L.** (Tk. Bahçe nanesi, Sp. Menta piperita, En. Peppermint). Herbaceous vivacious plant, with rhizomes. It has a strong spicy flavour. It is an hybrid obtained by crossing spearmint (*Mentha spicata* L. = *M. viridis* L.) x water mint (*Mentha aquatica* L.). The stems are quadrangular, of green or purple colour, and can reach upt to 0,8 m of height. Though the plant has a vertical growing, horizontal and branched stems may appear at the end of the season. The leaves are peciolated, oblong and having dentate margin in some degree; they have green colour, but can turn into purple, mainly with hydric deficit. The flowers are small, white or pale rose coloured; they are grouped in compact bunches.

- **Used parts**: fresh and dried leaves, and essential oil.

ORİGİN AND HABİTAT

- **Origin and geographical description:** peppermint is distributed in all the South of Europe and North of Africa. It is naturalized and seldom spontaneous.

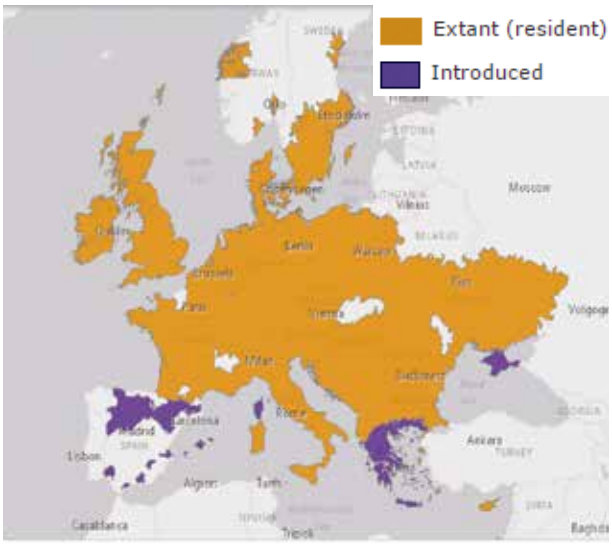

Figure ix.2. *Current distribution of Mentha spicata L. (http://maps.iucnredlist.org).*

Figure ix.3. *Current distribution of Mentha aquatica L. (http://maps.iucnredlist.org).*

- **Habitat**: can be found in both in high and low lands, but always in fresh conditions and in drained soils. It accepts all the climates, although it prefers areas near the water and with sunlight. Is resistant to frost (up to – 15ºC) and grows well in areas with fresh and wet spring and temperate summers but not dry. It can grow in a wide variety of soils (argilo-sandy, calcareous, argilo-calcareous or argilo-siliceous) but prefers calcareous ones. It is recommended that pH is neutral (6.6-7.5), while can grows also in lower pH (5.5-6.5). Soils should be wet and well drained, because peppermint does not resist waterlogging and at high humidity is susceptible to fungi diseases. It requires fertile soils, rich in humus, and it is not tolerant to salinity.

KULLANIMI VE PAZARLAMA [1,2]

- **Uses**: phytotherapy (oral use, cutaneous use), herbal teas, flavours, perfumes and cosmetics.

- **Properties[1,2]:**

    - Peppermint leaf. Traditional herbal medicinal product for the symptomatic relief of digestive disorders such as dyspepsia and flatulence.

    - Essential oil obtained by steam distillation from the fresh aerial parts of the flowering plant. WELL-ESTABLISHED: *Oral use*: symptomatic relief of minor spasms of the gastrointestinal tract, flatulence and abdominal pain, especially in patients with irritable bowel syndrome. *Cutaneous use*: symptomatic relief of mild tension type headache. TRADITIONAL: *Cutaneous and transdermal use*: relief of symptoms in coughs and colds, symptomatic relief of localised muscle pain and of localised pruritic conditions in intact skin. *Inhalation and oromucal use*: relief of symptoms in coughs and colds.

- **Market[1,2]:**

    - Medicinal sector: In traditional use, there exist herbal substance for infusion or other herbal preparation in liquid or solid dosage forms for oral use, and essential oil in liquid or semi-solid preparations (for cutaneous and transdermal use, for inhalation and for oromucal use). In well-established use, the essential oil is traded in gastro–resistant capsules (for oral use), and in liquid or semi-solid preparations (for cutaneous use).

    - Food sector: fresh leaves are used in salads and to flavour beverages. Dried leaves are used for herbal teas and for seasoning. The essential oil is widely used for flavouring foods (confectionery, liquors).

    - Cosmetic sector: according to the Cosmetics Ingredients Database, Mentha piperita leaf is used as refreshing; the herb extract as perfuming; the leaves extract and the juice as skin conditioning; the whole plant's essential oil as masking, perfuming, refreshing and tonic; and the water as deodorant, masking, refreshing and tonic.

    - Other sectors: the essential oil is used for flavouring medicines, tobacco, air fresheners, etc.

TECHNICAL DATA ON CULTIVATION [5, 6, 7]

The cultivation of peppermint could be found in France, north of Italy, Egypt, Balkans, Bulgaria, etc., but the main producer of peppermint essential oil is USA (industrialised crop), followed by India.

Figure ix.4. *Peppermint in the field.*

Figure ix.5. *Peppermint crop in Switzerland (using mulching)*

- **Commercial varieties** [5, 7]:

  For cultivation:

- *Mentha piperita* L. forma *rubescens* (Camus):
  - var. *sylvestris* (Hungary). Robust, rust resistant, very rich in menthone. For dry herb and essential oil.
  - var. *vulgaris* (group Mitcham). Horizontal, rust sensitive, rich in menthol (35-45%), low in limonene. Cultivars for dry herb: "Black Mitcham", "Milly Mitcham", "Ribercourt Mitcham", "Murray Mitcham", "Todd's Mitcham" (the two last are tolerant to Verticillium). Cultivars for essential oil: "Digne", "Turin", "Pessione", "Ribercourt Mitcham".
- *Mentha piperita* L. forma *pallescens* (Camus):
  - var. *officinalis* (group White mint). Erect. For dry herb.
    - Group 1. Vigorous growth, erect rich in pulegone and poor in piperitone.
    - Group 2. Plant few vigorous and less erect, poor in pulegone and rich in piperitone.
    - Group 3. Rust sensitive, rich in menthone and poor in β-cariophyllene and mircene.

Ornamental cultivars:

- *Mentha x piperita* L. forma *citrata* (Bergamot mint): "Basil", "Bergamot", "Citrata", "Chocolate", "Grapefruit", "Lime", "Orange", "Reverchonii", "Swiss Ricola",
- *Mentha x piperita* L. forma *ouweneelii* (Belgiam mint).
- *Other: "After Eight", "Agnes", "Chelan mint", "Crispa", "Extra strong", "Multimentha", "Oma Streib", "Persephone", "Piperita", "Priluskaja", "Reine Rouge", "Strawberry", "Swiss""*

- **Crop conditions**: the vegetative season starts in spring, when stems and leaves start developing form rhizomes. Peppermint flowers between June and September, according to local conditions and variety. The rhizomes are the way of resisting the winter. Although peppermint can be cultivated in many type of soils, best results are obtained in deep, structured soils, allowing the aeration and good penetration of the roots, and with high content in humus. In addition, despite it needs wet soils, do not have tolerance to prolonged asphyxia.

- **Length of cultivation**: a peppermint plantation should not remain more than 2 years, because the yield decreases from 3rd year. In order to avoid nematodes problems in the following crops, it is recommended to leave a fallow period of 3-6 years. Maize or cereals are good precedent crops for peppermintr.

- **Multiplication** [5]: being a sterile hybrid, peppermint propagation can only be done asexually, by rhizomes, cuttings or rooted plants.
  - From rhizomes: it is the simplest propagation method, but involves a high health risk (if rhizomes are infected with nematodes); so it is very important (mainly in old crops) to know if the field was infected. Rhizomes are obtained at the end of vegetative crop (from August to October) with the help of a potatoes harvester, and then selected and cut in 20-30 cm pieces.

- From cuttings: cuttings are obtained mainly in spring and it is taken the upper part of the shoots of mother plants, cutting an approximate length of 7 cm. Once harvested, remaining leaves are removed, leaving just the apical bud and a pair of leaves, and the cutting is damp in a hormonal solution (IBA – Indole-3-butyric acid). Finally, cutting are left to root in seedling trays with some heating.

- From rooted plants: in spring, from April to beginning of May, rooted herbs can be obtained, from old crops or from seedlings. Rooted plants come from a mother plant division, and should have around 10 cm height and developed roots.

- Before planting, it is recommended to work the soil deeply and, if necessary, to add organic manure well composted (20-30 t/ha) and basic fertilising (100 UF/ha P_2O_5 and 260 UF/ha of K_2O). To ease the further weed control, a false seed-bed technique is recommended before field preparation. Density of plantation can be between 70,000 to 130,000 plants/ha, with a spacing of 0.5-0.7 m between rows and 0.15-0.2 m between plants. Planting of rhizomes should be done between November and February, while cuttings and rooted plants during spring. Both materials are planted using a manual planting machine "Super Preffer".

  - By rhizomes: it is necessary that ¾ of the rhizome be white, and to remove the dry or diseased plant parts. The rhizome pieces are planted directly in the field at the established spacing, at a depth of 4-6 cm. Before planting could be stored in wet conditions.

  - By cuttings: they can be planted in the field when they have enough roots.

  - By rooted plants: can be planted directly after the plant division

- **Crop maintenance[5]:**

  - Irrigation: peppermint crop is very demanding in water, requiring 700-800 mm during vegetation. In France is watered with 30-40 mm weekly, from June to August (second harvest) in case of dry herb destination. In drier areas, could be watered more time if wanted a third harvest. For distillation, it is recommended not watering one week before the harvest in order to avoid the loss of essential oils.

  - Fertilisation: Peppermint is demanding in nitrogen and potassium. For a planting density of 100,000 – 130,000 plants/ha and a target yield of 6 t/ha of dry herb, ITEIPMAI (1996) recommends:

    - *Spring*: 100-120 UF/ha of N, first year brought in March-April if planted with rhizomes, and a month later if planted with cuttings and rooted plants. Following years when sprouting. Also annual addition of 100 UF/ha P_2O_5 and 260 UF/ha of K_2O.

    - *After first harvest*: 60 UF/ha of N, followed by irrigation.

  - Weed control: it is very important the first year of plantation, especially until plants are well established. The peppermint ability of propagating by rhizomes provides its spreading, then hindering the growth of weeds. It is important to know the usual weeds in the field, the life cycle of peppermint and the weeds, the critical seasons, implementing preventive measures (correct crop rotations and soil maintenance). Also with herbicides: ITEIPMAI (1996) recommended *Trifluralina* in pre-plantation, *Diquat, Diuron, Paraquat, Prometrina, Simazina* and *Terbacil* in pre-emergence treatment, and *Bentazona, Clopiralid, Fluazifop-p-butil, Linuron, Monolinuron, Napropamida, Piridat, Quizalofop etil, Teburame* and *Terbacil* in post-plantation or post-emergence treatment. *Terbacil* is used at a dose of 800 g/ha. Please, check authorised herbicides in your country.

- Diseases: caused by fungi
    - *Rust:* the most important is mint rust caused by *Puccinia menthae*. The symptoms are the appearance of small orange spots in the lower leaf face, which darken while fungus is developing. The attacks usually take place after first harvest. The same fungus could also affect rhizomes, deforming them and causing white spots. In areas with hotter and dryer weather conditions, this is a less important problem. Several pesticides could be used to prevent or cure this disease (Clortalonil, Mancozeb, Maneb, Triforina); please, check authorised pesticides in your country. Nevertheless, using healthy plant material and rust tolerant varieties is a wise precaution. Another control method consists in ploughing the remaining crop plants in autumn, and in spring, when the sprouts reach 2.5-5 cm height, burn them all in order to destroy the possible resistant fungus structures. After this treatment, the peppermint, regrow free of rust.
    - *Overground part plant diseases:* Anthracnose *(Sphaceloma menthae)* and *Ramularia menthae* cause leave spots; Oidium *(Erysiphe biocellata)*.
    - *Stem diseases: Verticillium* spp. ("Todd Mitcham" and "Murray Mitcham" cultivars are tolent).
    - *Root rot (Rhizoctonia solani)*.
- Pests:
    - *Insects:* flea bettles *(Longitarsus sp.)* cause small punctures in the young leaves in Spring, delaying the plant development; *Cecidomyiidae* and *Lepidoptera* larvae, colonise the stems and cause the plant drying; Chrysomelidae *(Cassida viridis, Chrysomela coerulans and Ch. Menthastri)* attack the overground part plant; mint aphid *(Aphis menthae)* attack the young buds; and the Italian tree cricket *(Oecanthus pellucens)* eats the leaves. These insects could be controlled by pesticides like *Deltametrine*.
    - *Mites:* the one that cause the most important problems is *Eriophyes menthae,* which deform the leaves and stop the plant growth. They can be controlled with sulphur; another mite localised in peppermint is the red spider mite *(Tetranichus urticae)*.
    - *Nematodes:* main attacking peppermint are *Pratilenchus laticauda, Pratilenchus penetrans* and *Zygotylenchus guevari*. They live in the soil and attack the roots, causing withering of the overground plant, forming stands. The best fight against nematodes is prevention: allow to rest the field 3-6 years before plating peppermint again, doing crop rotations and using sanitised plant material when planting.

- **Harvest[5,6]:**
    - Dry herb: In the first year, two harvests could be obtained if planting was done by rhizomes, and just one with other propagation material. In the following years, it can be obtained up to 3 harvests.
        - The first harvest is done when first yellow leaves appear at the stem base and before that flowering buds appear in the main stems (end June).
        - Second harvest is done in the second August fortnight.
        - Third harvest in the second September fortnight.

The necessary harvesters depend on the size of the farm. Small surfaces can use a forage cutter bar jointly with a tractor trailer. In bigger surfaces, a self-loading forage wagon harvesting could be used (e.g. Bonino).

Figure ix.6. *Bonino harvester.*

- Essential oil: the optimal season for harvesting peppermint for distilling is when first flowering buds appear, because in this moment the essential oil and menthol content are maximum. The menthol high content increase with the leaf age up to the start of flowering, decreasing quickly after it; in addition, during flowering undesirable compounds appear, compromising the essential oil quality. The traditional harvesting method is cutting the peppermint with a mower, leaving it 2-3 days tedding, then gathering in bundles and transporting directly to the distillery. Another method consists in cutting and chopping the fresh herb (like forage) and transporting directly (within an hour) to the distillery. Harvesting should be done during hot hours and without dew.

PROCESSING [5]

- **Post-harvest:** Before drying, peppermint is chopped and an airflow system machine separate leaves from stems. The product obtained is a mix of whole leaves and small leaf and stem fragments.

- **Drying:** several technical data have to be considered (average water content of peppermint crop is 80-85%, and have to reach 13-14% after drying; fresh leaves density is around 85 kg/m^3, areal part 65 kg/m^3 and dry leaves density 40 kg/m^3). Recommended drying temperature should be 40-45ºC, above 45ºC the leaves become dark. According to ITEIPMAI (1996) for drying a hectare, after chopping and ventilating the leaves, 8 days are needed using a box drying system of 30 m^3 and a hot air generator of 80.000 kcal/h.

- **Dry herb conditioning:** once dried, the whole leaves could be addressed to herbalists, while small leaf fragments (separated by airflow and successive sieves) are used for tea bags.

- **Distillation:** a pre-tedding peppermint during 36 hours could be distilled in 45 minutes, using a distiller of 4000 litres with a steam flow of 350 kg/ha and 300 g of pressure. If the peppermint is harvested fresh, the distillation last 1 hour and 40 min approximately, increasing the steam flow up to 380-400 kg/h.

Figure ix.7. *Dry whole leaves of Mentha x piperita L.*

YIELDS[5,6, 8]

- The yield and composition of the essential oils varies according of environmental factors (available sunlight, temperature, water, micronutrients, presence of salt in the soil, etc.), plant features (age, variety, etc.) and/or cultivation techniques (harvest season, plantation season, etc.). The long and shiny days increase the content of essential oil, and the advance of the harvest in the first year implies a yield improvement (increase of leaves, essential oil and menthol) in the second year.

- The first year, the yields are different according to the plant material used in the plantation. Then, the yield with rooted plants is 60% lower than using rhizomes.

- The rate leaves:plant is about 40-50%.

Table ix.1. Theoretical yields of Mentha piperita L.

Type of material	First year of cultivation	Following years of cultivation		Source
		First harvest	Second harvest	
Fresh plant		10-15 t/ha	5-8 t/ha	ITEIPMAI, 1996
Fresh leave		6-11 t/ha		ITEIPMAI, 1996
Dry plant	2-3 t/ha	3-5 t/ha		REY, 1997
Dry leaves		1.5-2 t/ha		ITEIPMAI, 1996
Small leaf fragments		1.6 t/ha		ITEIPMAI, 1996
Essential oil		60-70 kg/ha		ITEIPMAI, 1996

QUALITY [3, 4]

- **Herbal substances**:
    - *Menthae piperitae folium:*peppermint leaf consists of the whole or cut dried leaves of Mentha piperita L. The whole drug contains not less than 12 ml/kg of essential oil. The cut drug contains not less than 9 ml/kg of essential oil.
    - *Menthae piperitae aetheroleum*: peppermint oil is obtained by steam distillation from the fresh overground parts of the flowering plant of *Mentha piperita* L..
- **Main constituents**[3]:
    - Essential oil (1-3 %). Main constituents: *menthol*, in the form of (-)-*menthol* (35-55%) with smaller amounts of stereoisomers such as (+)-*neomenthol* (ca. 3%) and (+)-*isomenthol* (ca. 3%), together with *menthone* (10-35%), *menthyl acetate*, *menthofuran*, *cineole, limonene* and other monoterpenes. Small amounts of sesquiterpenes (*viridiflorol*).
    - Flavonoids: *luteolin* and its 7-glycoside, *rutin, herperidin, eriocitrin* and highly oxygenated flavones.
    - Others: phenolic acids and small amounts of triterpenes.
- **Legislation:**
    - *Real Decreto 2242/1984, de 26 de septiembre de 1984, por el que se aprueba la Reglamentación Técnico-Sanitaria para la elaboración, circulación y comercio de condimentos y especias* (Spanish regulation on seasonings and spicess
        - Mint– healthy, clean, fresh or dried, leaves and flowering tops of «*Menta piperita*», Linneo; «*Menta viridis*», Linneo, and «*Menta aquatica*», Linneo, or others.
    - *Real Decreto 3176/1983, de 16 de Noviembre, por el que se aprueba la Reglamentación Técnico-Sanitaria para la Elaboración, Circulación y Comercio de Especias Vegetales para Infusiones de uso en Alimentación* (Spanish regulation on food herbal teas).

- Mint- *Mentha piperita*, plant and leaves.

- **Standards[4]:**

  - ISO 5563:1984 – Dried peppermint (Mentha piperita Linnaeus) – Specitifcation. Covers the requirements for dried leaves or broken or rubbed dried leaves of peppermint. Describes sampling, methods of test, packing and marking. Annex A specifies a recommended procedure for identifying leaves of Mentha rubra Hudson, a method for the detection of carvone is indicated in Annex B and recommendations concerning storage and transport conditions are given in Annex C.

  - ISO 856:2006 – Oil of peppermint (Mentha x piperita L.). Specifies certain characteristics of the oil of peppermint (*Mentha x piperita* L.), with a view to facilitate assessment of its quality. As it is difficult to differentiate the specification of peppermint oils (*Mentha x piperita* L.) from different origins, they have been regrouped in ISO 856:2006. The following origins have been taken into consideration: USA, United Kingdom, France, Italy, India and China.

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x. *Rosmarinus officinalis* L.
LAMIACEAE

INTRODUCTION

DESCRIPTION OF THE SPECIES[5, 6]

Figure x.1. *Rosmarinus officinalis, flowering (left) and vegetative plant (right).*

- ***Rosmarinus officinalis* L.** (Tk. Biberiye, Sp. Romero, En. Rosemary). Perennial plant with many woody branches that reaches more than 1 m of height. The leaves are sessile and opposed, narrow and lanceolate, green greyish in the upper face and whitish in the lower face. The flowers are grouped in the axils of the leaves; they have pale blue colour with a tubular and bilabial corolla, surrounded by a bilabial chalice. The fruit is composed by 4 shiny parts of dark brown colour.

- **Used parts:** flowering tops, flowers and leaves, for obtaining fresh and dry herb, extracts and essential oils.

ORİGİN AND HABİTAT[2, 5, 6]

- **Origin and geographical description:** ALB; ALG; AZO; BAL; BER; BUL; CNY; COR; CVI; CYP; EAI; EGY; FRA; GRC; ITA; KRI; KRY; LBY; MDR; MOR; MXC; POR; SAR; SIC; SPA; TEX; TUN; TUR; YUG.

- **Habitat:** where it is found there are wide populations. It grows from sea level up to 1,200 m, but prefers low lands of semiarid climate, with precipitations ranging from 350 to 500 mm per year. The reported life zone for rosemary is 9-28oC. The flowering could happen all the year, but it is more important from April to September. It prefers clay calcareous soils, pH 7-8, exposed to the sun. A soil too much calcareous involves ferric chlorosis and the yellowish of the leaves. It can grow in poor soils, but develops better in deep, soft and permeable soils. The drought-tolerant plant grows in rocky to sandy soils, as long as there is adequate drainage and a minimum soil depth of about 0.2 m.

USES AND MARKET[3,4, 5, 6, 8]

- **Uses**: phytotherapy (oral use and use as bath additive), culinary, perfumes and cosmetics (soaps, creams, deodorants, hair tonics and shampoos), melliferous.

- **Properties:**

    - *Rosmarini folium* (rosemary leaf) and *Rosmarini aetheroleum* (rosemary essential oil). *Oral use*: Traditional herbal medicinal product for symptomatic relief of dyspepsia and mild spasmodic disorders of the gastrointestinal tract. *Bath additive*: Traditional herbal medicinal product as an adjuvant in the relief of minor muscular and articular pain and in minor peripheral circulatory disorders. Essential oil also *cutaneous use*.

- **Market**:

    - Medicinal sector: Herbal substance (whole or fragmented, dried leaf), herbal preparations: communited herbal substance, extracts (DER 1:17.5-18.9, extraction solvent liqueur wine; DER 1;12.5-13.5, extraction solvent: liqueur wine), expressed juice (DER 1:1.8-2.2 from Rosmarini herba recens), liquid extract (DER 1:1, extraction solvent ethanol 45% V/V), essential oil.

    - Food sector: the dry herb is used for seasoning grilled meat and fish, and jointly with thyme and laurel composes the "bouquet garni" for flavouring tomato sauces and ragout. Fresh herb serves for flavouring vinegars and beverages.

    - Cosmetic sector: according to Cosmetics ingredients database, the *Rosmarinus officinalis leaf* is used as skin conditioning; the *whole plant extract* is used as antimicrobial, refreshing and tonic; the *leaf extract* as antimicrobial, masking and skin conditioning; the *flower/leaf/stem extract* as masking and skin conditioning, and their *water* as masking and perfuming; the flowers extract as antioxidant, deodorant, perfuming and skin conditioning; *the flowering tops and leafs' essential oil* as perfuming, masking and skin conditioning; and the *flower wax* as masking.

    - Antioxidant: rosemary have antioxidant properties among animal and vegetal fats, due to rosmarinic acid, carnosiloque acid and carnosol. Antioxidant extracts are obtained and used for food and cosmetic uses.

    - Other: rosemary is often used as a ground coved along roads because of its beauty and deep root system, which helps stabilize the soils and allows the plant to withstand hot, dry periods. It is also considered a good source of nectar for bees, obtaining appreciated single-flower honeys.

TECHNICAL DATA ON CULTIVATION[5, 6, 9]

The rosemary crops are mainly produced in France, Spain, Middle east countries, Albania, Morocco and Tunis.

Figure x.2. *Field trial of Rosmarinus officinalis in Catalonia, Spain. 2nd year (left) and 6th year (right).*

Figure x.3. *Seedling of Rosmarinus officinalis L.*

- **Biogenetic types**:
    - Type eucalyptol and 1,8 cineole: mainly present in France, Greece, Balkans, Morocco and part of Italy.
    - Type camphor-borneol: mainly present in Spain.
    - Type α-pinene and verbenone: mainly present in France, Corsica and Algeria.

- **Commercial varieties**[6, 9, 10]: in spite of its multiple ornamental and aromatic uses, and the great interest in its cultivation, only a few cultivars or clones have been well characterized. Erect varieties are preferred for cultivation while postrated ones for covering the surface like a carpet in gardening.

Figure x.4. *Rosmarinus officinalis f. "postratus"*

- Varieties[6, 10]:
    - var. *genuina Turril* : forma *erectus, humilis, albiflorus ("*Lady in White");
    - var. *rigidus;*
    - var. *augustifolius;*
    - var. *latifolius;*
    - var. *pubescens*: forma *typica, roseus;*
    - var. *lavandulaceus;* var. *laxiflorus.;*
    - var. *angustissimus*: "Benenden Blue", "Corsicus Postratus", "Corsican Blue"
- Cultivars:
    - Forma *pyramidalis* (erect and high essential oil content).

- Forma *postratus* (for covering gardens): "Rampant Boule", "Sea level", "Lockwood de Forest", "Miss Jessops's postrate", "Gethsemane", "Corsica postratus", "Fredda", "Trewithen", "Sheila Dore", "Jackman's Postrate", "Deben Blue", "Venzano Postrate", "Capri", "Whitewater Silver"

- Other ornamental cultivars[10]: "Abraxas", "Alderly Blue", "Alderney", "Almdondsbury", "Amethyst Beauty", "Argenteovariegatus", "Arp", "Arta", "Athens Blue Spires", "Aureovariegatus", "Aureus", "Avicenna", "Baby P.J.", "Baie d'Audierne", "Baie de Douarnenez", "Barbacue", "Barcelona", "Blue boy", "Blue Lagoon", "Blue rain", "Blue Spear", "Blue Spire", "Bolham blue", "Bowles", "Cap Béar", "Capercaillie", "Cascade", "Charlotte", "Cisampo", "Collingwood Ingram", "Columbian", "Cottage White", "Dancing waters", "Eden", "Élite", "Erectus", "Eve", "Farinole", "Fastigiatus", "Fota Blue", "Foxtail", "Frimley Blue", "Genges Gold", "Gold dust", "Golden Rain", "Gorizia", "Green Ginger", "Guilded", "Gunnel's Upright", "Haifa", "Heavenly Blue", "Henfield Blue", "Herb Cottage", "Huntington Carpet", "Iden Blue Boy", "Iden blue", "Iden Pillar", "Jekka Blue", "Joyce DeBaggio", "Ken Taylor", "Kevock", "Knightshayes Blue", "Lady in Blue", "Lerida", "Lilies Blue", "Lockwood variety", "Loddon Pink", "Logee Blue", "Loupian", "Madeline Hill", "Majorca Pink", "Majorca", "Majorean", "Maltese white", "Marenca", "Margaret of Pershore", "Marinka", "Mason's Finest", "McConnell's Blue", "Minerve", "Miss Jessopp's Upright", "Montagnette", "Mrs. Harding", "Octopussy", "Pat Vlasto", "Pointe du Raz", "Primley Blue", "Punta di Canelle", "Rex", "Roman Beauty", "Rosemarey", "Russell's Blue", "Saint Floren", "Salem", "Santa Barbara Blue", "Santa Barbara", "Sarah's White", "Sawyer's Slect", "Severn Sea", "Shimmering Stars", "Silver Sparkler", "Sissinghurst Blue", "Sissinghurst White", "Sorcerer's Apprentice", "South Downs Blue", "Spanish Snow", "Spice Island", "Subbury Blue","Suffolk blue", "Sunkissed", "Tipsy", "Trusty", "Tuscan Blue", "Ulysee", "Vatican Blue", "Wilma's Gold", "Wimtim01", "Wisley Blue", "Wolros".

- **Multiplication:**

  - Sexual: a thousand seeds weight about 1,038 g and have a slow and irregular germination in dark conditions (only 40% of germination after 21 days at 20ºC). The seeding is done at the end of February beginning of March. It needs about 6 months.

  - Asexual: rosemary could also be propagated by cuttings, being safer and quicker. Semi-woody cuttings of 10-15 cm throughout the vegetation perido, in March-April or September-October, needing 2-3 months for rooting.

- **Length of cultivation:** it can remain from 5 to 10 years.

- **Crop conditions**: : the rosemary requires an adaptability study in the planned fields, because the altitude, soil quality and rainfall could affect in the production and yield. If the weather conditions are adequate referring to rainfall, it can flower all the year.

- **Cultivation establishment[5,6]**: the plantation is done by seedlings or cuttings, produced in the greenhouse, during autumn or spring. Before planting, the field should be subsoiled and harrowed, and manure added. Planting density from 10,000 to 20,000 plants/ha. The distance between rows depends on the maintenance or harvesting machine (100 to 150 cm) and 50 cm between plants (average 15.000 plants/ha).

- **Crop maintenance[6]**:

  - Fertilisation: annual mineral fertilisation is brought at the end of winter (100 UF of N, 100-150 UF of P_2O_5 and 100-150 UF of K_2O.

  - Weed control: It is recommended a mechanical weed control between rows, and in the

row can be done manually or by using a mulching system. Also with herbicides: ITEIP-MAI (1991) recommended terbacil (applied 3 weeks after cuttings plantation and at the end of winter each year, about 800 kg/ha after second year), *dichlobenil, diuron, lenacil, linuron, terbutryne +metobromuron*.

- Diseases:
  - *Caused by fungi: Botrytis* (drying of the upper plant after wet periods on young sprouts), *Ascochyta rosmarini* and *Coutura castagnei* can cause losses on leaves.
  - *Withering:* can be also cause by intensive harvesting (inadequate height of cutting).
- Pests:
  - *Caused by insects:* dark larvae of a coleopter *(Chrisolina americana)* and a chrysomela *(Arima marginata)* can cause important losses because attack tender sprouts apex. Other are cited: Tortrix pronubana, Lepyronia coleopterata and Phylaenus spumarius. Treatements would be applied in case of strong attack.

- **Harvest**: : first harvest takes place at one or one and a half year after plantation. For obtaining dry leaf, the harvest is done before flowering, in spring (March-April), even in autumn (September) except it summer has not been dry. For obtaining fresh herbs, the harvesting could be done all the year (necessary to have irrigation). For obtaining essential oil, the maximum content is during the flowering (May-June). In intensive cultivation, the rosemary could be harvested with a forage harvester. The height cut should be 30 cm minimum for not compromising the reshooting.

PROCESSING[6, 9]

***Figure x.6**. Dry leaves of Rosmarinus officinalis L.*

- **Drying**: the branches could be dried artificially in heated dryer (drawer system) at temperatures between 30-40ºC, and the plant pile could reach from 1.5 to 2 m of height (3-4 ton of fresh plants in a drawer of 20 m^2 / 100 kg of fresh plant per m^3).

Figurex.7. *Drawer dryer (hot air passes below the plant pile).*

- **Dry herb conditioning:** the dry leaves are obtained by threshing with the aid of a threshing machine. The dust is then removed by means of sieves equipped with different openings.

- **Distillation:** the essential oil is extracted from flowering tops by steam distillation or the use of organic solvents.

YIELDS[5]

Table x.1. *Theoretical yields of Rosmarinus officinalis L.*

Type of material	First year of cultivation	Following years of cultivation	Source
Fresh plant		10-16 t/ha	ITEIPMAI, 1991
Fresh plant		2 – 4 t/ha	BURILLO, 2003
Dry leaves		2.5 – 4 t/ha	ITEIPMAI, 1991
Dry leaves		1.5 – 2 t/ha	HORNOK, 1992
Fresh sprouts (for freezing)	7-9 t/ha	2nd year: 15-20 t/ha	ITEIPMAI, 1991
3rd year: 15-17 t/ha		% 0,5-0,6 taze bitki	ITEIPMAI, 1991
4th year and following years: 10 t/ha	ITEIPMAI, 1991	% 0,72-0,95 taze bitki	BURILLO, 2003
Essential oil		0.5-0.6 % of fresh plant	ITEIPMAI, 1991
Essential oil		0.72-0.95% of fresh plant	BURILLO, 2003
Essential oil		10 – 15 kg/ha	HORNOK, 1992

According to field research done in Aragon (Spain):

- the rosemary has a biannual production, and after the 4th year it does not longer produce. The average production of fresh biomass was from 2 to 4 t/ha and year, and the dry leaves rate is about 20%.
- Essential oil: from 17.2 to 37.2 kg/ha and year. A yield rate from 0.72% to 0.95% (essential oil from fresh biomass).

QUALITY[5, 7, 11, 12]

- **Herbal substances**:
    - Whole or fragmented, dried leaf. It contains not less than 12 ml/kg of essential oil and not less than 3 per cent of total hydroxycinnamic derivatives expressed as rosmarinic acid, both calculated with respect to the anhydrous drug.

- **Main constituents:**

    - Essential oil (1-2.5 % in dry plant; 1.1 to 2% in leaves and 1,4% in flowers). Composition may vary according to the chemotype or other factors. Characteristic components: ***1,8-cineole*** (20–50 %), ***α-pinene*** (15-26 %), ***camphor*** (10-25 %), *bornyl acetate* (1-5 %), *borneol* (1-6 %), *camphene* (5-10 %) and *α-terpineol* (12-24 %), *limonene, β-pinene, β-caryophyllene* and *myrcene*.

    - Phenolic diterpenes: *carnosol* (up to 4.6%), *carnos(ol)ic acid, rosmanol, isorosmanol, epirosmanol and rosmaridiphenol.*

    - Hydroxycinnamic derivatives: ***rosmarinic acid*** (2-3%).

    - Flavonoids: *nepetin, nepitrin, apigenin, luteolin.*

    - Triterpenoids: *oleanolic acid, ursolic acid, α and β-amyrin, rofficerone.*

    - Others: hydroxylated fatty acids, organic acids, tannins, mucilages, etc.

- **Legislation:**

    - *Real Decreto 2242/1984, de 26 de septiembre de 1984, por el que se aprueba la Reglamentación Técnico-Sanitaria para la elaboración, circulación y comercio de condimentos y especias* (Spanish regulation on seasonings and spices).

        - Rosemary– leaves and flowering tops of *«Rosmarinus officinalis», L*inneo, harvested during flowering.

    - *Real Decreto 3176/1983, de 16 de Noviembre, por el que se aprueba la Reglamentación Técnico-Sanitaria para la Elaboración, Circulación y Comercio de Especias Vegetales para Infusiones de uso en Alimentación* (Spanish regulation on food herbal teas).

        - Rosemary- Rosmarinus officinalis, leaf.

- **Standards**[12]:

    - ISO 1342:2012 – Essential oil of rosemary (*Rosmarinus officinalis* L.). Specifies certain characteristics of the essential oil of rosemary (*Rosmarinus officinalis* L.), in order to facilitate assessment of its quality.

    - ISO 11164:1995 – Dried rosemary (*Rosmarinus officinalis* L.) – Specification. Provides the requirements for dried rosemary (*Rosmarinus officinalis*) leaves in cut form.

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