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Review

Ecology, Cultivation, Composition and Utilization Of *Salvia Officinalis L. In Greece:* A Review

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Medicinal and aromatic plants have gain new attention in the past years due to their content in bioactive compounds and recognized health-promoting effects. One of the most important herb known is *Salvia officinalis L.*, rich in essential oils, phenolic compounds and vitamins. Also, it has several uses and medicinal impacts (e.g. antibacterial, antiviral, anti-oxidative, anti-inflammatory, antidiabetic and antitumor activities). Hence, the aim of this work is to review the literature on ecology, cultivation, composition and utilization of *Salvia officinalis L.* a standard literature search was performed using several electronic databases for identification of peer-reviewed articles. Medicinal and aromatic plants are a very important resource for the people for two reasons: They have contributed to the prosperity of the people through the health care program, and as a source of income derived from production of raw materials.

Keywords: Aromatic plants, sage, ecology, cultivation, utilization.

INTRODUCTION

From ancient times till today, a large amount of species of the Plant Kingdom used by humans for flavoring and pharmaceutical properties. That type of plants have the ability to accumulate odoriferous volatile ingredients in several of their organs which serve to attract beneficial insects, animals and birds and in the same time repel the harmful ones. In international terminology these plants are referred to as "Medicinal and Aromatic plants" (Medicinal and Aromatic Plants, MAPs). All plants that are fragrant are also medicinal, but in contrast, some pharmaceuticals are not necessary aromatic (wort, belladonna, etc.). Medicinal plants, which are not aromatic are too few, compared with the number of plants that are aromatic and pharmaceutically in the same time (Koutsos, 2006).

The first instructions for the use of medicinal plants recorded in Egyptian papyri which date from 2000 BC. This material seems to have been copied from other sources, which were written several centuries earlier (Castiglioni, 1958). Hippocrates (460 BC), "Father of Medicine", reports in his treatise of about 400 plants, most of which are medicinal and aromatic, Theophrastus (347 BC) describes a large number of native medicinal plants and Dioscorides (1st century BC) in the "De Materia Medica" mentions 600 medicinal plants. Fleisher and Fleisher (1988) in their comparative study on traditional use of aromatic and

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medicinal plants type "oregano" in Mediterranean concluded that a plant named hyssop (hyssop), which is mentioned in the Bible, is the carvacrol chemotype of the plant *Origanum syriacum L.* and it was used as a medicine and seasoning. Moreover, several plants were found to have similar composition to that of oil hyssop, including *Coridothymus capitatus L.*, *Satureja thymbra L.* and *Origanum vulgare L.* (Baricevic and Bartol, 2002).

The Greek Flora lists more than 6,000 species of Tracheophyta. 5-6 hundreds of these species are classified as aromatic and medicinal plants, which demonstrates that Greece has an advantage over other European countries in such conditions of herb's production. The soil and climatic conditions, moreover, are particularly prone to develop herbs which provide excellent quality products (Papanagiotou et al., 2001).

Plant Morphology

Sage (*Salvia officinalis L.*) is a perennial subshrub which can reach up to 60 cm in height and its stems are erect with hairy green branches. Leaves are petiolate, opposite, simple, elongated and have rugose surface which in upper surface are greenish but in the lower leaf surface there are white hairs. Flowers are on a long pedicel with 5-10 flowers that form spurious composed spike and the calyc is approximately 14 mm long and hairy. To sum up, flowering period is from March to July and that depend on the habitant climate condition of the environment (Grdisa et al., 2015).

Botanical description

The genus Salvia is classified in angiosperms, dikotylon plants and belongs to the order Lamiales, family of Labiatae (Lamiaceae or Labiatae). Genus Salvia includes aproximatelly up to 900 species and it is one of the largest genera of Labiatae (Hedge, 1992). The plants of this family is herbaceous, shrub or tree and bear glandular hairs on the leaves and stems. These hairs excrete essential oils. The stems of these plants are usually square and have usually crosswise opposite leaves or vertebrae, usually simple, without stipules. The flowers are born individually or several together in the leaf axils, usually as apical or ambivalent, trusses or ears. The flowers are perfect, radius shaped, with or without bracts. The calyx is normally tubular or bell shaped, without bearded throats, and divided into two parts or lips, the upper lip entire or three-toothed, the lower two-cleft.

The corolla is bell shaped and composed of 4-5 lobes, are two-lipped rarely one-lipped or radius shaped. It is possible the upper lip of the collar to consist of 3, 1 or no petals and the below one of 2 or 4 petals. The stamens are 2-4, and often form uncontoured pairs. Often the flowers are observed with stamens. The ovary is epiphytes and clusters, has four lobes, and also consists of two carpels, which form four spaces.

Species grown or cultured in Greece

Lamiaceae family in Greece count more than 270 taxa and many of them are endemic species. Genus Salvia include more than 20 species in Greek flora (Dariotis, 2016). From 20 species, only three of them (*Salvia officinalis L.*, S. *fruticosa* and S. *pomifera*) are used as spices or as ingredients of folk remedies.

Salvia officinalis

It's a small aromatic evergreen shrub. Its stem is square, multibranched, fluffy, 30-50 cm high, with bulbar or lanceolate leaves, serrated, fluffy, and green. It grows both in warm and cold regions (islands, mainland Greece) and in calcareous, medium fertility and arid fields.

Salvia pomifera

It's a shrub, 0,5-1 m high. There are many glandular stems on the top. Leaves are petiolate, oval or oblong oval, a little serrated. It's widely known as bitter sage (Cretan sage) which grows in South Greece at an altitude of 0-500 m, in W. Crete up to 1200 m, in stony hillsides (semi-shrub plant, 1 m high, with smooth round galls on stems, which are eaten by the Arabs and said to quench thirst. In old times villagers collected these galls at May Day and they boiled them in sugar.

Salvia sclarea

It is commonly known as erythranthis sklarea, gorgogiannis etc. It's located in in stony places in Thrace, Macedonia, Epirus, Thessaly, Peloponnesus and Ionian islands. It is also native to France in limestone hills, in Provence and in the seaside Alps. When it's cultivated, can reach a height of 1 to 1.5 meters.

Crop Ecology and Cultivation Practices

Propagation

Propagation of sage could be both sexually (seeds) and asexually (cutting and micro-propagation). Optimum temperature for sage's seeds to germinate range from 10-25^{o}C and it is favored by darkness. Sexual propagation is not recommending because of low germination of seeds and low seed viability. Asexually propagation is more favorable. Cutting is a method in which segments of 8-12 cm length cut from annual stems and continually they planted for rooting (Karamanos, 2000). Appropriate time for cut rooting is from period spring to the end of autumn (Nikolas et al., 2005). Micro-propagation could be

Figure 1. *Salvia officinalis* L. in an experimental field at University of Thessaly (Greece)

Figure 2. Efflorescent *Salvia officinalis* L. in an experimental field at University of Thessaly (Greece)

Figure 3. Distribution of Salvia *officinalis* L. in Greece. (Arne Strid & Panayotis Dimopoulos, Flora Hellenica database, personal communication).

Figure 4. *Salvia pomifera (http3).*

Figure 5. *Salvia sclarea (http4)*

especially by using either nodal segments (Gostin, 2008) or axillary and apical buds (Wielgus et al., 2011).

Fertilization-Irrigation

Fertilization, is one of the most important practices to obtain high yield in an agriculture system. Nowadays, the intensive agriculture productions require balanced and particular fertilization to achieve the optimum quality and high yield (Rioba et al., 2015). In order to have an increase on crops quality, especially for medicinal and aromatic plants, organic fertilization is estimated as more acceptable comparing to chemical fertilization. (Abou El-Fadl et al., 1990). To be more specific, the use of appropriate fertilizers (vermicompost and N fixing bacteria) result in positive effects in both dry matter and essential oil yield in sage and also increase water holding capacity which limits the detrimental effects of drought (Govahi et al., 2015). A promise cultivation practice for increasing nutrient absorb (especially phosphorus) is mycorrhizal colonization. Lots of researchers emphasize to positive effects of mycorrhizal colonization to growth of sage (Geneva et al., 2010; Tarraf et al., 2017; Tarraf et al., 2015). Comparing organic and conventional systems in relation to chemical composition of sage, it have been found that in organic systems, sage consists of more dry matter, phenolic acid, vitamin C and total flavonoids, otherwise in conventional system produce more carenoids (Kazimierczak et al., 2015).

Water is considered to be one of the most important and limited natural source in many Mediterranean countries. It has been found that drought stress frequently enhances the concentration of secondary plant products but it can causes reduce to the growth of the most plants (Selmar and Kleinwachter, 2013). Undoubted, water deficit cause a reduction on dry matter of sage (Govahi et al., 2015). In addition, it has been found that drought has an influence on the content of pharmacologically active secondary metabolites in aerial parts of sage (*Salvia officinalis L.*) and can be used as a cultivation practice to enhance the health-promoting phytochemicals (Bettaieb et al., 2011). A moderated stress condition enhances the synthesis of terpenes producing lesser biomass production (Nowark et

al., 2010). Irrigation is recommended to be in spring in order to induce a rapid plant growth and could be a second irrigation after the first cutting in order to help regrowth (Karamanos, 2000).

Experiments conducted to University of Thessaly's field found that sage reached a production of 3982 kg ha^{-1} applying organic fertilization (total N 6%) of 40 kg ha^{-1}, leaf area index 3.2 and a height of 52.3 cm, when cutting period was in July. Also, irrigation (100% of evapotranspiration) had a positive effect on sage productivity compare with drought stress treatment (4972 kg ha^{-1} vs 2346 kg ha^{-1}), on plant's height (64.7 vs 33.4) and leaf area index (4.3 vs 1.5).

Weed control

One of the major problem of sage cultivation is the weed competition and the critical period to control weed is after planting and those following harvest. Mitchell *et al*. (1995) claim that hand-weeding is the most labour requiring thought the most successful mean of control. Mechanical weeding require numerous treatments, so that it can be expensive in weedy fields (Karamanos, 2000). Also, herbicides could be a solution to the problem of weed control. Resent research state that some herbicides (linuron, linuron plus quizalofor, metribuzin, metribuzin primisulfuron) result in effectiveness results in weed control without negative effects to essential oil composition and content (Zhalnov and Zheljazkov, 2016). It can be concluded that weed control on sage cultivation is a major problem especially in case of biological system where chemical is not allowed.

Making an effort to relate plant's richness to soil parameters, Skoufogianni *et al.* (2017) found that in an organic cultivation of sage in the first establishment year, plants' richness related mostly to potassium, phosphorus and organic matter.

Harvest

Harvesting depends mainly on the time that plants have the maximum production of commercial products (in sage: dry matter and essential oil). It have been proved that yield of fresh herbal and essential oil depends on harvesting season, phenological phase and cutting height (Zutic et al., 2003). Thinking about harvesting season, Verma et al. (2015), propose harvesting in summer period when the criteria is yield and quality character of essential oil while Zutic et al. (2003), propose to be two harvesting periods for obtaining essential oil and good quality fresh herb: first from milk maturity to seed maturity and second 70-100 days later. Farhat et al. (2016) studying about phenological phase found that the highest yield of essential oil is in flowering phase. Cutting height should be 10-15 cm above the soil level because it helps sage regeneration (Zutic et al., 2003). After harvesting, biomass should be dry and it could be done either under shade or artificial drying. Artificial drying could be done with two methods in sage: freeze-drying and oven drying at 30°C and 60°C (Veskutonis, 1997). A more recent research show that drying aerial parts of sage by oven at 45°C, by infrared at 45°C and at ambient air, result in small losses of volatile compounds compared with fresh material and more specific the highest essential oil yield were obtained by infrared drying at 45°C (Sellami et al., 2012).

Essential Elements Composition and Salvia Utilization

Composition of sage

Sage consists of essential oil (up to 3%), hydroxycinnamic acid derivates (about 3.5%), flavonoids (1%), phenolic diterpenes, triterpenes, phenolic glycosides, polysaccharides and other constituents. Essential oil is consists of monoterpenoids (α-β thujone, camphor, 1,8cineol) and sesquiterpenoids (α-humulene, viridiflorol, β-caryophyllene) (Bradley, 2016).

Essential oil

Firstly, from Salvia's species, *S. officinalis L*. is considered to have the highest oil yield with higher total ketone content and lower total alcohol content (Newall *et al*., 1996). In order to have an optimal cultivation systems for obtaining volatile oil, crops should be accessed to variation in cultivation and environmental management factors. Especially, cultivation of Salvia because of xerophytic characteristics it has been assumed that production of high-quality oil is correlated with stressful condition (Hay, 1993). It have been mentioned that yield and the change in essential oil's composition are influenced by environmental conditions (Moksimovic et al., 2007; Russo et al., 2013). As far as composition of essential oil concerns, it is characterized by high content of oxygenated monoterpenes and the main composition of essential oil is camphor, cis-thujone and a-humulenen (Moksimovic et al., 2007). Specifically, according to Lakusic et al. (2013), the yield oil of sage varied between 0, 2 to 2,9% and it depends on geographical origin of plants. One other important factor that should be kept in mind is the developed stage of leaves, since leaves are the commercial part used for extracting essential oil and have been found that new leaves have less essential oil comparison to developed leaves on sage plants (Lukusic et al., 2013). Verma et al. (2015), mentioned that two factors (season and plant part) influence on the chemical composition and content of essential oil on *Salvia officinalis L*. and they found that essential oil from aerial parts of the plant is higher in summer (0.43%), lower in rainy season (0.31%) and spring (0.25%) and the lowest value is in autumn (0.22%). In addition, they claim that from

inflorescence plant part has the highest price (0.60), followed by leaf (0.23%) and stems (0.15%) when the collection became in the flowering stage in the spring. In the same research, the major composition of essential oil is cis-thujone, (E)-caryophyllene, manool, viridiflorol, 1.8 cineole, camphor, borneol, α-humulene, β-pinene, trans thujone and from them cis-thujone and manool were higher in stem oil, while (E) caryophyllene and viridiflorol in inflorence oil and finally leaf oil is higher in camphor. It seems that physiological stage could be a major factor influence significantly the yield and composition of essential oil since essential oil of *Salvia officinalis L*. get the maximum value to the flowering stage and the minimum at the vegetative stage (Farhat et al., 2016). According to the same researcher, composition of essential oil depends on physiological stage of plant and in flowering stage it is higher in 1,8 cineole, fruiting stage characterized by high amount of camphor and α-thujone and finally vegetative is rich in viridiflorol. To sum up, in Greece region, compounds of essential oil of *Salvia officinalis* L. are borneol (1.6%), (E)-β-caryophyllene (4.9%) and viridiflorol (1.1%) and the total oil were found to be 21,8 mL kg^{-1} (Raal et al., 2007).

Utilization

Sage, like all herbs, is widely used in many fields. First of all, is commonly used in cooking, because of its excellent and unique flavor. Especially, in western cuisine, is one of the most popular culinary herbs. Also is used as an ingredient in cosmetics, soaps and perfumes. Upon application to the skin is useful insect repellent. Dried leaves in closet between clothes, it repels moths (http1).

Modern research has confirmed the antiseptic, estrogenic, anti-inflammatory and antimicrobial action. It's used as a form of infusion or decoction to gargle for treating sore throats by laryngeal inflammation, bronchitis, etc. Also, it is considered to be good digestive tonic and helpful in fatty meats' digestion. Its estrogenic activity makes it useful drug for irregular menstruation and reduces hot flashes and sweating. Great is the sage consumption by people with diabetes as it reduces the sugar. It also makes it possible to reduce muscular spasms (http2).

Moreover, it is found that sage (*Salvia officinalis L*.) has allelopathic effects, which means the ability of plants to produce and to release in the environment chemical compounds that can affect positively or negatively to the development on other plants or microorganisms (Cheng and Cheng, 2015), of some cultivated plants such as maize (*Zea mays L*.), sunflower *(Helianthus annus L.)* and tomato (*Lycopersicum esculentum* Mill) (Simoneto and Cruz-Silva, 2010). Ravlic et al. (2016), state that sage, fennel and rue seed and their biomass have both negative and positive allelopathic effect on weed species hoary cress. Coverage soil with dry mass of sage show to have effect on tomato and guinea grass but not on chia plants (Cruz-Silva et al., 2016) and extracts of sage could be as an alternative.

CONCLUDING REMARKS

Aromatic and medicinal plants have gained much popularity in European and global markets in the last decade. The yields of such plants and particularly of *Salvia officinalis L* obtainable in Greece are of high quantity and best quality. Thus, the introduction of sage in crop rotation systems in Greece should be seriously considered for the near future. Extensive cultivation of sage might be proved to be highly beneficial also for the environment, with respect to biodiversity conservation and minimizing soil erosion, land degradation and desertification processes in many degraded lands of the semi-arid zone in Greece, where sage cultivation might be proved to be ideal.

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