Emirates Journal of Food and Agriculture. 2022. 34(7): 628-633
doi: 10.9755/ejfa.2022.v34.i7.2889
http://www.ejfa.me/

SHORT COMMUNICATION

Cultivation possibilities of *Salvia aramiensis* in the continental and the mediterranean type of climate

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ABSTRACT

Salvia aramiensis Rech., a perennial species native to the Eastern Mediterranean, is used for medicinal purposes and as herbal tea. The cultivation possibilities, herbage yield, essential oil content and components of *S. aramiensis* were investigated in two different elevations (Adana 28 m above sea level (asl) and Pozantı 1200 m asl) in the continental and Mediterranean type of climate for 2 years. The measured plant parameters were plant height, herbage, leaf and flower fresh and dry yields, essential oil content and composition. Plant height differences were not significant at both locations and years. The highest herbage yield (7406 kg ha-^{1}) was obtained from Adana in the 1st year and the lowest was (2222 kg ha-^{1}) obtained in Pozantı in the 2nd year. Essential oil contents varied between 1.5 and 2.9%. The highest leaf essential oil content and yield were obtained from Adana in the 2nd year and the lowest was obtained from Pozantı in the 1st year. The major essential oil found in the leaves and the flowers were α-pinene, 1,8-cineole, β-pinene, borneol, camphor and viridiflorol at both locations. The results of the study showed that *S. aramiensis* could better adapt and successfully cultivated under plain conditions of the Eastern Mediterranean region.

Keywords: Essential oil content; Herbage yield; Oil components; Sage; *Salvia aramiensis*.

INTRODUCTION

Salvia aramiensis Rech Fil. is a perennial woody species found in Amanos mountains and in the Southeastern Anatolia specific to the Eastern Mediterranean element in the squares of C5 (close to sea) - C6 (border with Syria) in nature according to the Davis grating system (Davis 1982; Turkish Plants Data Service (TÜBİVES 2021) (Fig. 1). *Salvia aramiensis* is used, like the other commercial sages, as culinary purposes and in folk medicines to treat colds, coughs and stomach pains (Bahadırlı, 2020). Dried leaves of *S. aramiensis* are used for as herbal tea.

Salvia aramiensis widely distributed on the hills at altitudes of 20 up to 400 m in the East Mediterranean region of Turkey. Currently, there has not been any report on the cultivation of *S. aramiensis* in Turkey, since almost all of the consumed *S. aramiensis* comes from the nature. The essential oil content of *Salvia* species varies between 0.02 and 3%. Essential oil content is greatly affected by environmental factors such as light (Circella et. al. 1995; Peer and Langenheim 1998; Johnson et al. 1997) nutrient availability (Hornok 1983; Franz 1989), growing season (Kokkini et al. 1997) and genetic make-up of the plant (Skoula et al. 1999; Skoula et al. (2000).

It can grow up to 1.5 m. The leaves are simple, petiolate. Two - ten flowered verticillasters were condensed at the tip of the plant. It has bracts and bracteoles. The flower colors range from mauve to pink. Flowering occurs from April to June.

About 86 *Salvia* species naturally grow in Asia Minor (Davis 1992), and many of them are endemic. Essential oil content of some *Salvia* species grown in Asia Minor varies between 0.1-4% (Tuzlacı 1982; Şarer 1983; Baytop 1989; Tanker et al. 1985; Şarer 1986a; Şarer 1986b; Bayrak and Akgül 1987; Başer 1993; Başer et al. 1995; Ceylan 1995; Özgüven et al. 1995; Kırıcı et al. 1996, Yenikalaycı and Özgüven 1999; Demirci et al. 2002a; Karaman et al.

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Received: 20 December 2021; **Accepted:** 24 June 2022

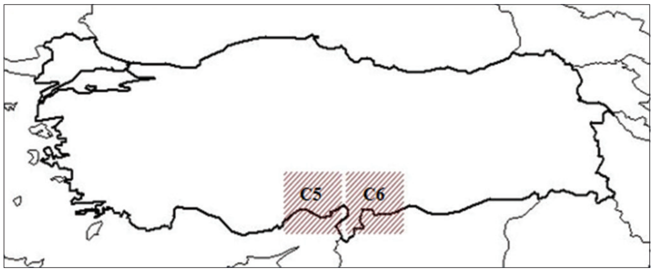

Fig 1. Distribution areas of *Salvia aramiensis* Rech. Fil.

2007). However, no research has been conducted most of the *Salvia* species grown in Anatolia. A few studies have been done on *S. aramiensis*.

Among the *Salvia* species collected from the Eastern Mediterranean Region, the highest genetic difference was obtained between *S. aramiensis* and *Salvia aucheri* spp. *aucheri* species, while the least genetic difference was determined between *Salvia hypergeia* and *Salvia tomentosa* species with 22.62% (Çardaklı et al. 2017). They emphasized that the uncontrolled collection of *Salvia* species from the nature threatens the existence of *Salvia* species. Therefore, it is necessary to start breeding programs as well as to protect the species and carry out genetic characterizations.

Salvia aramiensis, Salvia aucheri var. *aucheri*, and *Salvia fruticosa* had similar essential oil components and 1,8-sineole contents of these species were 55.6%, 39.2% and 52.8%, respectively (Özcan et al. 2019; Aşkun et al. 2008).

In Turkish flora, the genus *Salvia* is represented by 106 taxa and 93 species, 53 of which are endemic (Özhatay et al. 2011; Hedge 1982).

Kayıkçı and Oğur (2020) stated that *S. aramiensis* is one of the rare species in Turkey and it is classified in the VU (Vulnerable-Sensitive) category at the Regional and National level according to the International Union for Conservation of Nature (IUCN) categories. The researchers reported that the cultivation of *S. aramiensis*, which is collected from nature and consumed as herbal tea, will reduce the risk of extinction.

Salvia is one of the most exported essential oil bearing plants in Turkey. In 2020, 2.2 ton of dry sage leaf and 27.396 kg sage essential oil were exported and 8.155.503 and 173.504 US dollars were obtained, respectively (TÜİK, 2021). The trade of *Salvia* is carried out by collecting from nature and by cultivation in different provinces (Elmas 2021).

It is difficult to obtain standard products of the desired quality from naturally collected *Salvia* species. In addition, excessive and unconscious gathering leads to overexploitation, unsustainable depletion of *Salvia* populations and depletion of genetic resources. For this reason, in order to ensure its sustainable use, it is necessary to expand *Salvia* cultivation with high quality standards required for the world markets.

The purposes of the current study were to determine herbage yield, essential oil content and composition of *S. aramiensis* grown under the Mediterranean and the continental climate conditions and to determine the cultivation possibilities of *S. aramiensis* as an alternative crop in both clime types.

MATERIALS AND METHODS

Salvia aramiensis seeds were collected in Hatay/Dörtyol, Turkey at 28 m above the sea level at the end of June 1997 and 1998.

Salvia aramiensis Rech. Fil. is a perennial herbaceous plant that grows in *Pinus brutia* woodlands, rocky places, and limestones at 100-1500 m asl. in Hatay province, Turkey.

The field experiments were conducted for three years in an irrigated red silt loam soil at two altitudes in Adana (23 m) and in Pozantı provinces (1200 m), where the sampling of the harvested plants were taken in the 2nd and 3rd year, that is, 1st and 2nd year in advance, respectively. The experimental design in both altitudes was randomized complete block (RCBD) with 3 replications. All plots in both altitudes consisted of four 6-m rows. The seedlings of *S. aramiensis* planted into the soil with 60 cm inter-row spacing and 40 cm inter-plant spacing. Prior to harvest, the center two rows were end trimmed to final length of 5 m. At planting, sprinkler irrigation was used to help seed germination and emergence. Fertilizer was applied prior to planting at a rate of 80-80-0 kg ha^{-1} NPK. After each harvest 80 kg ha^{-1} N was applied as a top fertilizer. *S. aramiensis* seedlings were transplanted on April 20 and May 16 for Adana and Pozantı, respectively. The plants were not tall enough to harvest in the first year of the study. Therefore, plants were harvested in the second and third years of the study. In the second year, plants were harvested in June 2 and July 15 in Adana and Pozantı, respectively. In the third year, plants were harvested in June 7 and July 18 in Adana and Pozantı, respectively. Before the harvest, randomly selected five plants were removed from the first and fourth rows of each plot to measure plant parameters. The measured plant parameters were plant height, fresh and dry yields of herbage, fresh leaf yield, dry leaf weigh, fresh flower yield, dry flower yield, fresh stem yield, dry stem yield, fresh ratio of leaf, flower and stem, leaf essential oil content, essential oil yield and composition. After harvest, leaves and flowers of the plant were immediately separated and their fresh yields were taken, the plant parts were dried under shadow. Leaf and flower volatile oil were distilled with a Neo-Clevenger apparatus. Twenty grams of dried flowers and leaves were separately put in 500 mL flask containing 250 mL of water, and boiled for 2 h. The condensate was collected in the receptive flask, and the volatile oil was removed with the help of a pipette. The extracted volatile oils were stored in the tightly closed glass vials in the refrigerator at 4 °C. The essential oil was analyzed by an HP (Hewlett Packard) 6890 series GC/MS, equipped with a fused silica capillary column supelco (50 m, 0.25 mm internal diameter, film thickness 0.2 μm). The column temperature was programmed from 120 to 250 °C at a rate of 5 °C/min. After staying 5 min at 200 °C the column temperature was gradually increased at a rate of 10 °C/min up to 240 °C. Helium was used as the carrier at the flow rate of 1.5 mL/min with 2-μL injection volume.

RESULTS AND DISCUSSION

Most agronomic and biometric characteristics of *S. aramiensis* were affected by location and year (Table 1). Plant height values varied between 80.8 and 89.4 cm at both locations and years. However, plant height differences between locations and years were not significant. When herbage fresh and dry yields were in consideration, the highest values were obtained in Adana and the lowest values were obtained in Pozantı in the 1st and 2nd year. Yılmaz and Özgüven (1988), Yenikalaycı and Özgüven (1999) observed similar pattern of leaf fresh and dry yields responses of *Salvia officinalis* and *Salvia aucheri* Bentham var. *aucheri* in Adana and Pozantı. The highest herbage fresh yield (26573 kg ha-^{1}) was obtained in Adana in the 1st year of the study. However, in the 2nd year of the study, the herbage fresh yield (9719 kg ha-1) considerably decreased in Adana. In contrast to Adana, herbage fresh yield increased in the 2nd year in Pozantı. This may due to the altitude, soil, moisture and microclimate differences between these two locations. Since the plants grown in Adana had more tiller and leaves than the plants grown in Pozantı. Herbage dry yield showed the same pattern of variations as in herbage fresh yield. The highest values for herbage dry yields (7406 and 5108 kg ha-^{1} in the 1st and 2nd year, respectively) were obtained in Adana. Leaf fresh yields were affected by the altitude differences between the two locations. Leaf fresh yield had similar pattern of variation in the previous studies done with *Salvia officinalis* and *Salvia aucheri* Bentham var. *aucheri* (Yılmaz and Özgüven 1988; Bernath et al. 1991; Yenikalaycı and Özgüven 1999; Çalışkan et al. 2019). Leaf number per plant (data not given) and leaf yield were higher in Adana than in Pozantı. Leaf dry yield between locations and years was not significant. Fresh and dried flower yields of *S. aramiensis* varied significantly between years and locations.

Table 1: Average values of plant parameters of *Salvia aramiensis*

Parameter	Locations				LSD (p ≤ 0.05)
	Adana		Pozantı		
	1st yr	2nd yr	1st yr	2nd yr	
Plant height (cm)	80.8	89.4	81.1	84.5	NS
Fresh herbage yield (kg ha^{-1})	26573^{a}	9719^{b}	4508^{c}	5984^{c}	2866
Dry herbage yield (kg ha^{-1})	7406^{a}	5108^{b}	1477^{d}	2222^{c}	609
Fresh leaf yield (kg ha^{-1})	9433^{a}	6480^{b}	2584^{d}	3850^{c}	1108
Dry leaf yield (kg ha^{-1})	2510	3192	520	1376	NS
Fresh flower yield (kg ha^{-1})	5944^{a}	689^{b}	462^{b}	456^{b}	341
Dry flower yield (kg ha^{-1})	943^{a}	372^{b}	109^{c}	113^{c}	94
Fresh stem yield (kg ha^{-1})	11190^{a}	2549^{b}	1527^{c}	1710^{c}	353
Dry stem yield (kg ha^{-1})	2472^{a}	974^{b}	337^{c}	368^{c}	272
Fresh leaf ratio (%)	36.0^{c}	66.7^{a}	57.4^{b}	64.3^{ab}	7.4
Fresh flower ratio (%)	23.7^{a}	7.0^{c}	10.2^{b}	7.6^{c}	1.6
Fresh stem ratio (%)	40.1^{a}	26.1^{c}	33.8^{b}	28.5^{bc}	5.4
Leaf essential oil content (%)	2.0^{b}	2.9^{a}	2.1^{b}	1.5^{c}	0.2
Leaf essential oil yield (kg ha^{-1})	188^{a}	190^{a}	53^{b}	55^{b}	14

NS: Nonsignificant

The highest flower fresh yield (5944 kg ha-1) was obtained in Adana in the 1st year and the lowest yield (456 kg ha-1) was obtained in Pozantı in the 2nd year. In the second year of the study, flower fresh and dry yields considerably decreased in Adana. Whereas, similar decrease for flower fresh and dry yields were not observed in Pozantı. When stem fresh and dry yields were in consideration, the highest values were obtained in Adana in the 1st year of the study. Stem fresh and dry yields also decreased in the 2nd year in Adana. In contrast to Adana, stem fresh and dry yields increased in Pozantı in the 2nd year of the study. Respect to the fresh leaf ratio, the highest value was obtained in the 2nd year in both locations. The result of this study showed that *S. aramiensis* had more leaves in the 2nd year than in the 1st year. In the 1st year, the highest fresh flower and stem ratios were obtained in Adana with 23.7 and 40.1%, respectively. Flower ratios considerably decreased in the 2nd year of the study at both locations.

Leaf volatile oil contents of *S. aramiensis* ranged from 1.5 and 2.9% according to locations and years. The highest leaf volatile oil content was obtained in Adana in the 2nd year. The essential oil content differences between the two locations most probably resulted from soil, moisture, temperature and altitude differences. Similar results were

Table 2: Average values of essential oil content in flowers and leaves of *Salvia aramiensis*

Compound	Locations							
	Adana				pozantı			
	Flower		Leaf		Flower		Leaf	
	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
α-pinene	13.75	15.02	5.23	4.69	19.61	21.24	8.21	7.45
Camphene	0.07	0.03	0.03	0.05	0.12	0.25	0.02	0.08
β-pinene	4.62	3.82	7.19	7.62	3.04	4.12	8.19	9.14
Myrcene	0.33	0.41	1.01	0.26	-----	0.03	0.35	0.52
α-terpinene	0.04	0.05	0.08	0.06	0.03	0.01	0.08	0.07
Limonene	0.06	0.04	0.07	0.03	-----	0.03	0.02	0.03
1,8-Cineole	2.85	2.95	4.38	3.62	3.24	4.45	2.28	3.02
α-thujone	1.08	2.12	0.06	0.03	3.21	3.23	0.12	0.09
p-Cymene	-----	0.04	0.02	-----	-----	0.01	0.01	-----
Terpinolene	0.01	-----	-----	-----	0.02	-----	0.12	0.04
Camphor	9.39	10.87	0.87	0.59	11.43	11.18	1.41	0.72
Linalool	0.02	0.04	0.04	0.05	-----	0.03	-----	0.25
Linalil asetat	-----	0.01	0.03	-----	-----	0.01	0.02	0.02
Bornil asetat	-----	-----	0.05	-----	5.14	4.85	0.03	-----
Borneol	5.83	7.19	5.04	6.12	8.22	9.12	6.11	5.31
α-terpineol	0.21	0.21	0.07	-----	0.19	0.27	-----	0.09
Isoborneol	0.08	0.02	0.05	-----	-----	0.11	0.28	0.37
Terpinene-4-ol	0.07	1.05	0.03	0.05	0.92	0.92	1.42	0.02
β-caryofillen	6.04	6.19	1.03	0.92	8.84	9.82	1.19	1.04
α-humulon	1.02	1.41	1.21	0.81	1.15	1.24	1.20	1.20
Viridiflorol	2.13	2.94	2.03	1.97	2.53	3.05	2.87	2.35
α-gurgunen	1.09	1.08	1.56	-----	1.57	1.14	1.29	1.26
Total	48.69	46.49	30.80	24.90	69.26	65.11	35.31	33.07

obtained by Pitarevic et al. (1985) and Bernath et al. (1991). In the 2nd year of the study, volatile oil content increased in Adana, whereas it decreased in Pozantı. This probably have resulted from altitude differences between the two locations. The results obtained for the volatile oil content agree with those found in *S. fruticosa* by Bayrak and Akgül (1987). When the leaf essential oil yield was in consideration, the highest yields in the 1st and 2nd year were 188 and 190 kg ha-1 in Adana, while the lowest values were 53 and 55 kg ha-1 in Pozantı, respectively.

The constituents of *S. aramiensis* oil grown at two locations are given in Table 2. Essential oil of *S. aramiensis* grown at two altitudes had similar pattern of constituents. The major volatiles found in the leaf were α-pinene, 1,8-cineole, β-pinene, borneol, and viridiflorol at both locations. This represents over 28% of total volatile content in each year and location. In Adana, the major volatiles found in the flowers were α-pinene, 1,8-cineole, β-pinene, camphor, borneol, β-caryofillen and viridiflorol. Together these represent over 50 and 72% of total volatile content in Adana and Pozantı, respectively in either year. The remaining compounds were each in very small amounts (less than 1%) in the leaves and flowers of the plant grown in both locations. The composition of the volatile oil agreed with the findings of the previous authors (Özgüven et al. 1985; Şarer 1986a; Bayrak and Akgül 1987; Bellomaria et al. 1992; Akgül 1993; Yenikalaycı and Özgüven 1999; Demirci et al. 2002a; Demirci et al. 2002b; Karaman et al. 2007; Akın et al. 2010; Monica et al. 2010; Abbas et al. 2015; Başer et al. 2015; Hatipoglu et al. 2016; Polatoğlu et al. 2017).

CONCLUSION

According the results obtained in the two years and the two regions, *S. aramiensis* had the best adaptation and production potential in the Mediterranean type of climate (Adana) rather than the continental type of climate (Pozantı). Among the essential oil components, α-pinene, 1,8-cineole, β-pinene, borneol, camphor and viridiflorol were the major essential oil volatiles found in the leaves and flowers of *S. aramiensis* grown in both locations. To obtain herbage yield as high as 7406 t ha-1 with the essential oil yield of 188 kg ha-1, *S. aramiensis* could be cultivated in (28-250 m above the sea level) the Mediterranean type of climate.

ACKNOWLEDGMENT

The author would like to thank the retired lecturer Dr. Ali Bayrak for his kind help for essential oil analysis and Dr. Mehmet Arslan (Erciyes University, Agriculture Faculty) for reviewing the earlier version of the manuscript.

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