Journal of Natural Products
Vol. 49, No. 2, pp. 326-329, Mar-Apr 1986

THE INFLUENCE OF SEASON AND HARVEST FREQUENCY ON ESSENTIAL OIL AND HERBAL YIELDS FROM A PURE CLONE OF SAGE (*SALVIA OFFICINALIS*) GROWN UNDER CULTIVATED CONDITIONS[1]

ELI PUTIEVSKY, UZI RAVID, and NATIV DUDAI

Department of Medicinal and Aromatic Plants, Agricultural Research Organization, Neve Ya'ar, Post Haifa 31999, Israel

Sage (*Salvia officinalis* L.) is one of the important herbs used as a flavoring in meat, poultry, and cheese dishes, and in vinegar. It is also significant as an essential oil in pharmacy (1). The largest exporters, with the highest quality sage, are Yugoslavia (mainly from Dalmatia) and Albania. In these two countries, the plants are collected from wild populations, air-dried, and then processed.

Plants are collected once a year, during the summer. Having bright leaves (almost white), 1.5% essential oil on the basis of dried leaves, and a special aroma, the leaf is of high quality. The essential oil, including a high percentage of thujones (50%) and a low percentage of camphor (20%), is considered to be of superior grade (2,3).

The yield and composition of essential oil obtained from sage plants collected from various locations in Yugoslavia (4), and at different times (5) were studied in a wild population. It is well known that large variation is found when morphological as well as yield components are tested in wild populations (6). In this work, we eliminate these two factors—variation, and differing climate conditions—by growing under cultivated conditions a pure clone of sage plants. Data were collected on yield components and herb quality as well as on the essential oil at different seasons and harvest frequencies.

MATERIALS AND METHODS

Seeds of *S. officinalis*, received from Kew Gardens, London, in 1975, were grown at the Neve Ya'ar Experiment Station located in northern Israel. These plants were examined for yield components, and one plant was selected and propagated vegetatively, by stem cuttings. In November 1981, a new field was planted with stem cuttings from this selected plant, 35×15 cm between cuttings. Approximately 1 month before planting, 800 kg potassium fertilizer and 500 kg phosphate fertilizer ha-1 were applied to the entire experimental field. Ammonium nitrate fertilizer was applied immediately before planting and after each harvest, 300 kg ha-1 on each occasion. From the end of March and until November, the field was irrigated weekly with 300m^3 water ha-1.

Seven different treatments of harvest frequencies were examined (Table 1). The experimental design was a Latin square with seven replicates, each 5 m×2 m. All harvesting was done with a motorized cutter. From each replicate, all the fresh matter was weighed, and a sample of 400-500 g was dried for 48 h at 40°. The leaves were separated manually and weighed. The essential oil was hydrodistilled from dry leaves in a modified Clavenger apparatus, for 2 h at 100°. In order to present only the relevant results, we do not report the yield components per harvest, but rather per treatment as per harvest date in 2 years of growth (Table 2 and Figures 1-2).

From the cooled essential oil, a neat sample of 0.1 ml was analyzed on a Varian 3700 Gas Liquid Chromatograph, with a flame ionization detector and a Hewlett-Packard 3390 integrator. The column, 5% Carbowax 20 M on Chromosorb W 80/100 mesh, 3 m×4 mm (i.d.), with a gas flow of 30 ml N_2/min, was held at 70° for 2 min, then programmed to 200° at 6°/min, and held at 200° for 4 min.

RESULTS

On the average, all yield components were the same in the first and second years of growth, that is, sage plants had already reached the maximum yield in the first year of growth.

The fresh matter in 2 years of growth varied between 4.0 and 5.4 kg/m^2 per

[1]Contribution from the Agricultural Research Organization, the Volcani Center, Bet Dagan, Israel, No. 1443-E, 1985 Series.

TABLE 1. Harvest Schedules during Two Years of Growth of *Salvia officinalis*

Treatment No.	Harvests per year	Harvest dates		
		Spring	Summer	Autumn
1	3	+	+	+
2	2	+	+	
3	2	+		+
4	1	+		
5	2		+	+
6	1			+
7	4	+	+	+

treatment, except no. 6, which yielded only 2.1 kg/m^2 (Table 2).

The herbal yield (dried leaves) was found to be very low in plants harvested once a year, mainly in those harvested in the spring, and somewhat higher in those harvested in ther autumn. The percentage of dried leaves (calculated from the fresh matter) in the spring was low (14-15%) (Figure 1), which caused a decrease in the leaf yield, even though the fresh yield was quite high. On the other hand, in the autumn, the percentage of dried leaves was quite high (25%) (Figure 1) and balanced the low yield of fresh matter. In all the five other treatments, which included two to four harvests per year, the yield of dried leaves was quite similar: 918 g/m^2-1100 g/m^2 (Table 2). Another important herbal parameter is leaf color, which determines the quality. Leaves which are green in the spring, change consistently to silver during the year (Figure 1). It should also be noted that there is a direct correlation between leaf color and the time elapsing between harvests: the longer the time, the more silvery the color.

The essential oil yield was found to be highest in treatments which incorporated harvests at least twice a year and which included a summer harvest (treatments 1,2,3,5, and 7) (Table 2). The highest content of essential oil (almost 2%) was obtained in the summer, while it was somewhat lower in the autumn (1.5%) and very low in the spring (0.7%) (Figure 1). In the two other treatments (nos. 4 and 6), the yield of essential oil was significantly lower, especially in treatment 4 (4.6 cc/m^2), which had been harvested only in the spring. The percentage of α and β thujone in the essential oil increased during the season from 8% in April to more than 40% in December (Figure 2). At the same time, the percentage of borneol decreased very sharply (from 25% to 5%), and that of eucalyptol (1,8-cineole) decreased slightly (from 12% to 8%). The camphor percentage had risen in the spring (from 10% to 25%) and then decreased

TABLE 2. Yield of Fresh Matter, Dried Leaves, and Essential Oil of *Salvia officinalis* in the First Two Years of Growth under Different Harvest Treatments

Total yield in 2 years of growth	Harvest treatment No.[a]						
	1	2	3	4	5	6	7
Fresh matter (g/m^2)	4987x[b]	5418x	4373xy	4020xy	4602xy	2150z	5043x
Dried leaves (g/m^2)	1015x	947x	966x	491z	1100x	753y	918x
Essential oil (c/m^2)	16.7x	14.1xy	13.2xy	4.6z	18.7x	11.1y	15.2x

[a]For explanations, see Materials and Methods and Table 1.

[b]Figures followed by different letters differ significantly at $p<0.05$.

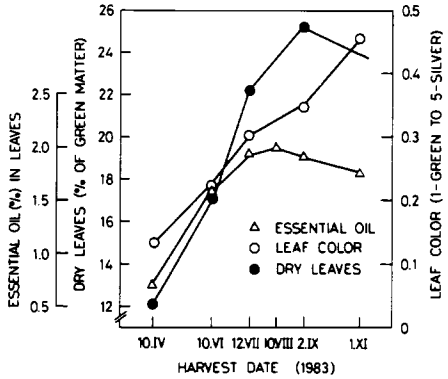

FIGURE 1. Essential oil content, leaf color, and percent dry leaves at different harvest dates in the second year of growth of *Salvia officinalis*.

somewhat (to 20% at the end of the autumn). In the case of α and β pinene, the change during the year was very small (from 6% to 11%, stabilizing at 9%) (Figure 2).

DISCUSSION

High quality of sage plants is a combination of several factors: leaf color (silver), content of essential oil (>1.5%), and essential oil composition (mainly high thujones and low camphor content) (7). It was found through experimentation (5,8) that the best time to harvest wild sage is from July to December. In cultivated conditions, where variation is negligible (by using a pure clone), the harvest time is the same. Even so, under cultivation we can obtain two high-quality and high-yield harvests, the first in July and the second in October-November, instead of one harvest of wild populations. In July, the essential oil content was high, as was the thujone concentraton in the essential oil, while the camphor concentration was low and the leaves had the desirable silver color. In October, there exists the most desirable combination of essential oil components and leaf color, while essential oil content is quite high.

The explanation of Burmeister and Guttenberg (9) that the long dry period for the vegetation in wild populations is the basis for higher essential oil production and content is not relevant in cultivated fields, which are irrigated during the dry season. In other spices of the Labiatae family (10), it is known that two factors affect the essential oil content and composition: season and reproductive stage. In sage, flowering was found to have little influence on the content of essential oil, while in the other species of the Labiatae, at flowering essential oil is at the highest level (6). On the other hand, in July, when the days are very long and warm, the essential oil content in sage is the highest, as in oregano and basil (11,12). Furthermore, in spring, when plants are in bloom, no new regeneration is found. In summer, starting in July, new vegetation exists and a greater number of young leaves with high essential oil content were observed in sage (8), as was subsequently found to be the case in mint and in oregano (14).

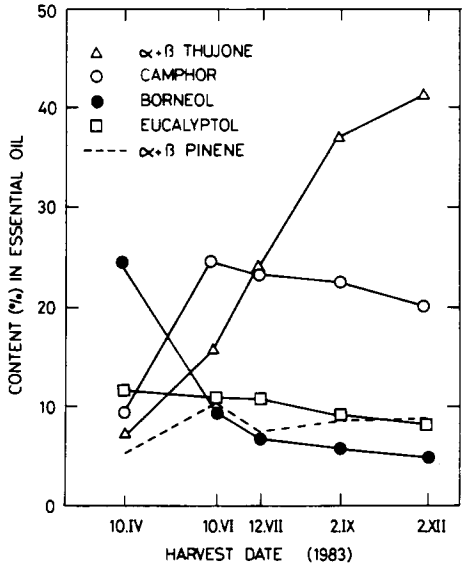

FIGURE 2. Content of five components in the essential oil of *Salvia officinalis* at different harvest dates.

LITERATURE CITED

1. F. Stary and V. Jirasek, "Herbs," London: Hamlyn Publ., 1977.
2. M.B. Embong, D. Haziger, and S. Molner, *Can. Inst. Fd. Sci. Technol. J.*, **10**, 201 (1977).
3. H.Y. Rhyu, *J. Fd. Sci.*, **44**, 758 (1979).

4. D. Kustrak, J. Kuftinec, and N. Blazevic, *J. Nat. Prod.*, **47**, 520 (1984).
5. I. Pitarevic, J. Kuftinec, N. Blazevic, and D. Kustrak, *J. Nat. Prod.*, **47**, 409 (1984).
6. E. Putivesky and U. Ravid, *Wld Crops*, **7**, 237 (1982).
7. E. Guenther, "The Essential Oils," vol. III, D. van Nostrand Inc., New York, 1949.
8. K.E. Rasmussen, S. Rasmussen, and A. Baerheim Svendsen, *Sci. Pharm.*, **39**, 159 (1971).
9. J. Burmeister and H.V. Guttenberg, *Planta Med.*, **8**, 1 (1960).
10. D. Basker and E. Putievsky, *J. Hort. Sci.*, **53**, 179 (1977).
11. E. Putievsky, *J. Hort. Sci.*, **58**, 113 (1983).
12. A. Fleisher, E. Putievsky, A. Berg, and Nava S. *Hassadeh*, **60**, 859 (1980) (In Hebrew).
13. S. Duriyaprapan and E.J. Britten, *J. Exp. Bot.*, **33**, 810 (1982).
14. H. Maares, *Flav. Ind.*, **6**, 278 (1974).

Received 19 July 1985