EFFECT OF PLANTING DENSITY, SPACING AND NUMBER OF CUTS ON GROWTH, YIELD AND OIL OF *SALVIA OFFICINALIS*, L. PLANTS

SHALAN, M. N., T. A.T. ABDEL-LATIF AND E. A. E. EL-GHADBAN

Medicinal and Aromatic Plants Research Department, Horticultural Research Institute, ARC, Giza, Egypt.

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Abstract

The present work was conducted to study the effect of spacing, number of plants/ hill and number of cuttings on plants of *Salvia officinalis*, L. during two successive seasons of 2003/2004 and 2004/2005. The investigation was carried out in the experimental farm at Baramoon, Dakahlya Governorate, Egypt. Plants harvested at 26 May (First cut) and 26 October (Second cut) – on other hand, plants harvested at 23 April (First cut), 9 June (Second cut) and 26 October (Third cut). On other side plants were cultivated as one plant/hill and others as two plants in every hill at different distances between plants as (30, 40 or 50 cm) in both the two seasons. The obtained results indicated that plant height (cm) showed that one plant/hill at 30 cm apart between hills with two cuttings showed the tallest plant height over all remain treatments, while one plant/ hill at 40 cm distance between hills and two cuttings showed the most furious branches. In general differences were statistically significant in both the two seasons for all growth traits.

Two plants/ hill at 50 cm apart between hills with three cuttings showed more fresh and dry yield per plant (gm) and per plot (kg) and same trend was obtained when essential oil percentage, essential oil yield / ml per plant and per plot were concerned. Differences were statistically significant in both the two seasons.

GLC analysis for sage oil recorded sixteen components, α– thujone was found to be the main component.

INTRODUCTION

Sage (*Salvia officinalis* L.), is a common name for a large genus of about 900 species of flowering plants of wide distribution. The sages are members of the family Lamiaceae (formerly Labiatae) or commonly the mint family. The scientific name of common sage is *Salvia officinalis.* It is cultivated as ornamentals for their attractive flowers and/or foliage, which is often hoary in appearance because of a dense covering of hairs. Common sage is native to the Mediterranean region and is now grown there. Also, it is grown for its leaves, which contain pungent oil and are used in stuffing meats, poultry, and sausage. A tea may also be made from the leaves. Sage is one of the most important herbs used as a flavoring in meat, poultry and cheese dishes, and in vinegar. It's also significant as an essential oil in pharmacy (Stary and Jirasek, 1977). The oil of sage is sometimes used in the manufacture of perfumes and cosmetics. In folk medicine it has been known for its antispasmodic, astringent and tonic effects and is an authorized drug in most pharmacopoeias.

More recently, it has been reported that sage oil and particularly some of its main components such as thujone, camphor and 1,8 cineole, possess antimicrobial, antioxidant and possible anticancer properties (Morris *et al.* 1979 and Piccaglia *et al.* 1993) .

The biological activity and the uses of the oil depend on its chemical composition which is pre-determined by the genotype, and greatly affected by environmental factors and agronomic techniques (Piccaglia *et al.* 1989 and Benath *et al.* 1991).

The content and composition of essential oil in the leaves and flowers of *Saliva officinalis* have been studied by Couladis *et al.* (2002). They mentioned that the yield of oil was oxygenated monoterpenes: alpha-thujone (15.79 plus or minus 4.9 %), beta-thujone (3.49 plus or minus 1.4 %), 1.8 cineole [eucalyptol] (12.09 plus or minus 3.5 %), camphor (11.49 plus or minus 7.69 %), borneol (4.17 plus or minus 2.23 %) and bornyl acetate (2.19 plus or minus 1.22 %). Among the dominant sesquiterpenes were: alpha-humulene (7.70 plus or minus 3.12 %), viridiflorol (13.19 plus or minus 5.17 %) and manool (7.67 plus or minus 2.98 %). In the flowers, percentage of alpha-thujone and camphor were significantly lower than in leaves and averaged (9.97 plus or minus 1.49 and 5.82 plus or minus 5.6 %, respectively), whereas the ratios of borneol (6.35 plus or minus 2.47 %) and sesquiterpenes, particularly manool (13.48 plus or minus 3.56 %), were height.

The effects of planting density and harvesting method on the yield and composition of the essential oil of *Salvia officinalis*, growing in northern Italy, were investigated by Piccaglia *et al.* (1997), who mentioned that planting density had little effect on yield or essential oil composition.

Salvia officinalis harvested in spring at flowering stage (first cut) gave the highest yields of fresh and dried matter. Harvesting regimes with 3 successive harvests produce the highest biomass yield. Twenty-nine compounds were identified in the essential oil. The highest content of thujones was found in the essential oil from the autumn harvest.

The aim of this work was to study the yield and composition of the oil of sage which has been grown under varied conditions of spacing, plant distribution in the field and number of cutting.

MATERIALS AND METHODS

The present study was conducted at the experimental farm of Baramoon Station, Mansoura, Dakahlya Governorate, during the two successive seasons of 2003/2004 and 2004/2005.

Seeds of sage were obtained from Medicinal and Aromatic Plants Department in EL-Dokki, Agricultural Research Center Cairo, Egypt. Seeds were first sown in nursery beds prepared on November in both seasons. The growing seedlings were transplanted after 90 days from the sowing at 30, 40 or 50 cm apart between hills in plots of area (3 x 3 m) contained 5 rows at 60 cm wide. Two treatments were applied, in the first each hill contained one plant and the second treatment each hill contained two plants. The physical and chemical properties of Baramoon Station soil is presented in (Table A). All other agricultural practices have been done according to sage recommendations.

Table A. Some physical and chemical characteristics of the experimental soil in the two seasons.

Items	value	Items	value
Sand (%)	16.53	Total nitrogen (%)	0.53
Silt (%)	35.25	Water soluble phosphorus (%)	0.05
Clay (%)	45.50	Available potassium (meq/l)	0.06
Organic matter (%)	1.68	Available iron (ppm)	17.9
EC mmhos/cm	1.44	Available manganese (ppm)	3.70
pH	7.60	Available zinc (ppm)	5.10

The experimental design was split-split design with three replicates:

1. The main plots contained the number of cuttings, two cuts (at 26 May and 26 October) and three cuts (at 23 April, 9 June and 26 October).
2. Sub-plots contained number of plants in hills, one plant or two plants per hill.
3. Sub-sub-plots contained spacing (30,40 and 50 cm) apart which represented 50, 40 and 30 plants/plot in one plant per hill case and 100, 80 and 60 plant/plot in two plants per hill that equal 23, 18 and 14 thousands and 46, 36 and 28 thousands plants/feddan and were harvested in determined time. Data were recorded for growth characters just before cutting and yield and oil characters after cutting. These characters were the following, plant height/cm, number of branches per plant, fresh and dry weights of whole herb per plant (g) and per plot (kg), essential oil percentage (%) and essential oil yield/plant (ml) and/plot (ml.).

The percentage of volatile oil was determined according to the method described in **British Pharmacopoeia (1963)**.

The oil yield per plant and per plot was calculated by multiplying the percentage of the oil weight of the dry herb per plant and per plot.

G.L.C. analysis was carried out in the Central Laboratory of Horticultural Research Institute, Agricultural Research Center. Quantitative determination was done according to Hoftman (1967). The analysis conditions were as follow:

The chromatograph apparatus was fitted with 1.5 m long x 4 mm O.D. coiled glass column peaked with diatomareatic (100-120 mesh) and coated with 10 % PEGA.

Temperature program linear increase with a rate of 4°c/min was from 70°c to 190°c.

Flow rates of gases were nitrogen (at 30 ml/min), hydrogen (at 33 ml/min) and air 330 ml/min.

Detector and injector temperatures were 300°c and 250°c, respectively.

The data were statistically analyzed according to Steel and Torrie (1980). The significant difference was detected by using (L.S.D.) at (5%) and (1%) levels of significance.

RESULTS AND DISCUSSION

Vegetative growth characters

The used treatments number of cuts (two or three times) and number of plants in hills (one plant or two plants per hill) under three spaces (30, 40 or 50 cm) showed significant differences on the vegetative growth of *Salvia officinalis* plants during the two seasons of 2003/2004 and 2004/2005.

Plant height

The results of plant height are presented in Table (1). Plants subjected to three cutting were shorter than that subjected to two cutting, but the difference was significant in the second season only. This result was expected as the plants suffered three cutting prolonged less time before harvesting. Number of plants per hill caused significant difference; a single plant in a hill was taller than two plants per hill. This result can be due to the large part of soil and solar energy for single plant than the part of each of the two plants. The planting spaces (30, 40 or 50 cm) showed significant differences in plant length. However, each increase in plant density caused remarked decreasing in plant height. Obviously, each increment in plant density accompanied with plant height decreasing. All interactions between the three studied factors were non-significant except the interaction between number of cutting and number of plants /hill in the first season which was highly significant.

Table 1. Plant height (cm) of *sage* plants as affected by spaces, number of plants in hills and number of cuttings during 2003/2004 and 2004/2005 seasons.

Seasons		2003/2004					2004/2005				
		Planting distances (C)			Means A x B	Means of (A)	Planting distances (C)			Means A x B	Means of (A)
No. of cuttings (A)	No. of plants in hill (B)	30	40	50			30	40	50		
Two	One plant	62.12	59.82	55.60	59.18	55.53	63.14	60.80	58.44	60.79	56.00
	Two plants	52.93	51.94	50.79	51.89		52.80	50.84	50.00	51.21	
Three	One plant	61.10	58.33	57.61	59.01	52.89	60.34	56.30	54.22	56.95	52.19
	Two plants	48.21	46.86	45.20	46.76		49.66	47.32	45.30	47.43	
Means of (C)		56.09	54.24	52.30			56.49	53.81	51.99		
Means B x C	One plant	61.61	59.08	56.60	Means of (B)	59.10	61.74	58.55	56.33	Means of (B)	58.87
	Two plants	50.57	49.40	48.00		49.32	51.23	49.08	47.65		49.32
Means A x C	Two cuts	57.53	55.88	53.19			57.97	55.82	54.22		
	Three cuts	54.65	52.60	51.40			55.00	51.81	49.76		
LSD at 5%		A = NS B = ** C = 1.44 A x B =** A x C = NS B x C = NS A x B x C = NS					A = * B = ** C = 1.30 A x B = NS A x C = NS B x C = NS A x B x C = NS				

* and ** are significant at 0.05 and 0.01 levels.

Number of branches

The data in Table (2) revealed that differences between two and thee cutting was insignificant in the first season but it reached significance in the second season. On the other hand, it was clearly indicated that the effect of two cuttings was more effective than three cuttings when number of branches per plant was considered. Number of plants per hills displayed significant results in both the two seasons; one plant in hill had more ability to branch than two competitive plants per hill.

Also, planting distances showed that 40 cm between plants gave the best results of branching in comparison with 30, 50 cm apart. These results hold true in both the two seasons.

Interaction between no. of cuttings and number of plants in hills showed insignificant differences in first season while it was statistically recorded significant results in the second one. Interaction of number of cuttings with planting distances clearly emphasized significant results in both two seasons. Interactions of number of plants in hills with planting distances and interactions between the three factors under

the study showed insignificant differences in both two seasons. Two cuttings with one plant in every hill at planting distance of 40 cm apart realized the most efficiency effect concerning the number of branches per plant in both two seasons.

Table 2. Number of branches of *sage* plants as affected by planting spaces, number of plants in hills and number of cuttings during 2003/2004 and 2004/2005 seasons.

Seasons		2003/2004					2004/2005				
		Planting distances (C)					Planting distances (C)				
No. of cuttings (A)	No. of plants in hills (B)	30	40	50	Means A x B	Means of (A)	30	40	50	Means A x B	Means of (A)
Two	One plant	42.6	45.0	40.3	42.6	41.5	43.70	46.82	47.36	45.96	43.39
	Two plants	40.2	42.3	38.6	40.4		40.60	42.32	39.56	40.83	
Three	One plant	41.6	44.0	36.3	40.6	39.6	41.61	45.72	37.66	41.66	40.01
	Two plants	39.6	40.8	35.2	38.5		38.72	41.63	34.72	38.36	
Means of (C)		41.0	43.0	37.6			41.16	44.12	39.83		
Means B x C	One plant	42.1	44.5	38.3	Means of (B)	41.6	42.65	46.27	42.51	Means of (B)	43.81
	Two plants	39.9	41.6	36.9		39.5	39.66	41.97	37.14		39.59
Means A x C	Two cuts	41.4	43.7	39.5			42.15	44.57	43.46		
	Three cuts	40.6	42.4	35.8			40.17	43.68	36.19		
LSD at 5%		A = NS B = ** C = 0.66 A x B = NS A x C = ** B x C = NS A x B x C = NS					A = ** B = ** C = 1.30 A x B = * A x C = ** B x C = NS A x B x C = NS				

* and ** are significant at 0.05 and 0.01 levels.

Fresh and dry weight per plant and per plot

Data presented in Tables (3, 4, 5 and 6) revealed that there were significant differences in the three studied factors in both the two seasons. Plants of sage at 50 cm apart produced the highest fresh herb (gm/plant) in the two seasons. As for number of plants in the hill, the data clearly emphasized that two plants/hill gave the best results in this concern. Also, harvesting sage plants three times during the season gave the highest fresh herb in the two seasons. This trend was clearly showed in case of dry herb.

Regarding the dual interactions, it was observed that two plants/hill harvested three times annually produced the highest fresh herb in the two seasons. It was also observed that two plants/hill spaced at 50 cm apart yielded the highest fresh herb/plant in the two seasons.

Concerning number of cuttings interaction with plant distances, it was obvious that sage plants spaced at 50 cm apart and annuall harvested three times displayed the highest fresh herb/plant in the two seasons. It could be concluded that planting two sage plants per hill at 50 cm apart and harvesting three times annually gave the highest fresh herb (gm/plant) in the two seasons. These results hold true when dry herb per plant was considered.

Concerning the yield of fresh herb of sage plants as affected by planting distances, number of plants per hill and number of cuttings, it was clearly indicated that harvesting sage plants three cuts during the season gave the highest yield of fresh herb per plot. Also, it was observed that planting sage at 30 cm apart resulted in the highest fresh herb/plot in the two seasons. Regarding the number of plants per hill the results clearly indicated that two plants per hill yielded the highest fresh herb per plot in the two seasons.

Table 3. Herb fresh weight /plant (g) of *sage* plants as affected by spaces, number of plants in hills and number of cuttings during 2003/2004 and 2004/2005 seasons.

Seasons		2003/2004					2004/2005				
		Planting distances (C)			Means A x B	Means of (A)	Planting distances (C)			Means A x B	Means of (A)
No. of cuttings (A)	No. of plants In hills (B)	30	40	50			30	40	50		
Two	One plant	365.89	370.66	380.72	372.42	383.98	367.23	372.33	380.61	373.39	381.45
	Two plants	385.00	396.41	405.19	395.53		382.60	390.00	395.90	389.50	
Three	One plant	473.32	517.20	572.91	521.14	555.71	466.40	512.78	571.63	516.94	539.68
	Two plants	487.43	605.31	678.12	590.29		456.10	566.60	664.60	562.43	
Means of (C)		427.91	472.40	509.23			418.08	460.43	503.18		
Means B x C	One plant	419.61	443.93	476.82	Means of (B)	446.78	416.82	442.55	476.12	Means of (B)	445.16
	Two plants	436.21	500.86	541.66		492.91	419.35	478.30	530.25		475.97
Means A x C	Two cuts	375.45	383.54	392.96			374.92	381.16	388.26		
	Three cuts	480.38	561.26	625.52			461.25	539.69	618.11		
LSD at 5%		A = ** B = ** C = 0.75 A x B = ** A x C = ** B x C = ** A x B x C =**					A = ** B = ** C = 0.71 A x B = ** A x C = ** B x C = ** A x B x C =**				

* and ** are significant at 0.05 and 0.01 levels.

This contrast in the results between herb yield per plant and per plot can be due to the behavior of the single plant in the low density when it show the best growth but the yield per plot of low plant density would be less than the accumulation of herb in plot have more number of plants/per plot.

The interaction between the studied factors, it was apparent that planting two sage plants in the hill and harvesting three times annually gave the highest fresh herb per plot. The data clearly emphasized that two plants at 30 cm apart resulted in the highest fresh herb per plot. Also, the results recorded the highest fresh herb per plot in case of planting distances at 30 cm and harvesting three times during the season. The results clearly showed that planting two sage plants at 30 cm apart and harvesting three times during the season gave the highest fresh herb per plot in the two seasons.

In general, it was observed that the wider space gave the highest growth and yield of fresh and dry herb/plant compared with the closer space and this results may be attributed to the minimum competition in all growth factors in case of the wider space. However, the closer space resulted in the highest fresh and dry herb per plot according to the large number of plants in the unit area under the conditions of this study in Tables (3, 4, 5 and 6).

Table 4. Herb dry weight /plant (g) of *sage* plants as affected by spaces, number of plants in hills and number of cuttings during 2003/2004 and 2004/2005 seasons.

Seasons		2003/2004					2004/2005				
		Planting distances (C)			Means A x B	Means of (A)	Planting distances (C)			Means A x B	Means of (A)
No. of cuttings (A)	No. of plants in hills (B)	30	40	50			30	40	50		
Two	One plant	109.22	110.65	113.65	111.17	114.62	109.62	111.14	113.61	111.46	113.86
	Two plants	114.93	118.34	120.95	118.07		114.21	116.42	118.18	116.27	
Three	One plant	141.29	154.39	171.01	155.56	165.88	139.22	153.06	170.63	154.30	161.20
	Two plants	145.50	180.69	202.42	176.20		136.14	169.13	198.99	168.09	
Means of (C)		127.74	141.02	152.01			124.80	137.44	150.35		
Means B x C	One plant	125.25	132.52	142.33	Means of (B)	133.37	124.42	132.10	142.12	Means of (B)	132.88
	Two plants	130.21	149.51	161.68		147.14	125.18	142.77	158.59		142.18
Means A x C	Two cuts	112.07	114.49	117.30			111.92	113.78	115.90		
	Three cuts	143.39	167.54	186.71			137.68	161.10	184.81		
LSD at 5%		A = ** B = ** C = 1.30 A x B = ** A x C = ** B x C = ** A x B x C =**					A = ** B = ** C = 1.50 A x B = ** A x C = ** B x C = ** A x B x C =**				

* and ** are significant at 0.05 and 0.01 levels.

Table 5. Herb fresh weight /plot (kg) of sage plants as affected by spaces, number of plants in hills and number of cuttings during 2003/2004 and 2004/2005 seasons.

Seasons		2003/2004					2004/2005				
		Planting distances (C)			Means A x B	Means of (A)	Planting distances (C)			Means A x B	Means of (A)
No. of cuttings (A)	No. of plants in hills (B)	30	40	50			30	40	50		
Two	One plant	27.44	20.76	17.13	21.78	34.03	27.54	20.85	17.13	21.84	33.73
	Two plants	57.75	44.60	36.52	46.29		57.39	43.88	35.59	45.62	
Three	One plant	35.50	28.96	25.78	30.08	48.93	34.98	28.72	25.72	29.81	46.90
	Two plants	73.11	68.42	61.81	67.78		68.42	63.73	59.81	63.99	
Means of (C)		48.45	40.68	35.31			47.08	39.30	34.56		
Means B x C	One plant	31.47	24.86	21.45	Means of (B)	25.93	31.26	24.78	21.42	Means of (B)	25.82
	Two plants	65.43	56.51	49.17		57.03	62.90	53.81	47.70		54.80
Means A x C	Two cuts	42.60	32.68	26.83			42.47	32.37	26.36		
	Three cuts	54.31	48.69	43.80			51.70	46.22	42.76		
LSD at 5%		A = ** B = ** C = 1.06 A x B = ** A x C = ** B x C = ** A x B x C =**					A = ** B = ** C = 1.37 A x B = ** A x C = ** B x C = ** A x B x C =**				

* and ** are significant at 0.05 and 0.01 levels.

Table 6. Herb dry weight /plot (kg) of sage plants as affected by spaces, number of plants in hills and number of cuttings during 2003/2004 and 2004/2005 seasons.

Seasons		2003/2004					2004/2005				
		Planting distances (C)			Means A x B	Means of (A)	Planting distances (C)			Means A x B	Means of (A)
No. of cuttings (A)	No. of plants in hills (B)	30	40	50			30	40	50		
Two	One plant	8.19	6.20	5.11	6.50	10.16	8.22	6.22	5.11	6.52	10.07
	Two plants	17.24	13.31	10.89	13.81		17.13	13.10	10.64	13.62	
Three	One plant	10.60	8.65	7.70	8.98	14.56	10.44	8.57	7.68	8.90	14.01
	Two plants	21.83	20.33	18.22	20.13		20.42	19.03	17.91	19.12	
Means of (C)		14.47	12.12	10.48			14.05	11.73	10.34		
Means B x C	One plant	9.40	7.42	6.40	Means of (B)	7.74	9.33	7.39	6.39	Means of (B)	7.71
	Two plants	19.53	16.82	14.56		16.97	18.77	16.07	14.27		16.37
Means A x C	Two cuts	12.72	9.76	8.00			12.67	9.66	7.88		
	Three cuts	16.22	14.49	12.96			15.43	13.80	12.80		
LSD at 5%		A = ** B = ** C = 1.06 A x B =** A x C = NS B x C = NS A x B x C = NS					A = ** B = ** C = 0.78 A x B = ** A x C = * B x C = NS A x B x C = NS				

and ** are significant at 0.05 and 0.01 levels.

Table 7. Essential oil (%)of sage plants as affected by spaces, number of plants in hills and number of cuttings during 2003/2004 and 2004/2005 seasons.

Seasons		2003/2004					2004/2005				
		Planting distances (C)			Means A x B	Means of (A)	Planting distances (C)			Means A x B	Means of (A)
No. of cuttings (A)	No. of plants in hills (B)	30	40	50			30	40	50		
Two	One plant	0.795	0.829	0.833	0.819	0.844	0.786	0.825	0.835	0.815	0.842
	Two plants	0.853	0.870	0.886	0.870		0.856	0.870	0.881	0.869	
Three	One plant	0.892	0.930	0.958	0.927	0.975	0.890	0.933	0.956	0.926	0.973
	Two plants	0.893	0.980	1.200	1.024		0.890	0.981	1.190	1.020	
Means of (C)		0.858	0.902	0.969			0.855	0.902	0.965		
Means B x C	One plant	0.844	0.880	0.896	Means of (B)	0.873	0.838	0.879	0.896	Means of (B)	0.871
	Two plants	0.873	0.925	1.043		0.947	0.873	0.926	1.036		0.945
Means A x C	Two cuts	0.824	0.850	0.859			0.821	0.847	0.858		
	Three cuts	0.893	0.955	1.079			0.890	0.957	1.073		
LSD at 5%		A = ** B = ** C = 0.004 A x B = ** A x C = ** B x C = ** A x B x C =**					A = ** B = ** C = 0.006 A x B = ** A x C = ** B x C = ** A x B x C =**				

* and ** are significant at 0.05 and 0.01 levels.

Table 8. Essential oil yield /plant (ml) of sage plants as affected by spaces, number of plants in hills and number of cuttings during 2003/2004 and 2004/2005 seasons.

Seasons		2003/2004					2004/2005				
		Planting distances (C)			Means A x B	Means of (A)	Planting distances (C)			Means A x B	Means of (A)
No. of cuttings (A)	No. of plants in hills (B)	30	40	50			30	40	50		
Two	One plant	0.868	0.917	0.947	0.911	0.969	0.862	0.917	0.949	0.909	0.960
	Two plants	0.980	1.029	1.072	1.027		0.978	1.013	1.041	1.011	
Three	One plant	1.260	1.343	1.640	1.414	1.623	1.239	1.428	1.630	1.432	1.756
	Two plants	1.299	1.770	2.429	1.833		1.212	2.659	2.368	2.080	
Means of (C)		1.102	1.265	1.522			1.073	1.504	1.497		
Means B x C	One plant	1.064	1.130	1.293	Means of (B)	1.163	1.051	1.173	1.290	Means of (B)	1.171
	Two plants	1.140	1.400	1.750		1.430	1.095	1.836	1.704		1.545
Means A x C	Two cuts	0.924	0.973	1.010			0.920	0.965	0.995		
	Three cuts	1.280	1.556	2.034			1.225	2.043	1.999		
LSD at 5%		A = ** B = ** C = 0.002 A x B = ** A x C = ** B x C = ** A x B x C =**					A = ** B = ** C = 0.012 A x B = ** A x C = ** B x C = ** A x B x C =**				

* and ** are significant at 0.05 and 0.01 levels.

Table 9. Essential oil yield/plot (ml) of sage plants as affected by spaces, number of plants in hills and number of cuttings during 2003/2004 and 2004/2005 seasons.

Seasons		2003/2004					2004/2005				
		Planting distances (C)					Planting distances (C)				
No. of cuttings (A)	No. of plants in hills (B)	30	40	50	Means A x B	Means of (A)	30	40	50	Means A x B	Means of (A)
Two	One plant	65.10	51.35	42.62	53.02	86.39	64.65	51.35	42.71	56.24	87.18
	Two plants	147.00	115.76	96.48	119.75		146.70	113.96	93.69	118.12	
Three	One plant	94.50	75.21	73.71	81.14	142.67	92.93	79.97	73.40	82.10	137.98
	Two plants	194.85	199.13	218.61	204.20		181.64	186.64	213.12	193.85	
Means of (C)		125.36	110.36	107.86			121.52	107.98	108.23		
Means B x C	One plant	79.80	63.28	58.17	Means of (B)	67.08	78.79	65.66	63.06	Means of (B)	69.17
	Two plants	170.93	157.45	157.54		161.97	164.25	150.30	153.40		155.99
Means A x C	Two cuts	106.05	83.56	69.55			105.68	82.65	73.20		
	Three cuts	144.68	137.17	146.16			137.37	133.30	143.26		
LSD at 5%		A = ** B = ** C = 3.75 A x B =** A x C = ** B x C = ** A x B x C =**					A = ** B = ** C = 4.49 A x B = ** A x C = ** B x C = ** A x B x C =**				

* and ** are significant at 0.05 and 0.01 levels.

Effect of number of cuttings, number of plants in hills, spaces and their interactions on volatile oil percentage, volatile oil yield (ml / plot) of sage plants:

Data presented in Table (7, 8 and 9) illustrated more significant differences in term of essential oil percentage, essential oil yield per plant and per plot (gm) in both the two seasons. The treatment of three cuttings x two plants/ hill x 50 cm as planting distance, proved the most production of essential oil percentage, oil yield per plant and per plot (gm) in both the two seasons.

Essential oil components

The oil composition of sage from different planting densities (30, 40 and 50 cm) between plants and number of plants/ hills at harvest date of 26 October of second season at vegetative stage is reported in Table (10), since sixteen compounds were identified in the oil by G.L.C. which was characterized by a predominance of monoterpenes the total amount of which ranged from 75.4 % to 97.29 %.

Important variations in quantitative composition were observed in the oils obtained from sage harvested plants under the present study. The resulted chromatograms revealed that main identified components in sage oil are α-thujone, d-linalool, d-camphor, 1.8 cineole (eucalyptol), α-pinene, eugenol, bornyl acetate, linalyl acetate and camphene, respectively. The relative percentage areas indicated the effect of different treatments on the composition of each sample will be demonstrated. It is evident from the results in Table (10) that cultivated two plants in the hill at (50 cm) planting distance caused an stimulation of main component, namely α-thujone while other components recorded increasing values when plants cultivated as one plant in hill at planting distance (50 cm).

One plant/hill was the most effective factor than two plants/ hill, whereas the factor of planting distances did not affect real increments or claim differences between treatments. There are other factors which may be more effective for identify the ratio of components i.e. these differences are assumed to be due to the different climatic conditions and soils. These findings are in good agreement with those reported by (Holla and Vaver Kova 1993).

All the oils obtained from the different harvesting regimes can be considered to be of commercial interest because of their high α and β-thujone content (>18%) and low camphor amount (<15%) and, in particular, the oils from autumn harvested stage which possessed a thujone content of 28-39 %. These findings are supported by Lawrence (1992).

RECOMMENDATION

It can be recommended to cultivate sage plants two plants/hill at 50 cm apart between hills on one side of ridges 60 cm apart and to be cut three times per season to obtain the highest oil yield. While in case of the herb production it could be recommended to space sage plants at 30 cm apart with the same previous factors.

Table 10. Effect of number of plants/hill and spaces on the identified constituents of sage oil obtained from G.L.C. and calculated as relative percentages, second season.

Components	One plant in hill			Two plants in hills		
	30 cm	40 cm	50 cm	30 cm	40 cm	50 cm
A- Pinene	3.8	3.98	4.5	2.9	3.6	4.1
A & β- Thujone	28.8	31.02	39.1	30.6	35.8	39.1
1.8-Cineole (eucalyptol)	7.9	8.53	9.21	7.3	8.2	8.9
Borneol	1.31	1.30	1.26	1.3	1.3	1.1
d- Linalool	15.90	16.20	17.60	14.3	15.1	16.2
Linalyl acetate	2.3	2.5	2.9	2.1	2.3	2.6
B- Pinene	0.30	1.52	1.83	0.3	1.1	1.2
Bornyl acetate	2.8	2.6	2.1	1.9	1.5	2.0
Camphene	2.10	2.60	3.60	2.0	2.4	2.9
A- Terpinene	0.50	0.48	0.40	0.6	0.5	0.6
Myrcene	0.50	0.50	0.50	0.5	0.6	0.7
d- Limonene	1.00	1.3	1.9	0.9	1.1	1.2
p- Cymene	1.10	1.6	1.8	1.0	1.3	1.5
Methyl chavicol	0.60	0.52	0.43	0.5	0.5	0.4
d- Camphor	11.8	12.3	12.9	10.7	11.7	12.6
Eugenol	3.26	2.68	2.45	3.5	2.9	2.4

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تأثيرالكثافة النباتية ومسافات الزراعة وعدد الحشات علي النمو وإنتاج الزيت في نبات (***Salvia Officinalis*** **L.) المريمية**

محمد ناجي شعلان ، طه أحمد طه عبد اللطيف ، الموافي عبده الموافي الغضبان

قسم بحوث النباتات الطبية والعطرية- معهد بحوث البساتين- مركز البحوث الزراعية – مصر

تمت هذه الدراسة في مزرعة البرامون (بالمنصورة) بمحافظة الدقهلية التابعة لمعهد بحوث البساتين خلال موسمي ٢٠٠٣/٢٠٠٤, ٢٠٠٤/٢٠٠٥ بهدف دراسة تأثير عدد النباتات في الجورة الواحدة (نبات أو نباتين) و مسافات الزراعة بين النباتات (٣٠،٤٠ أو ٥٠ سم علي جانب واحد من الخطوط التي تبعد ٦٠ سم عن بعضها) و كذلك عدد الحشات (حشتين أو ثلاث حشات) فى الموسم وذلك علي النمو ونسبة وجودة الزيت العطري في نبات المريمية.

و يمكن تلخيص النتائج فيما يلي:

أوضحت الدراسة أن زراعة نبات واحد في الجورة علي مسافة ٣٠ سم بين الجور مع إجراء حشتين كانت أفضل المعاملات لكل من إرتفاع النبات وعدد الأفرع الجانبية في موسمي النمو.

بينما أبرزت النتائج أن زراعة نباتين في كل جورة علي مسافة ٥٠ سم بين الجور مع اخذ ثلاث حشات في كل موسم نمو هي الأفضل مقارنة بباقي المعاملات و ذلك فيما يخص الوزن الطازج والوزن الجاف في كل من محصول النبات أو القطعة التجريبية و كذلك كانت الأفضل في الحصول علي أعلي إنتاج للزيت الطيار في موسمي النمو.

بلغ عدد المكونات الرئيسية للزيت الطيار ستة عشر مركباً حيث امكن فصلها كروماتوجرافياً و كان المكون الرئيس هو الفاثيوجون (**α-Thujone**).