ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Hortorum Cultus 7(2) 2008, 73-81*

DEPENDENCE ON HARVEST DATE AND YIELDING OF MARJORAM (*Origanum majorana* L.) CV. 'MIRAŻ' CULTIVATED FROM A SEEDLING

Grażyna Zawiślak
University of Life Sciences in Lublin

Abstract. Studies were carried out in 2003–2005. The dependence between harvest date and yielding of marjoram (cv. 'Miraż') was investigated. The plantation was set from a seedling produced in a greenhouse. Plants were set in 30 × 40 cm spacing. Two weeks after setting, part of plants were cut and shoot tips with the first leaf pair were removed. The herb harvest was made twice: in the middle of July and at the end of August. Ground herb was subjected to determinations of essential oils. Qualitative and quantitative composition of marjoram oil was determined by means of gas chromatography coupled with mass spectrometry (GC/MS). The harvest date had significant influence on marjoram yielding. Higher yield of a fresh herb was achieved at the end of August (44.6 dt·ha^{-1}) than in the middle of July (30.5 dt·ha^{-1}). The essential oil content in the herb of marjoram cv. 'Miraż' was 1.7–2.2%. Trans-sabinene hydrate, terpinen-4-ol, and sabinene dominated in marjoram essential oil.

Key words: *Origanum majorana* L, marjoram, yield, essential oil composition, trans-sabinene hydrate, terpinen-4-ol

INTRODUCTION

Marjoram (*Origanum majorana* L.) grows wildly in Mediterranean, Middle East, and India [Załęcki et al. 1995; Senderski 2004], and it is cultivated across the Europe, North America, and Asia as spice and for pharmaceutical purposes [Strzelecka and Kowalski 2000, Lewkowicz-Mosiej 2003, Senderski 2004].

According to Novak et al. [2002], marjoram was brought to European markets mainly from Egyptian, German, and Polish cultivations.

In Poland, marjoram has been widely used. It plays a role of spice, mainly for indigestible food (roasted lamb, pork, greasy poultry), to soups, and sausages. It is used in production of liqueurs and tinctures [Buchwald et al. 2000].

Corresponding author – Adres do korespondencji: Grażyna Zawiślak, Department of Vegetable and Medicinal Plants, University of Life Sciences in Lublin, ul. Leszczyńskiego 58, 20-068 Lublin, Poland, e-mail grazynazawislak@poczta.onet.pl

Marjoram herbs have antibacterial and antiviral properties, and also intensify the gastric juice secretion [Strzelecka and Kowalski 2000, Matławska 2005].

Marjoram oil is used in cosmetic and perfume industries [Jędrzejko et al. 1997, Vera and Chane-Ming 1997, Strzelecka and Kowalski 2000, Senderski 2004].

In practice, there are two ways of plantation setting: seed sowing directly into the soil and seedling setting [Rumińska 1991, Załęcki et al. 1995, Buchwald et al. 2000]. The former way is often applied in regions with lighter and warmer soils [Rumińska 1991].

Seed sowing directly into the ground in a less labor-consuming method, but more seeds are needed [Czarnecki and Załęcki 1986].

Setting the plantation from a seedling is recommended on heavy and easily encrusting soils [Rumińska 1991, Frąszczak 2004] and in regions where spring becomes late [Frąszczak 2004]. Plantation set from a seedling is less dependent on weather conditions as compared to direct sowing, in which drought and low temperatures during emergence and initial development have negative influence of later yields [Frąszczak 2004]. In opinion of Rumińska [1991], the cultivation of marjoram from a seedling allows for achieving higher yields. Jadczak and Orłowski [1998] found that cutting the plants had significant effect on yields of marjoram cultivated from seedling. Buchwald et al. [2000] recommend to cut marjoram after seedling setting to help better propagation of plants.

The present research aimed at evaluating the influence of harvest date and plant's cutting on yield of marjoram (*Origanum majorana* L.) cv. 'Miraż' cultivated from a seedling.

MATERIAL AND METHODS

The experiment was carried out in 2003–2005. The marjoram seedling (cv. 'Miraż') was produced in a greenhouse in The Experimental Farm Felin, and then set into the field at the end of May at 30 × 40 cm spacing. The experiment was set in four replications on plots of 1.44 m^2 area each. Two weeks after setting, part of plants was cut by removing the shoot tips with the first leaf pair. Herb harvest was performed twice: at the beginning of flowering (middle of July) and at the end of August. The herbs were cut at the level of 5 cm above ground (first harvest) or 10 cm (second harvest). Marjoram herb was dried under natural conditions, and then ground through of 4–5 mm mesh sieve. Yields of fresh and dried herb was assessed.

Achieved results were statistically processed by means of variance analysis for *k*-fold cross-classification.

Essential oil content in ground herb was determined according to Polish Pharmacopoeia VI [2002] by distillation with water vapor.

The qualitative and quantitative composition of the sage essential oil was determined by means of gas chromatographic analysis and mass spectrometer (GC/MS). In the research we used an ITS-40 apparatus (GC/ITMS system, Finnigan MAT, USA) with a DB-5 column (J&W, USA), 30 metres of length, 0.25 mm in diameter and with 0.25 μm thick stationary phase film. The injector temperature was 280°C. We used a temperature gradient (35°C for 2 minutes, and then an increase by 4°C up to 280°C).

Table 1. Dependence on harvest date and yielding of marjoram (*Origanum majorana* L.) cv. Miraż
Tabela 1. Zależność między terminem zbioru a plonowaniem majeranku ogrodowego (*Origanum majorana* L.) odmiany Miraż

Management system of plant Sposób prowadzenia roślin	Harvest date Termin zbioru	Yield of fresh herb Plon świeżego ziela dt·ha^{-1}				Yield of air dry herb Plon powietrznie suchego ziela dt·ha^{-1}				Yield of wiped herb Plon ziela otartego dt·ha^{-1}			
		2003	2004	2005	średnio mean	2003	2004	2005	średnio mean	2003	2004	2005	średnio mean
Uszczykiwane Cutting	first – pierwszy	33.7	39.2	19.4	30.8 a	6.4	9.0	5.2	6.9 a	5.4	5.5	3.5	4.4 a
	second – drugi	29.0	66.0	36.4	43.8 a	5.9	16.3	8.7	10.3 a	3.5	10.1	5.9	6.5 a
	∑	62.7 a	105.2 a	55.8 a	74.6 a	12.3 a	25.3 a	13.9 a	17.2 a	7.7 a	15.6 a	9.4 a	10.9 a
Nieuszczykiwane Uncut	first – pierwszy	36/8	36.1	18.0	30.3 a	8.0	8.3	5.9	7.4 a	4.7	5.2	3.8	4.6 a
	second – drugi	20/8	75.9	39.6	45.4 a	4.2	15.6	10.2	10.0 a	2.8	10.1	8.0	7.0 a
	∑	57.6 a	12.0 a	57.6 a	75.7 a	12.2 a	23.9 a	16.1 a	17.4 a	7.5 a	15.3 a	11.8 a	11.6 a
Średnio Mean	first – pierwszy	35.2	37.6	18.7	30.5 a	7.2	8.6	5.5	7.1 a	4.4	5.3	3.6	4.4 a
	second – drugi	24.9	70.9	38.0	44.6 b	5.0	15.9	9.4	10.1 a	3.1	10.1	6.9	6.7 b
	∑	60.1 a	108.5 b	56.7 a	75.1	12.2 a	24.5 b	14.9 a	17.2	7.5 a	15.4 c	10.5 b	11.1

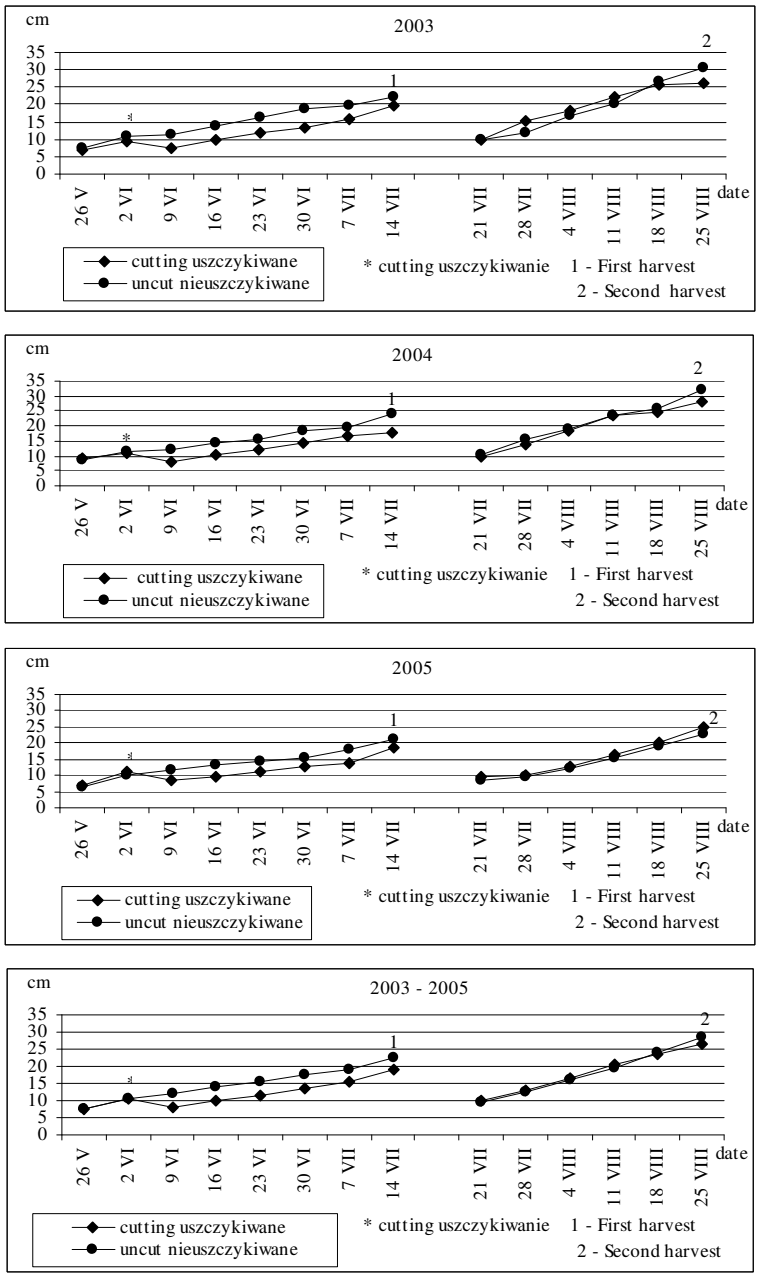

Fig. 1. Height of marjoran (*Origanum majorana* L.) cv. Miraż
Rys. 1. Wysokość majeranku ogrodowego (*Origanum majorana* L.) odmiany Miraż

The qualitative analysis was made on the basis of MS spectrums, comparing them with the spectrums of NIST library (62,000 spectrums) and LIBR terpene library (TR), provided by Finnigan MAT company. Identification of the compounds was confirmed by retention indices from literature data.

RESULTS

Cutting the plants two weeks after the seedling setting did not significantly affect their height (fig. 1). Plants that were cut appeared to be by 3.8 cm shorter before the first harvest, while their height before the second harvest was lower by 2.4 cm.

Performed studies revealed no significant influence of plant cutting on fresh herb yield, yield of air-dried herb, and ground herb yield (tab. 1). Weight of fresh herb achieved from cut plants was 74.6 dt·ha^{-1}, on average, and from uncut plants 75.7 dt·ha^{-1}. Mean weight of ground herb for cut marjoram was 10.9 dt·ha^{-1}, and for uncut plants 11.6 dt·ha^{-1}.

A significant dependence between harvest date and yielding of marjoram was found. Weight of fresh herb obtained from the second harvest (end of August) was considerably higher (44.6 dt·ha^{-1}) than that achieved at the first harvest date (mid of July) (30.5 dt·ha^{-1}) (tab. 1). Moreover, marjoram harvested at the end of August was taller (26.3–28.7 cm) than plants cut in the middle of July (18.8–22.6 cm) – fig. 1.

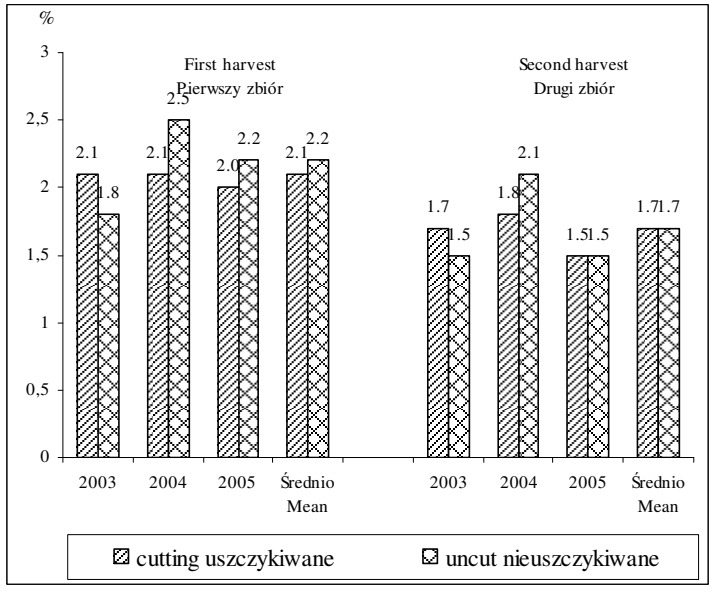

Fig. 2. Essential oil content in the wiped herb of marjoram cv. Miraż
Rys. 2. Zawartość olejku eterycznego w zielu otartym majeranku ogrodowego odmiany Miraż

Laboratory determinations revealed higher content of essential oils in marjoram herb harvested in the mid of July (first harvest) as compared to that cut at the end of August (second harvest) – fig. 2.

Average content of essential oil in ground herb obtained in the mid of July was from 2.1% (cut plants) to 2.2% (uncut plants). Herbs collected in the second date (end of August) contained slightly less active substance (1.7%; from cut and uncut plants).

Table 2. Percentage composition of essential oils of marjoran (*Origanum majorana* L.) cv. Miraż

Tabela 2. Zawartość procentowa składników olejku eterycznego z ziela majeranku ogrodowego (*Origanum majorana* L.) odmiany Miraż

Związek Compound	RI Indeks retencji	Percentage – Zawartość			
		harvest date – termin zbioru			
		first pierwszy	second drugi	first pierwszy	second drugi
		2004		2005	
α-thujene	928	1.0	1.3	1.3	1.5
α-pinene	935	0.4	0.5	0.5	0.6
sabinene	975	6.2	7.6	8.2	8.9
β-pinene	979	0.2	0.3	0.4	0.4
β-myrcene	993	1.3	1.6	1.5	1.7
α-phellandrene	1007	0.2	0.3	0.2	0.2
α-terpinene	1018	2.2	4.1	4.8	5.9
p-cymene	1028	0.3	0.2	0.2	0.2
limonene + β-phellandrene	1031	2.7	3.1	2.6	3.1
1,8-cineole	1035	0.1	0.1	0.1	0.1
(E)-β-ocimene	1050	0.1	0.1	tr	0.1
γ-terpinene	1061	3.5	6.2	7.9	9.0
cis-sabinene hydrate	1070	5.5	6.3	6.6	6.0
terpinolene	1091	0.7	1.3	1.5	1.8
trans-sabinene hydrate	1103	**50.3**	**38.1**	**29.4**	**27.9**
n.i.	1122	0.5	0.9	1.2	1.1
n.i.	1139	0.2	0.3	0.5	0.4
terpinen-4-ol	1171	**5.9**	**11.1**	**14.6**	**14.0**
α-terpineol	1183	3.5	3.8	3.1	2.5
cis-piperitol	1188	0.1	0.2	0.3	0.1
cis-dihydrocarvone	1190	0.1	-	0.1	0.1
trans-dihydrocarvone	1197	-	-	0.2	0.1
trans-piperitol	1199	-	0.1	0.2	0.2
4-terpineol acetate	1249	2.1	1.8	6.1	3.4
linalylacetate	1251	8.5	5.9	4.2	5.9
thymol	1301	-	0.2	-	-
n.i.	1305	0.3	0.5	0.6	0.5
carvacrol	1311	0.1	0.1	0.6	0.2
bicycloelemene	1342	0.2	0.1	0.4	0.4
neryl acetate	1370	-	0.1	-	-
geranyl acetate	1389	tr	0.1	-	-
β-caryophyllene	1426	2.7	2.9	1.8	2.2
α-humulene	1461	0.1	0.1	0.1	0.1
bicyclogermacrene	1504	0.7	0.4	0.9	1.4
caryophyllene oxide	1594	0.1	0.1	-	0.1

n.i.. – not identified

The largest amounts of essential oil were found in marjoram herb in 2004 achieved from cut plants (2.5%), and the smallest in 2005 (1.5%) (herb from both cut and uncut plants).

GC/MS analysis revealed the presence of 35 compounds in marjoram essential oil, 3 of which were not identified (tab. 2). Components that dominated in essential oil were trans-sabinene hydrate and terpinen-4-ol. Also sabinene, γ-terpinene, linalyl acetate, and cis-sabinene hydrate were present in large percentage.

The highest content of trans-sabinene hydrate (50.3%) was found in essential oil achieved in the mid of July 2004 (first harvest); however, quantity of terpinen-4-ol (5.9%) was very low as compared to the oil obtained from herb harvested in the second date of 2004 and oil in 2005.

DISCUSSION

Jadczak and Orłowski [1998] found the dependence of plant's cutting on yield size of marjoram cultivated from a seedling. Here presented studies did not reveal significant influence of plant cutting on marjoram's fresh herb and air-dried herb yields. Instead, significant interaction between harvest date and marjoram yielding was observed. Yields of fresh herb, air-dried herb, and ground herb achieved from the first harvest date was considerably higher than from the second one.

In present experiment, dry herb yield ranged from 12.2 to 24.5 dt·ha^{-1}, which is consistent with opinion of Załęcki et al. [1995], according to whom yield of the fresh marjoram's herb is 10–15 dt·ha^{-1}, on average. However, there are seasons when higher yields can be achieved.

Experiments made by Czarnecki and Załęcki [1986] revealed that yield of dry herb harvested in July was 3.08 dt·ha^{-1}, while in presented research, it was twice as much amounting to about 7.1 dt·ha^{-1}.

Kohlmünzer [1998] and Matławska [2005] found that essential oils content in marjoram's herb may be from 0.2 to 2.5%, and according to Kluszczyńska [2001] up to 0.7–3.5%. Studies of Czarnecki and Załęcki [1986] showed the oil level of about 1.18–1.58%, whereas those of Tabanca et al. [2004] 1.07–2.26%. Seidler-Łożykowska and Kazimierczak [2005] determined the essential oil content in marjoram's herb of cv, 'Miraż' at the level of 1.6%. In present study, content of essential oil achieved from marjoram (cv. 'Miraż') was similar level of 1.7–2.2%. Analyzed material met the requirements of Polish Pharmacopoeia VI [2002], according to which essential oil cannot be lower than 0.5%.

Experiments of Vera and Chana-Ming [1999] revealed presence of 45 compounds in essential oil extracted from *Origanum majorana* L., among which 2 were not identified. Komaitis et al. [1992] identified 45 compounds in marjoram's oil. Own study results showed 35 chemicals (3 were not identified) in oil achieved from marjoram cv. 'Miraż'.

Vera and Chana-Ming [1999] as well as Baranauskiene [2005] found that main components of marjoram's essential oil are: terpinen-4-ol, cis-sabinene hydrate, p-cymene, and γ-terpinene. Achieved results revealed that trans-sabinene hydrate (27.9–50.3%) dominated in marjoram's oil. Content of terpinen-4-ol ranged at the level

of 5.9–14.6%, which is consistent with studies by Tabanca et al. [2004]. In experiments made by Edris et al. [2003], contents of terpinen-4-ol was higher amounting from 25.3% to 37.5%, and according to Vera and Chana-Ming [1999] 38.4%.

Dudai et al. [2003] proved that terpinen-4-ol also dominated in oil from *Origanum dayi* Post, and according to Baser et al. [2003], it was main component of oil from *Origanum syricum* var. *sinaicum* (Boiss).

CONCLUSIONS

1. The harvest date had significant influence on marjoram's yielding. Higher yields were achieved at the end of August than in the mid of July.
2. No significant effect of marjoram cutting on fresh and air-dried herb was found.
3. Content of essential oil in ground herb achieved from the first harvest date (mid of July) was higher than from the second one (end of August).
4. The main components of marjoram's essential oil are: trans-sabinene hydrate, terpinen-4-ol, and sabinene.

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ZALEŻNOŚĆ MIĘDZY TERMINEM ZBIORU A PLONOWANIEM MAJERANKU OGRODOWEGO (*Origanum majorana* L.) ODMIANY 'MIRAŻ' UPRAWIANEJ Z ROZSADY

Streszczenie. Badania przeprowadzono w latach 2003–2005. Badano zależność między terminem zbioru a plonowaniem majeranku ogrodowego odmiany 'Miraż'. Plantację założono z rozsady wyprodukowanej w szklarni. Rośliny posadzono w rozstawie 30×40 cm. Dwa tygodnie po posadzeniu część roślin przycięto, usuwając wierzchołki pędów z pierwszą parą liści. Zbiór ziela wykonano dwukrotnie: w połowie lipca oraz pod koniec sierpnia. Oznaczono zawartość olejku eterycznego w zielu otartym. Skład jakościowy i ilościowy olejku majerankowego wyznaczono metodą chromatografii gazowej i spektrometrii masowej (GC/MS). Termin zbioru miał istotny wpływ na plonowanie majeranku ogrodowego. Większy plon świeżego ziela uzyskano ze zbioru sierpniowego (44,6 dt·ha^{-1}) niż lipcowego (30,5 dt·ha^{-1}). Zawartość olejku w zielu majeranku ogrodowego odmiany 'Miraż' wahała się w granicach 1,7–2,2%. Najważniejszymi składnikami olejku majerankowego są: trans-sabinene hydrate, terpinen-4-ol, sabinene.

Słowa kluczowe: *Origanum majorana* L., majeranek ogrodowy, plonowanie, skład olejku eterycznego, trans-sabinene hydrate, terpinen-4-ol

Accepted for print – Zaakceptowano do druku: 13.08.2005