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Research Article

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Cultivation Possibilities of Lemon Balm (*Melissa officinalis* L.) in the Central Anatolia Region of Turkey

Abstract

This study was carried out to determine yield and quality characteristics of lemon balm (*M. officinalis* L.) in 7 districts (7 locations) under Kayseri ecological conditions for 3 years in 2015-2017. In this research, herbage yield, essential oil content, essential oil yield and components were determined. Dry herbage yields varied between 5250-6100 kg ha^{-1}, essential oil contents varied between 0.07-0.24%, and essential oil yields as 4.2 lt ha^{-1}. The main essential oil components were gereniol (1.90-20.77%), nerylacetate (1.13-34.63%), linalool (4.04-25.34%), neral (5.10-12.96%), caryophylleneoxide (0.78-15.17%), geranial (1.20-14.19%), β–caryophyllene (8.50-12.93%). In terms of herbage yield and essential oil quality, Yahyalı and Kocasinan districts, had favorable environmental conditions for lemon balm cultivation.

INTRODUCTION

Lemon balm (*Melissa officinalis* L.) is a perennial plant from the Lamiaceae family naturally distributed in the Mediterranean countries, the Southern Alps and coastal areas of Turkey (Arslan, 2006; Baser, 2016). There are three subspecies belonging to the species *Melissa officinalis* (subsp. *Inodora Bornm*. subsp. *Altissima Arcangeli*, subsp. *officinalis*) and only subsp. *officinalis* is lemon scented subsp. and used for medicinal and other purposes. The other two subspecies are not used for medicinal purposes since they are odorless or foul smelling (Ceylan, 1997; Baytop, 1999).

Medical use of *M. officinalis* dates back to 2000 years. The Latin name of the plant, *Melissa*, means “bee leaf”. In addition, the Latin origin of the name is "honey", and it is often used to feed bees because the plant is rich in nectar (Charles, 2013). *Melissa officinalis*, which has taken its place in the life of mankind with its medicinal properties and preserved its importance throughout history, is still used as a folk remedy in the treatment of many diseases. *Melissa officinalis*, which is used in the treatment of many diseases from gastrointestinal system diseases to nervous system diseases, cardiovascular diseases and asthma, is a plant that widely used both in the form of standardized extracts in modern medicine and in folk medicine (Baskal et al., 2017).

Lemon balm cultivation area in 2019 was 20.9 ha, production was 93 tons and the average yield was 4450 kg ha^{-1} in Turkey. The provinces with the highest production are Karaman (62 tons $year^{-1}$), Adana (13 tons $year^{-1}$) and Samsun (8 tons $year^{-1}$) (Anonymous, 2019).

Dry herbage yields of lemon balm recorded by different researchers were 4560-10320 kg ha^{-1} (Demir et al., 2000), 8340-10420 kg ha^{-1} (Tınmaz et al., 2002) and 10340-10903 kg ha^{-1} (Katar, 2004). Essential oil contents of lemon balmwere between 0.06 and 0.47% recorded by most of the researchers (Başer, 2016; Bodrugand Kırtoga, 1983; Ceylan, 1995; Özgüven et al., 1999; Tinmaz et al., 2002; Katar, 2004; Kizil, 2009; Abdellatif et al., 2014; Uzun et al., 2014). However, some researchers found lower (0.007%) essential oil contents (Arslan, 2006; 0.01% Koç, 2002; 0.03% Awake and Gürbüz, 2014; 0.09% Yazici et al., 2020). Essential oil yield has been reported between 18.0 and 18.70 lt ha^{-1} (Katar, 2004).

Among the essential oil components, geranial, neral (citral) and citronellal are the main components (Başer, 2016). The fragrance in essential oil generally comes from citral and citronellal. Essential oil contains 40% citronellol, linalool and geraniol in general. Citral content varies between 14.2 and 68.6% (Ozguven et al.,1999). Other essential oil components are β – caryophyllene, caryophylleneoxide, citral, Z-citral, germacrene-d (Uzun et al., 2014).

The purposes of the present study were to investigate cultivation possibilities of lemon balm in various districts of Kayseri, and to determine the highest quality lemon balm cultivation areas and to suggest to as an alternative crop that could bring higher income to farmers.

MATERIAL and METHODS

The lemon balm seedlings used in the field studies were supplied by the Aegean Agricultural Research Institute/Menemen/ Izmir in 2015 and 2016.

In the field research, lemon balm seedlings were planted in 70 x 30 cm row spacing at the first week of May in 2015 and 2016. During the soil preparation, 20-20-0 compound fertilizer was applied to the base with pure 50 kg ha^{-1} N and P. Plants were harvested 10 cm above the soil level at the flowering stage in the second and third years. Since the plants did not reach a sufficient size in the first year when the seedling was planted, no harvests were made. In the first year, the upper parts of the plants were cut to increase the tillering before winter freezing. In 2016 and 2017, the plants were harvested 10 cm above the soil level in the first harvest at the flowering

period in June, and the second harvest in September-October before winter. Essential oils were extracted by water distillation for 3 h from air-dried leaves of lemon balm using a Clevenger-type apparatus. The study was conducted under farmer conditions using with completely randomized design, replicated three times.

The GC analyses were carried out using Hewlett-Packard 6890 GC with FID. A HP-5 MS capillary column (30 m × 0.25 mm i.d. 0.25 µm film thickness) was used. The carrier gas was helium (1.4 mL/min). The column was temperature programmed as follows: 5 min at 45 °C; then at 3 °C /min to 220 °C and held for 10 min. The injector and detector temperatures were 220 and 250 °C, respectively. Injection was carried out in automatic mode. Samples [0.5 µL of the oil solution in hexane (1:100)] were injected by the split less technique into the helium carrier gas. Peak areas and retention times were measured by electronic integration.

Kayseri is one of the coldest provinces of Central Anatolia, where the study was conducted. Winter months are freezing cold, summer months are hot and dry. The summer season is short. As well as the temperature difference between the winter and summer, the temperature difference between day and night is high. It can be seen that temperatures can rise up to 39.8 ^{o}C in the summer and fall down to -32.5 ^{o}C in the winter. In Kayseri, which has the characteristics of continental climate, rains come across winter, spring and autumn months. Twenty two percent of the average annual rainfall of 416 mm in the last twenty years was seen in autumn, 36% in spring, 32% in winter and 10% in summer. The winter season lasts long and rains are usually in the form of snow. Agricultural production areas are generally between 1000-1700 m above sea level (Anonymous, 2020). In Kayseri, 1st - 4th class agricultural lands are 546.221 hectares, and agriculture is generally carried out on these lands. The locations of Yeşilhisar, Yahyalı, Kocasinan and Develi where the studies were conducted are in the class of 1st class agricultural lands with brown soil structure. Melikgazi and Tomarza locations are classified as 2nd class agricultural lands in red brown soil, while İncesu location has sandy soil structure.

The current study was carried out in 7 districts and 7 locations between 2015 and 2017 in Kayseri under a typical continental type of climate. The province and production areas where the field studies were carried out in 2015 and 2016 were shown in Table 1.

Table 1. Province and production area of lemon balm in 2015 and 2016

Years	Locations	Area (ha)
2015	Yeşilhisar/Center	0.020
2015	Melikgazi/Center	0.025
2015	Yahyalı/Mustafabeyli	0.030
2015	Kocasinan/Yazır	0.015
2016	Tomarza/Işıklar	0.100
2016	Develi/Sindelhöyük	0.030
2016	İncesu/Garipçe	0.075
	Total	0.295

RESULTS and DISCUSSION

As it was seen in Table 1, studies were carried out in the area of 0.09 ha in 4 districts at 4 locations in 2015, and 3 locations and 0.25 ha in 3 districts in 2016. Field experiments were established in a total area of 0.295 ha.

In the first year of the field studies, which were established in 2015 and 2016, a harvest from higher points was carried out in order to increase the tillering and root development of the plants before winter. However, herbage yield was not taken due to the low yield. In all locations, although

the above-ground parts of the plants were completely dry in the winter, with the arrival of spring, new shoots formed in the plants and there was no regeneration problem and plant development. Due to winter and cold weather in Kayseri, no negative survival effects were observed in plants. Plant growth and yields were very good after the first year. The plants were harvested two times a year, at during the flowering period. The first harvest was made in June and the second harvest was made before winter in September-October. In all locations, while high herbage yields were obtained in June, a lower herbage yields were obtained in the second harvest.

Since the studies were conducted under the conditions of farmers, data could not be recorded regularly in all locations. The reasons for this may be due to the fact that the producers are no experience in lemon balm cultivation, lack of sufficient equipment, uncertainty in marketing the products. The data on 2016 dry herbage yield, essential oil content and essential oil yield in Kocasinan Yazır and Yahyalı Mustafabeyli locations were given in Table 2.

Table 2. Total dry herbage, essential oil content and essential oil yield values in 2016

Reviewed Features	Kocasinan Yazır	Yahyalı Mustafabeyli
Dry herbage yield (kg ha^{-1})	6100	5250
Essential oil content (%)	0.07	0.08
Essential oil yield (lt da^{-1})	0.42	0.42

As shown in Table 2, the total dry herbage yield in the second year in Kocasinan Yazır location was 6100 kg ha^{-1}, the essential oil content was 0.07% and the essential oil yield was 4.2 lt ha^{-1}, the total dry herbage in the second year in the location of Yahyalı Mustafabeyli was 5250 kg ha^{-1}, the essential oil content was 0.08% and essential oil yield was 4.2 lt ha^{-1}.

In the third year, dry and fresh herbage yields were higher than the second year, but these data could not be recorded since the yield values could not be weighed. In the ecological conditions of Kayseri, no climatic problem or serious harmful effects of disease problem was observed in the lemon balm plant.

In the second year dry herbage yields of the locations were between 5250-6100 kg ha^{-1}. The highest herbage yields were obtained in the third year. Dry herbage yield values are consistent with the findings of Demir et al. (2000), but were relatively low compared to the findings of other researchers (Tinmaz et al., 2002; Katar, 2004). The reasons of low yield were due to inexperienced farmers for lemon balm cultivation, the lack of equipment, infrastructures and no record for the third year harvest.

Essential oil yields were 4.2 lt ha^{-1} at the locations. Essential oil yields and herbage yield per hectare were low due to the mentioned reasons. Katar (2004) reported higher essential oil yields per hectare compared with our study. In Table 3, the essential oil contents of 4 locations obtained in the 2017 harvest are given.

Table 3. Essential oil contents of lemon balm grown at different locations in 2017

Location Name	Essential Oil Content (%)
Yahyalı Mustafabeyli	0.17
Kocasinan Yazır	0.13
Tomarza Işıklar	0.09
İncesu Garipçe	0.24
Average	0.16

Table 3 shows the essential oil contents in the four locations. Accordingly, the highest essential oil contents were obtained in İncesu Garipçe location with 0.24% and the lowest was obtained in Tomarza Işıklar location with 0.09%.

Essential oil contents varied between 0.07-0.24% among the locations. The essential oil contents are consistent with the findings of most researchers (Bodrugand Kırtoga, 1983; Ceylan, 1995; Ozguven et al., 1999; Tınmaz et al., 2002; Katar, 2004; Kızıl, 2009; Abdellatif et al., 2014; Uzun et al., 2014). Our result for essential oil content was higher than some the researchers (Arslan, 2006; Koc, 2002; Uyanık and Gurbuz, 2014).

The essential oil components of lemon balm grown in the locations were given in Table 4.

Table 4. Essential oil components of lemon balm grown in different locations in 2017

Components	İncesu Garipçe	Kocasinan Yazır	Tomarza Işıklar	Yahyalı Mustafabeyli
Myrcene	0.65	-	0.64	-
α-Terpinene	0.57	-	-	-
γ-Terpinene	4.09	-	-	-
trans *β*–Ocimene	0.58	-	0.91	-
p-Cymene	1.45	-	-	-
Citronellal	2.26	-	5.14	-
α-Copaene	0.39	-	0.75	-
β–Bourbonene	0.66	-	-	-
Camphor	0.44	-	1.81	1.44
Citronella	-	0.93	-	-
α-cubebene	-	0.62	-	-
Linalool	6.61	4.04	25.34	23.43
Linalylacetate	2.38	0.47	5.67	10.79
Lavandulylacetate	-	-	-	1.51
Chrysanthenol	-	1.03	-	-
β–Caryophyllene	12.93	12.57	8.50	9.03
trans-*β*-Farnesene	0.55	-	0.52	0.50
Lavandulol	-	-	0.60	-
α-Humulene	0.99	0,84	0.74	0.70
Neral	12.96	23.47	5.12	8.99
Methylgeranate	-	0.55	--	-
α-Terpineol	0.52	0.80	3.17	3.72
Borneol	-	-	0.73	0.62
Germacrene D	3.94	1.83	2.32	2.07
Nerylacetate	-	34.63	1.13	1.47
Geranial	-	1.20	7.74	14.19
Geranylacetate	0.80	1.02	2.60	3.63
δ-Cadinene	0.57	-	0.58	0.65
Nerol	-	-	0.70	0.97
Geraniol	20.77	14.21	1.90	2.83
Caryophylleneoxide	8.28	0.78	15.17	12.02
Humuleneepoxide II	-	0.51	-	-
Hexahydrofarnesylacetone	-	0.52	-	-
Thymol	10.51	-	1.44	-
Carvacrol	6.09	-	5.87	0.53
α-Cadinol	1.01	-	0.91	0.91

As seen in Table 4, 36 different components were determined in the essential oil analysis of the lemon balm grown in different locations. In Incesu location, the major components were gereniol (20.77%), neral (12.96%), β-caryophyllene (12.93%), thymol (10.51%) and caryophylleneoxide (8.28%).

Nerylacetate (34.63%), neral (23.47%), geraniol (14.21%), β-caryophyllene (12.57%) and linalool (4.04%) appeared in Kocasinan location. linalool (25.34%), caryophylleneoxide (15.17%), β-caryophyllene (8.50%), geranial (7.74%) and carvacrol (5.87%) were detected as main components in Tomarza location. The main components in Yahyalı location were linalool (23.43%), geranial (14.19%), caryophylleneoxide (12.02%), linalylacetate (10.79%) and β-caryophyllene (9.03%).

Geranial, one of the components desired in the essential oil of the lemon balm, was detected at the highest level of Yahyalı Mustafabeyli (14.19%) and in Tomarza Işıklar location (7.74%). In terms of neral (citral) Kocasinan Yazır location was the highest with 23.47%, followed by İncesu Garipçe location with 12.96%. Citronellal ratios varied between 5.14-2.26% in Tomarza and İncesu locations, respectively.

Main components in the essential oil of lemon balm were geraniol (1.90-20.77%), nerylacetate (1.13-34.63%), linalool (4.04-25.34%), neral (5.12-23.47%), caryophylleneoxide (0.78-15.17%), geranial (1.20-14.19%), β-caryophyllene (8.50-12.93%). In terms of essential oil components, our findings are consistent with Uzun et al. (2014), and according to Ozguven et al. (1999) findings, the neral content is somewhat low.

In the Musyafabeyli the highest geranial content were obtained. However, highest neral content was obtained in the Kocasinan Yazır location.

Despite the higher essential oil content (0.26%) in Incesu Garipçe compared to other locations, lower herbage yields were obtained in this location due to the excessive sandy soil structure.

CONCLUSION

In terms lemon balm of cultivation promising results were obtained from a tree-year study carried out in 7 different locations in 7 districts for 3 years in Kayseri.

The results showed that, lemon balm can be grown in almost all of the studied locations in Kayseri. Climatic factors have not appeared to be an important limiting problem for lemon balm cultivation in Kayseri in which the temperature drops down to -25-30 ^{o}C. Considering the yield and quality criteria, Kocasinan Yazır and Yahyalı Mustafabeyli looked like most favorable conditions for lemon balm cultivation. We believe that the districts of Kocasinan and Yahyalı are suitable regions for lemon balm cultivation due to the proper soil structure, irrigation possibilities of the lands and lower altitude compared with other locations.

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