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RESEARCH ARTICLE

Determination of yield parameters and essential oil composition in some lemon balm (*Melisa officinalis* L.) populations

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ABSTRACT

In this research, it is aimed to determine some parameters such as seedling growth, yield and essential oil components of lemon balm (*Mellissa officinalis* L.) populations belong to Samsun, Ordu, Trabzon and Artvin provinces in Turkey. Some morphological parameters such as plant height, number of leaves, peduncle lenght, leaf length, some yield parameters such as fresh herb yield (gr/plant), drug herb yield (gr/plant) and drug leaf yield (gr/plant) and some quality parameters such as essential oil ratio (%) and essential oil components of the populations were investigated. According to the results of the research, it was determined that the plant height values between 41.36 cm and 100.41 cm, the yield of fresh herb varies between 164.34 g/plant and 481.45 g/plant and the essential oil ratio values vary between 0.19% and 0.325%.

Keywords: Drog herb; Fresh herb; β-Caryophyllene; Caryophyllene oxide.

1. INTRODUCTION

In recent years, medicinal and aromatic plants have had a great place in both world trade and direct usage. These plants can be consumed as fresh vegetables and drug herbs, as well as herbal by-products. Most of these plants are obtained by collecting from nature. The collection of plants in this way both damages nature and causes undesired quality at the drugs. In addition, these collections cause destruction in these plants in terms of genetics in the natural flora. Species of *Mellissa Officinalis* L. have sedative, stomachic, carminative, diaphoretic, and antiseptic effects are in the group of these plants. And they have lemon-scented which are perennial herbaceous plants that are relatively rare in our country (Baytop, 1991). The lemon balm (*Melissa officinalis* L.) is 28-95 cm tall and has an upright and branched structure. Its leaves are wide and elliptical. While lemon balm spreads naturally up to 0 - 1500 m in Anatolia, it can be seen in almost every region (Davis, 1982).

Mostly, lemon balm has 3 subspecies at the coastlines of our country. It is known that among these subspecies, *subsp officinalis* has lemon-scented and can be used for treatments while the others have bad or no scent and can't be used for treatments. This subspecies is cultivated in Europe, widely (Baytop, 1999). Studies have shown that *M.officinalis* is a plant with high antioxidant and antimicrobial activity, and it also contains natural flavonoid and phenolic compounds (Tittel et al., 1982; Dastmalchi et al., 2008; Mahady et al., 2005; Lahucky et al., 2010).

In addition, it has been proven that *M.officinalis* has positive effects on patients with Alzheimer's disease (Moradkhani et al., 2010). It is known that the essential oil of *M.officinalis* varies between 0.01 and 0.25%, and methylheptenone citronellal, linalool, neral, geranial, geranyl acetate, caryophyllene, and caryophyllene oxide components are defined as the main components (Schilcher et al., 2016). In this research, it is aimed to determine some morphological parameters such as plant height, the number of leaves, peduncle length, leaf length, some yield characteristics such as fresh herb yield (gr/plant), drug-herb yield (gr/plant), and drug leaf yield (gr/plant) and some quality parameters such as essential oil ratio (%) and essential oil components of some *M.officinalis* populations have a great place among pharmaceutical and spice plants.

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MATERIAL AND METHODS

In the study, they were collected from different places belonging to the Labiatae family; *M. officinalis ssp.* from Samsun/Gelemen, Kurupelit, and Tekkeköy populations coded as M1, M2 and M3 of *officinalis*, M4 population of *M.officinalis ssp.officinalis* from Ordu/Çambaşı, M5 population of *M. officinalis ssp.altimissia* from Trabzon/Demirtaş plateau, *M.officinalis ssp.*

Inadora M6 population, *M.officinalis ssp.altimissia* M7 population from Arsin district and M8 population of *M.officinalis ssp.altimissia* from Artvin/Ardanuç, totally 8 lemon balm populations were studied. When the soil structure at the depth of 0-30 cm of the experimental site is examined, it has been determined that the soil structure is sandy- clayey-loam, the soil pH is neutral. The salt content is very low, lime-free, organic matter amount is moderate, N content is moderate and rich in terms of P and K.

Seeds belonging to the populations were germinated in viols and after the germinated seedlings reached a certain maturity, they were transferred in the experimental area divided into 4 m X 2.4 m plots, plant per field 30 cm X 40 cm. The research was carried out in the experimental area for 2 years.

Necessary cultivation applications were completed both in the viols and in the trial area. Phenological observations, morphological measurements, yield, and quality characteristics of each population were determined on 20 plants. 1000-grain weight, leaf length, leaf width, and petiole length were studied only in the first year of the study, while other parameters were studied in the second year. The essential oil ratio was made in the Clevenger apparatus by distillation method and the essential oil composition was made in Ankara University, Faculty of Agriculture, Field Crops laboratory. The obtained values of morphological and some quality parameters were evaluated with the simple statistical method in the Microsoft Excel program, and mean standard error, and coefficient of variation values were determined, and the populations were compared with each other with the t-test.

RESULTS AND DISCUSSION

Phenological parameters

While the populations started to germinate on the 15th and 21st days from sowing, it was observed that it was earlier than Ceylan's stated time (21. - 28. days). In addition, while the exit rates in populations during this period were between 5.3% (M2) and 75.5% (M4), only M4 was higher than the rate (70%) stated by Ceylan (1997). At the beginning of the generative period in populations, the first budding started on 101th (M1) day and continued until 131th (M3) day. The first blooms started on 09 July and lasted until 143th day from sowing. In July, most of the populations (M3, M4, and M7) did not bloom for a 50% flowering period. However, the flowering plants of these populations formed seeds. Populations started occurring fruit between days 123 and 162. (Table 1).

Morphological and quality parameters

The 1000-grain weight of *M.officinalis* populations ranged from 0.37 g to 0.64 g. When the results obtained are examined according to the varieties, *M.officinalis subsp. officinalis* between 0.43 and 0.64, *M. officinalis subsp.inadora* 0.41g and *M.officinalis subsp. altimissia* was found to be 0.40 – 0.47 g (Table 2). Ceylan, Tınmaz and Winiarczyk et al. stated in their research, as in our study, that there are differences between *M.officinalis subsp.officinalis* populations in terms of 1000-grain weights (Ceylan, 1997; Tinmaz, 1999; Winiarczyk et al., 2016).

According to the measurements taken in the first year of vegetation, the leaf length was determined between 24.91mm (M1) – 49.66 mm (M2). It was determined that the variation in M1, M2, M5, M6, M7, and M8 populations were quite low (% CV.: 7 – 20). However, variation values (% CV.: 27.3 and 23.7%) were found as high in M3 and M4 populations. According to subspecies It was determined that *ssp. altimissia* populations have leaf lengths between 30.78 – 33.26 mm, *ssp inadora* population 29.56 mm and *ssp officinalis* populations between 24.91 – 49.66 mm. In these populations, leaf width was found to vary between 24.42 mm (M8) – 43.06 mm (M2). Davis, Ceylan, and Aharizad reported in their studies that there is a difference between populations in terms of leaf length, similar to our research (Ceylan, 1997; Aharizad et al., 2012). In addition, as a result of the analysis of the values obtained in terms of leaf width of these populations, it was observed that the coefficient of variation was 31% (Table 2). This

Table 1: Phenological values observed in *Melissa officinalis* populations in the first year of vegetation

	M1	M2	M3	M4	M5	M6	M7	M8
Germination Time (Day)	17	15	15	17	21	15	18	18
Germination Time (%)	65.5	5.3	5.8	75.5	20	44.7	7.4	5.8
Budding Begining Time (Day)	101	108	131	126	122	111	127	126
First Flowering Time (Day)	108	117	143	131	131	124	131	131
50% Flowering Time (Day)	116	131	--	--	138	131	--	138
%100 Flowering Time (Day)	131	144	--	--	153	145	--	156
Fruit Occuring Begining Time (Day)	147	158	160	162	159	123	156	145

Table 2: Morphological values detected in lemon balm populations only in the first year of vegetation

Populations	1000-grain weight	Leaf Length (mm)	Leaf Width (mm)
M1			
Mean	0.54	24.91	24.99
St.Error		1.656	1.627
CV		0.199	0.195
M2			
Mean	0.64	49.66	43.06
St.Error		2.918	3.014
CV		0.204	0.242
M3			
Mean	0.43	40.08	42.87
St.Error		2.921	0.86
CV		0.273	0.075
M4			
Mean	0.61	45.17	42.61
St.Error		2.68	2.523
CV		0.237	0.237
M5			
Mean	0.55	33.06	28.03
St.Error		0.951	0.702
CV		0.1	0.087
M6			
Mean	0.41	29.58	24.14
St.Error		0.789	0.992
CV		0.075	0.116
M7			
Mean	0.40	34.49	29.2
St.Error		1.215	0.852
CV		0.122	0.105
M8			
Mean	0.47	30.78	24.42
St.Error		1.199	0.946
CV		0.135	0.14
MEAN			
Mean		37.06	33.50
St.Error		1.097	1.04
CV		0.288	0.31

situation is due to the high values of variation found in the M2 and M3 populations. Apart from these, there is no remarkable difference in terms of leaf width among other populations. When considered according to subspecies, it was determined that *ssp.altimissia* had leaf widths between 24.42 – 29.20 mm, *ssp inadora* subspecies 24.14 mm, and *ssp officinalis* 24.99 – 43.06 mm. Ahizad et al*.,* (2012) and Russo (2019) reported that different lemongrass populations differ statistically in terms of leaf width. As seen in Table 3, the plant heights were between 41.36 cm (M8) - 100.41 cm (M2) according to the combined analysis of the two years in the populations. It was observed that the populations were more sized in the second year of vegetation according to the years. In addition, large differences were observed both within and between populations. It is considered that this difference may be due to the difference between genotypes as well as the variation that each population has shown in different years. As a result of the T-test analysis of the combined data, M2, M3, M4, and M6 populations were not different from each other, while M3, which had the highest value, was different according to M1 (t=2.08*).

In addition, M5 and M7 populations were determined to be different from M1 with the smallest value and M8 smaller than themselves (t=6.35**). When examined according to varieties, ssp. officinalis 84.64 – 100.41 cm, with ssp. inadora 89.86 cm and ssp. altimissia was determined to have an average plant height between 41.36 – 59.42 cm (Table 3)

Özgüven et al*.,* (1995), Tınmaz (1999), Ceylan et al*.,* (1994), Sarı and Ceylan (2002) reported that there are differences in plant height between populations as in our study. According to the averages of the two years, the number of leaves on the stem ranged from 44.29 (M1) to 50.24 (M5), while it was found to vary between 36.32 (M6) - 50.35 (M5) in the first year, and between 45.88 (M2) -52.75 (M8) in the second year (Özgüven et al*.,* 1995; Ceylan et al*.,* 1994; Gazelle and Sarı 2001).

According to the t-test for the number of leaves, no difference was found between the populations. It was determined that subspecies ssp. oficinalis 44.29 45.53 pcs., ssp. inadora 43.06 pcs and ssp. altimissia had a leaf number in the range of 45.06 – 50.24. In addition, when analyzed by years, it was seen that there were differences in the yields of M1, M4, M5, M6, M7, and M8 populations according to years. In addition, according to the combined analysis, the difference by years (t=3.93**) was the main factor that increased the coefficient of variation in the populations. Ahmadi et al. also reported that the leaf numbers of two different genotypes were different in their research (Ahmadi et al*.,* 2021). At Flowering Period, peduncle lengths in these populations ranged from 5.37 mm (M7) to 7.54 mm (M3) based on the combined analysis of the two years. The coefficient of variation within the populations was determined as 23%. According to the t-test, it was seen that there was no difference between M5, M6, M7, and M8 populations. M5 with the highest value was found to be different from M1 with a larger mean value, M1 was different from the closest M4 (t=2.36*), M2, M3, and M4 populations were found to be statistically same from each other. According to the subspecies, it was determined that they had peduncle lengths in the range of ssp.inadora 5.76mm, ssp.officinalis 6.31 – 7.54 mm and ssp altimissia 5.37 – 6.09 mm. In addition, according to the t-test, there was a difference between years (t=6.82**); It was determined that it occurred between 5.33 mm (M5) - 8.16 mm (M3) in the first year, and 4.19 mm (M7) - 6.74 mm (M3) in the second year. It is considered that the density in the parcels due to coming to the new shoots in the second year causes

Table 3: The mean values of *Melissa officinalis* L. populations in terms of morphological characteristics

Populations	Plant Height (cm)			Leaf Number			Peduncle Lenght (mm)		
	First Year	Second Year	Mean	First Year	Second Year	Mean	First Year	Second Year	Mean
M1									
Mean	52.90	124.31	84.64	42.40	46.80	44.29	6.19	6.46	6.31
St.Error	2.68	2.51	6.27	1.30	1.29	0.99	0.23	0.22	0.16
CV	0.23	0.08	0.44	0.14	0.11	0.13	0.16	0.14	0.15
M2									
Mean	65.76	123.47	94.62	45.18	45.88	45.53	7.82	6.56	7.19
St.Error	3.62	2.51	5.47	1.90	0.78	1.01	0.22	0.23	0.19
CV	0.23	0.08	0.34	0.17	0.07	0.13	0.12	0.14	0.15
M3									
Mean	81.78	121.38	100.41	44.56	46.57	45.44	8.16	6.74	7.54
St.Error	2.33	4.67	4.24	1.12	0.88	0.75	0.26	0.27	0.22
CV	0.12	0.15	0.25	0.11	0.07	0.09	0.14	0.15	0.17
M4									
Mean	55.55	126.00	86.86	43.50	47.50	45.28	7.06	6.50	6.81
St.Error	3.47	2.64	6.32	1.25	1.32	0.96	0.35	0.16	0.21
CV	0.28	0.08	0.44	0.13	0.11	0.13	0.22	0.10	0.19
M5									
Mean	51.35	68.00	59.42	50.35	50.13	50.24	7.24	4.88	6.09
St.Error	2.08	2.13	2.08	1.37	0.92	0.82	0.25	0.18	0.26
CV	0.17	0.13	0.20	0.11	0.07	0.09	0.14	0.15	0.24
M6									
Mean	51.84	140.93	89.64	36.32	50.50	43.06	5.33	6.34	5.76
St.Error	1.75	3.25	7.96	0.84	1.21	4.12	0.14	0.30	0.17
CV	0.15	0.09	0.51	0.10	0.08	0.95	0.12	0.18	0.17
M7									
Mean	43.11	72.50	57.81	42.56	47.56	45.06	6.89	4.44	5.63
St.Error	1.99	1.73	2.80	1.06	0.41	0.70	0.30	0.14	0.26
CV	0.20	0.10	0.29	0.11	0.04	0.09	0.18	0.13	0.28
M8									
Mean	28.60	57.31	41.36	40.50	52.75	45.94	6.31	4.19	5.37
St.Error	1.61	1.52	2.65	1.55	1.14	1.42	0.21	0.29	0.25
CV	0.25	0.11	0.38	0.17	0.09	0.19	0.15	0.28	0.28
MEAN									
Mean	53.46	103.33	76.60	43.02	49.41	45.95	6.84	5.72	6.32
St.Error	1.48	2.84	2.14	0.55	1.04	0.59	0.11	0.12	0.09
CV	0.34	0.31	0.47	0.16	0.24	0.21	0.20	0.23	0.23

the peduncle lenght to be less. In the research, it has been determined that the peduncle length values of different genotypes are different (Sağlam, 2005).

Fresh herb yields of the populations ranged from 164.34g/plant (M8) to 481.45g/plant (M3) according to the two-year combined analysis, 300.04 g/plant as mean was obtained. According to the results of the combined analysis of two years, it was determined that there were differences (CV: 0.63) between populations. According to the t-test, no statistical difference was found between the M1 and M8, M3 and M4, M2, M5, M6 and M7 populations. However, M1 was determined to be different from the closest M5 (t=2.78**) which is bigger than itself. When evaluated according to varieties, the fresh herb was obtained in the range of 258.38 g/plant in *ssp. inadora*, 174.55 - 481.45 g/plant in *ssp.officinalis*, and 164.34 - 334.11 g/plant in *ssp.altimissia*. When the results were examined by years, it was seen that there was a difference (t=5.14**) in terms of fresh herb yield according to the t-test. Although the number of leaves and branches decreased in the second year of vegetation, the increase in yield is thought to be due to the large number of seconder stems formed from the shoots formed in the second year. In terms of drug-herb yield, the two-year average yields of the populations varied between 54.30 g/plant (M8) – 177.08 g/plant (Mel 3).

In addition, there are large differences (CV: 0.60) in the populations studied in this study in terms of drug-herb. It can be said that These differences are due to the variation in the populations themselves and the yield difference in different years. According to the t-tests, it was determined

that M2 was different from M6 (t=3.28**) with the lowest value and M4 with the highest value (t=2.00*). When the results were analyzed according to the Varieties, *ssp. officinalis* 61.13 – 149.15 g/plant, *ssp.inadora* 75.70 g/plant, *ssp. altimisia* 54.30 – 106.19 g/plant ranges. When the drug-herb yield was analyzed by years, it was determined that the 2nd year yields were high (t=5.67**). It can be said that the reason for this is that *Melissa officinalis* populations have stronger root structures in the second year of vegetation, stronger than the first year, forming a more dense structure with strong shoots under the ground and increasing the yield.

According to the two-year combined analysis, the average drug herb yields of the populations ranged from 23.82 g/plant (M1) to 56.91 g/plant (M7). The combined drug leaf yield average of two years was 39.86 g/plant, and its variation (CV.: 0.56) was found to be high. According to the t-test, drug leaf yields from M7 to low value M4 (t=2.19*), M3 M2 (t=2.70**), M4 M8 (t=2.47*), M2 M6 (2.70**) and M8 M1 (2.19*). Populations according to t-test, drug leaf yields towards lower value M7 from M4 (t=2.19*), M3 from M2 (t=2.70**), M4 from M8 (t=2.47*), M2 from M6 (2.70**) and M8 were determined to be different from M1 (2.19*). *ssp.officinalis* 23.82 – 50.87 g/plant, ssp. It has been determined that *altimissia* 30.53 – 56.91 g/plant and *ssp.inadora* 28.43 g/plant form drug leaves. Some researchers showed that fresh herb yield and drug-herb yield values in lemon balm differ between populations Özgüven et al., 1995; Ceylan et al., 1994; Sarı and Ceylan, 2002; Telli and Basalma (2002), Gürbüz et al., (2008), reported that there was a statistical difference in terms of fresh herb yield, drug herb yield and drug leaf yield of lemon balm lines (Table 4).

Table 4: The means of *Melissa officinalis* L. populations in terms of some herb and leaf parameters

Populations	Fresh Herba Yield (gr/plant)			Drog Herba Yield (gr/plant)			Drog Leaf Yield (gr/plant)		
	First Year	Second Year	Mean	First Year	Second Year	Mean	First Year	Second Year	Mean
M1									
Mean	120.34	242.31	174.55	36.49	93.97	61.13	21.67	26.69	23.82
St.Error	7.92	30.38	17.31	2.50	11.44	6.99	1.36	3.45	1.70
CV	0.29	0.50	0.60	0.31	0.47	0.68	0.28	0.50	0.42
M2									
Mean	242.10	338.06	290.08	89.11	123.25	106.18	47.50	28.23	37.87
St.Error	20.55	22.84	17.28	7.97	7.25	6.08	3.95	1.65	2.69
CV	0.35	0.28	0.35	0.37	0.24	0.33	0.34	0.24	0.41
M3									
Mean	383.30	591.86	481.45	125.26	177.08	149.65	53.05	48.41	50.87
St.Error	38.64	65.97	40.82	12.64	22.30	13.05	5.77	5.58	3.99
CV	0.43	0.45	0.49	0.43	0.50	0.51	0.46	0.46	0.46
M4									
Mean	342.23	485.56	405.93	89.31	148.73	115.72	46.79	37.52	42.67
St.Error	49.60	48.07	36.43	12.79	14.97	10.81	6.52	4.72	4.20
CV	0.65	0.40	0.54	0.64	0.40	0.56	0.62	0.50	0.59
M5									
Mean	294.44	300.44	297.35	97.89	91.63	94.85	53.80	39.75	46.99
St.Error	30.24	30.63	21.19	9.62	8.56	6.39	5.37	3.76	3.49
CV	0.42	0.41	0.41	0.41	0.37	0.39	0.41	0.38	0.43
M6									
Mean	159.76	392.21	258.38	48.99	111.94	75.70	25.98	31.77	28.43
St.Error	12.23	29.26	24.67	3.26	9.44	7.00	1.64	2.80	1.57
CV	0.33	0.28	0.55	0.29	0.32	0.53	0.28	0.33	0.32
M7									
Mean	351.22	317.00	334.11	107.69	104.70	106.19	63.94	49.89	56.91
St.Error	37.97	38.22	26.71	12.47	13.58	9.09	7.58	6.12	4.95
CV	0.46	0.51	0.48	0.49	0.55	0.51	0.50	0.52	0.52
M8									
Mean	123.45	215.46	164.34	40.21	71.93	54.30	25.16	38.19	30.53
St.Error	13.15	22.63	14.47	4.39	7.30	4.80	2.68	4.19	2.55
CV	0.48	0.42	0.53	0.49	0.41	0.53	0.48	0.41	0.49
MEAN									
Mean	248.98	359.02	300.04	78.01	115.52	95.34	41.57	37.85	39.86
St.Error	13.23	16.86	11.04	4.05	5.24	3.44	2.06	1.67	1.35
CV	0.65	0.53	0.61	0.63	0.51	0.60	0.60	0.50	0.56

While the essential oil ratio, which is one of the characteristics showing the quality characteristics of the populations, varied between 0.19% and 0.325% in the first year, it was observed that it changed between 0.1% and 0.35% the in second year. In both years, it was determined that M7 produced more essential oil content than other populations. When examined according to the varieties, it was determined that the *ssp.altimissia* variety produced more essential oil than the other varieties. While these obtained values were higher than the values obtained by Ceylan and Sarı 2002, it was seen that they were compatible with the values obtained by Özgüven et al., 1995. When the essential oil chemical component analyzes of the populations were examined, it was determined that the ratio of components above

Table 5: Essential oil ratios and chemical components of *M.officinalis* L. populations

POPULATIONS	M1	M2	M3	M4	M5	M6	M7	M8
Essential Oil Rates (%)								
First Year	0.19	0.2	0.17	0.18	0.20	0.18	0.325	0.3
Second Year	0.1	0.1	0.1	0.1	0.25	0.1	0.35	0.2
1.4-Methano-1H-indene.octahydr	-	-	2.34	-	1.155	2.31	-	-
1H-Cycloprop[e] azulen-7-ol	-	-	-	4.64	-	-	-	-
2-Hexadecen-1-ol	-	-	-	1.17	1.18	-	-	-
3-Cyclohexen-1-ol	-	-	1.02	-	-	-	-	-
4.7.10-cycloundecatriene1.1.4	-	-	-	-	1.86	1.89	-	-
8.9-dimethoxy	-	-	-	1.25	-	-	-	-
β-Cubebene	-	-	-	1.89	-	-	17.19	-
β-Caryophyllene	22.21	22.21	16.52	15.28	19.53	24.50	24.93	7.61
β- Pinene	-	-	-	-	1.06	-	0.98	-
β-Bourbonene	1.04	1.04	1.31	1.23	1.06	-	0.83	-
β-Elemene	1.21	1.21	1.18	1.53	1.3	-	1.24	-
β-Pinene	2.45	2.45	1.69	-	-	-	-	-
Aromadendrene	-	-	-	-	-	-	6.7	-
Benzenemethanol. 4-(1-methyleth)	-	-	-	1.58	-	-	-	-
Bicylo[3.1.0]hept-2-ene-2-menth	-	-	-	1.14	-	-	2.14	-
Bicylo[4.1.0]heptane. 3-methyl-	-	-	-	-	-	1.33	-	-
Carvacrol	0.72	0.72	-	0.92	-	-	-	-
Caryophyllene oxide	6.54	6.54	3.19	6.26	10.17	12.21	12.15	1.72
Citral	2.38	2.38	5.31	1.1	1.21	17.88	-	35.97
Z-Citral	1.53	1.53	3.73	-	1.1	13.79	-	28.93
Citronellal	-	-	-	-	1.61	1.77	-	4.59
Copaene	-	-	-	1.32	1.38	-	0.84	-
Cyclooctane.ethenyl-	-	-	-	-	-	-	-	2.18
Cycloheptane	-	-	1.4	-	-	-	-	-
Cyclohexanol. 3-ethenyl-3-methy	-	-	-	1.21	-	-	-	-
Cyclohexane	-	-	-	-	-	-	2.85	-
delta-cadinene	-	-	-	-	-	1.12	-	-
Gamma-curcumene	3.12	3.12	-	-	-	-	-	-
Geraniol	-	-	-	-	1.02	-	-	1.07
Geranyl acetate	-	-	1.62	-	-	-	-	3.4
Germacrene-d	23.61	23.61	21.78	24.02	21.5	6.5	0.84	1.98
1H-Naphthol[2.1-b] pyran. 3-ethen	-	-	-	1.57	-			-
Naphthalene	1.11	1.11	1.15	5.13	1.78	1.2	1.08	-
Neryl acetate	-	-	-	-	1.13	-	-	-
Piperitone Oxide	2.75	2.75	-	-	-	-	-	-
trans-anethol	1.28	1.28	-	-	1.2	5.68	-	1.5
T-Muurolol	2.74	2.74	1.33	1.09	1.1	1.13	-	-
Valencene	-	-	1.78	-	1.085	-	-	-
α .-humulene	2	2	1.54	1.57	1.8	-	2.05	-
α –Cadinol	-	-	-	-	-	-	1.55	-
α –Cubebene	1.45	1.45	-	-	-	-	-	-
α –Copaene	-	-	1.25	-	-	1	-	-
γ –Cadinene	1.78	1.78	1.78	2.48	1.46	-	1.2	-
Total	77.92	77.92	68.61	76.38	74.69	92.31	76.57	88.95

1% ranged from 68.61 to 88.95%. When the essential oil chemical component analyzes of the populations were examined, it was determined that the ratio of components above 1% ranged from 68.61 to 88.95%. When examined the varieties, the main components in the essential oil are *subsp.officinalis* subspecies β-Caryophyllene 15.28 – 22.21%, Caryophyllene oxide 3.19-12.21%, Citral 1.1-5.31%, Z-Citral 1.53-3.73%, Germacrene-d 11.34%. -24.02, Naphthalene 1.11-5.13%, in subsp inadora subspecies β-Caryophyllene 24.93%, Caryophyllene oxide 12.15%, β-Cubebene 17.19%, Aromadendrene 6.7%, Cyclohexane 2.85%, α-humulene 2.05% Germacrene-d 1.0% and Naphthalene was in the range of 1.08%, in *subsp.altimissia* subspecies β-Caryophyllene 7.61-1857, Caryophyllene oxide 1.72-11.49%, Citral 17.88-35.97%, Z-Citral 13.79-28.93%, Germacrene-d 1.98-6.5%, Naphthalene 0% -1.2, trans anethol 1.18%-5.68%, Citronellal 1.77-4.59%, Geranyl acetate 1.4-3.4. The ratio of Citral + Z-Citral components, which is expected to be high in *Melissa officinalis*, in the essential oil varies between 1.1-64.9%. When we examined according to the varieties, it was determined that M5, M7, and M8 populations in the *ssp.altimisia* variety produced more citral and Z-Citral than other varieties with ratios ranging from 31.67% to 64.9%. The yield and quality characteristics of these populations are important for breeding (Sadraei et al*.,* 2003, Meftaizade 2013, Abdellatif et al*.,* 2018, Kittler et al*.,).* In their 2018 research, they reported that they found the highest (z)-citral (neral), (e)-citral (geranial), citronella,l b-caryophyl-lene, b-caryophyllene oxide components in *M.officinalis subsp.officinalis* species (Table 5).

CONCLUSION

When the results of the research were examined in general, significant differences were determined between the lemon balm populations collected from different provinces in terms of the morphological parameters, yield parameters, and essential oil components examined. Samsun/Tekkeköy population had the highest values in terms of fresh-herb yield, drug-herb yield, and drug leaf yield. In all populations, β-Caryophyllene and Caryophyllene oxide were the highest detected essential oil components

REFERENCES

Aharizad, S., M. H. Rahimi, M. Moghadam and N. Mohebalipour. 2012. Study of genetic diversity in lemon balm (*Melissa officinalis* L.) populations based on morphological traits and essential oils content. Ann. Biol. Res. 3: 5748-5753.

Ahmadi, T., L. Shabani and M. R. Sabzalian. 2021. Led light sources improved the essential oil components and antioxidant activity of two genotypes of lemon balm (*Melissa officinalis* L.). Bot. Stud. 62: 9.

Baytop, T. 1991. Pharmacoptic Botany Textbook. Istanbul University Publication No: 3637, Istanbul, Turkey.

Baytop, T. 1999. Herbal Treatment in Turkey (Past and Present). Istanbul University Publications, Istanbul, p. 217.

Ceylan, A. 1997. Medicinal Plants -II (Containing Essential Oils)," Ege University Faculty of Agriculture Publication No: 481. Bornova-Izmir, Turkey, p. 225-257.

Ceylan, A., E. Bayram and N. Özay. 1994. Researches on agronomic and technological properties of *Melissa officinalis* L. Doğa. Turk. J. Agric. Forest. 18: 125-130.

Dastmalchi, K., H. D. Dorman, P. P. Oinonen, Y. Darwis, I. Laakso and R. Hiltunen. 2008. Chemical composition and *in vitro* antioxidative activity of a lemon balm (*Melissa officinalis* L.) extract. LWT. 41: 391-400.

Gazelle, A. and A. O. Sari. 2001. Research on Some Agronomic and Quality Criteria of *Melissa officinalis* L. of Different Origins in Menemen and Bozdağ Ecological Conditions. Aegean Agricultural Research Institute, Department of Field Crops (PhD Thesis) İzmir.

Gürbüz, B., R. Bahtiyarca, A. Ipek, Y. Arslan, T. Akar, B. Coşge and H. Telli. 2008. An investigation on herb yield and some features of selected lemon balm (*Melissa officinalis* L.) lines in Ankara conditions. J. Facul. Agric. Akdeniz Univ. 21: 85-96.

Lahucky, R., K. Nuernberg, L. Kovac, O. Bucko and G. Nuernberg. 2010. Assessment of the antioxidant potential of selected plant extracts --*in vitro* and *in vivo* experiments on pork. Meat Sci. 85: 779-784.

Mahady, G. B., S. L. Pendland, A. Stoia, F. A., Hamill, D. Fabricant, B. M. Dietz and L. R. Chadwick. 2005. *In vitro* susceptibility of helicobacter pylori to botanical extracts used traditionally for the treatment of gastrointestinal disorders. Phytother. Res. 19: 988-991.

Moradkhani, H., E. Sargsyan, H. Bibak, B. Naseri, M. Sadat-Hosseini, A. Fayazi-Barjin and H. Meftahizade. 2010. *Melissa officinalis* L., a valuable medicine plant. J. Med. Plants Res. 4: 2753-2759.

Özgüven, M., S. Kirici, S. Tansi, P. Aksungur and A. Yaman. 1995. Medicinal Plants Research and Development Project. TÜBİTAK, Project no: TOAG-990/DPT, Turkiye.

Russo, M. 2019. Investigations on the Effect of Light Reduction on Yield, Growth, and Secondary Metabolites of Lemon Balm (*Melissa officinalis* L.) (Doctoral Dissertation, Justus-Liebig-Universität Gießen).

Sağlam, B. 2005. A Research on Yield and Quality with the Effect of Organic Fertilizer on Ontogenetic and Diurnal Variability in Some Plants of the Labiatae Family (*Origanum onites* L., *Melissa officinalis* L., *Thymus praecox*). Ondokuz Mayis University Institute of Science Master's Thesis, Samsun.

Sari, A. O. and A. Ceylan. 2002. Yield characteristics and essential oil composition of lemon balm (*Melissa officinalis* L.) grown in the Aegean region of Turkey. Turk. J. Agric. Forest. 26: 217-224.

Schilcher, H., S. Kammerer, T. Wegener and D. Volkmann. 2016. Leitfaden Phytotherapie. 5th ed. Elsevier, Urban Fischer Verlag, Mu¨Nchen, pp. 224-225.

Telli, H. Y. and D. T. D. Basalma. 2002. Comparison of Selected Lemon Balm (*Melissa officinalis* L.) Lines in Terms of Drug Yield and Essential Oil Content (Doctoral dissertation, Ankara University, Institute of Science and Field Crops Department).

Tinmaz, A. B. 1999. Determination of Appropriate Planting Frequency and Harvest Time of Ogulotu (*Melissa officinalis* L.) Plant (Master Thesis). Çanakkale Onsekiz Mart University, Institute of Science, Field Crops Department, Çanakkale.

Tittel, G., H. Wagner and R. Bos. 1982. Chemical composition of the essential oil from Melissa. Plant Med. 46: 91-98.

Winiarczyk, K., K. Seidler-Łożykowska, J. Gębura and J. Bocianowsk. 2016. Vitality and germination of lemon balm (*Melissa officinalis* L.) seeds. J. Appl. Bot. Food Qual. 89: 156-162.