



Yield, Essential Nutrients and Essential Oils of Peppermint (*Mentha x piperita* L.) Grown Under Organic Farming Conditions

**Bihter ÇOLAK ESETLİLİ^{1*}, Özgür ÇOBANOĞLU¹,
Mahmut TEPECİK¹, Bintuğ ÖZTÜRK², Dilek ANAÇ¹**

¹Department of Soil Science and Plant Nutrition, Faculty of Agriculture, Ege University Bornova,
Izmir

²Department of Pharmaceutical Botany, Faculty of Pharmacy, Ege University, 35100 Bornova, Izmir,
*e-posta: bihter.colak@ege.edu.tr, Tel:0 232 311 15 15

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Abstract: The aim of this study was to examine the yield, essential plant nutrients (N, P, K, Ca, Na, Fe, Zn, Mn, Cu and B), essential oil and oil components of peppermint (*Mentha x piperita* L.) which was grown under organic farming conditions. Different certified organic fertilizers or natural inputs were the treatments of the study and tested in the nutrition of peppermint. Their effects on different parameters were examined.

Results showed that fresh and dry herb yields differ according to the treatments and were found higher in the parcels where bone meal and potassium feldspate were given. Impact of different inputs/fertilizers on the secondary plant nutrients indicated that the peppermints of the parcels that received bone meal and potassium feldspate or rockphosphate and zeolite were richer in this regard. The essential oil yield (%) and compositions of essential oils of peppermint were highly affected by the bone meal applications.

Key Words: Organic fertilizers and inputs, essential plant nutrients, *Mentha x piperita* L., organic agriculture, essential oil.

Organik Şartlarda Yetiştirilen Nanenin (*Mentha x piperita* L.) Verim, Besin Maddesi ve Uçucu Yağ İçeriği

Özet: Bu çalışmada, nanenin (*Mentha x piperita* L.) verim, temel besin elementleri (N, P, K, Ca, Na, Fe, Zn, Mn, Cu ve B), uçucu yağ ve bileşenleri üzerine organik tarım sistemi ile yetiştiriciliğin etkisinin belirlenmesi amaçlanmıştır. Sertifikalı farklı organik gübre ve girdi uygulamalarının etkisinin incelendiği denemede, nanenin besin maddesi içeriği belirlenmiştir. Ayrıca farklı parametreler üzerine etkileri de saptanmıştır.

Uygulamalara göre taze ve kuru herba verimi istatistiki olarak farklılaşmış ve kemik unu ile potasyumlu feldispat uygulanan parsellerde daha yüksek bulunmuştur. İkincil bitki besin elementi üzerine de kemik unu ve potasyumlu feldispat ile hamfosfat ve zeolit uygulamaları daha ön plana çıkmıştır. Nane uçucu yağ verimi ve bileşenleri üzerine kemik unu uygulamalarının önemli düzeyde etkili olduğu saptanmıştır.

Anahtar Kelimeler: Organik gübre ve girdiler, tıbbi bitkiler, *Mentha x piperita* L., organik tarım, uçucu yağ.

Introduction

Peppermint (*Mentha* sp.) is a widespread herb with economic importance and is a member of **Lamiaceae** family. Its origin is the Mediterranean Region, especially Anatolia and Egypt. Different types of peppermint are commercially grown in many countries due to its valuable essential oil. Annual production exceeds 4000 tones globally and 80 % of this production is from United States (USA). Peppermint is commonly grown in gardens, front yards and fields. It is consumed as spice and herbal tea in Turkey owing to its medically antispasmodic, carminative, antimicrobial, stimulant and diuretical effects (Baytop, 1984). Peppermint oil is the primary source of menthol which has wide fields of application in medicine, food and cosmetic industries (Hornok, 1992; Aflatuni, 2005). Annual production of peppermint essential oil is globally 6000-8000 tones and is in the second rank after citrus oil. The countries producing highest amount of peppermint oil are USA, France, Brazil, Argentina, Western European countries, China, Peru, Thailand and Korea. The highest imports are from the above mentioned countries to the countries in European Union (Ceylan et al., 1994; Pranz et al., 1984). Peppermint oil production in USA in the year 2006 was 3289 tons from an area of 32076 ha (USDA, NASS, Crop Report, 2007). With its high quality, USA is one of the primary countries in the peppermint essential oil market.

The essential oil content of peppermint and its oil components are economically important. Researches on this topic have stated that environment, harvest date, photoperiod (Clark and Menary, 1979a, 1979b), latitude, in general growing conditions (Topalov, 1962) and agronomic practices like harvest stage (Clark and Menary, 2006), irrigation (Nedkov and Georgiev, 1991; Ram et al., 1995; Topalov, 1962), pesticide applications (Zheljzakov and Margina, 1996) or fertilization (Mitchell and Farris, 1996; Scavroni et al., 2005; Topalov, 1962) have influence on peppermint essential oil content and components.

The aim of this study was to examine the yield, essential plant nutrients (N, P, K, Ca, Na, Fe, Zn, Mn, Cu and B), essential oil and oil components of peppermint grown under organic farming conditions where different certified organic fertilizers / natural inputs are practiced.

Materials and Methods

This study was carried out in the agricultural areas of a certificated organic farm in Kuşadası, Aydın (37° 45' 45" N, 27° 17' 48" E; 67 m above sea level) in the year 2011 may. An experiment was established where different “certified organic fertilizers/natural inputs” were tested and compared in accordance with the above stated objective. The

statistical layout of the experiment was randomized complete block ($5 \times 4 = 20\text{m}^2$) design with three replications.

Fertilizer/inputs were applied according to the recommendations of soil testing NPK requirements ($28 \text{ kg da}^{-1} \text{ N}$, $20 \text{ kg da}^{-1} \text{ P}_2\text{O}_5$, $28 \text{ kg da}^{-1} \text{ K}_2\text{O}$) of principles of organic farming. As a standard practice 3000 kg da^{-1} farmyard manure and 50 kg da^{-1} sulphur were incorporated to the experimental plots including the control treatment. Then the following different fertilizers combinations were applied as the treatments of this study. Respectively, rock phosphate (RP), bone meal (BM), potassium feldspate (KF) and zeolite (Z) were given as 100, 60, 100 and 100 kg da^{-1} ;

- 1) Rockphosphate (RP) +Potassium feldspate (KF)
- 2) Bonemeal (BM) + KF
- 3) BM + Zeolite (Z)
- 4) RP + Z
- 5) Control

The composition of these fertilizers are given in the following Table 1.

Herba were harvested nearly in 120 days. Herba yield were weighed and dried. Essential plant nutrients in the herba were digested according to Aqua Regia ($\text{HCl}:\text{HNO}_3$, 3:1) method (ISO, 1995) and in the digest phosphorus (P) (Lott et al., 1956), potassium (K), calcium (Ca), sodium (Na), iron (Fe), copper (Cu), zinc (Zn), manganese (Mn) and boron (B) (Kacar, 1972) were measured. Total N was determined by Kjeldahl method (Kacar, 1972).

Table 1. The composition of fertilizers/inputs

	Potassium feldspat	Zeolite	Bone Meal	Rock phosphate	Sulfur	Animal manure
N (%)	0.09	0.11	8.40	0.14	trace	0.24
P_2O_5 (%)	0.05	0.03	10.11	29.21	trace	0.13
K_2O (%)	0.17	1.02	0.11	0.31	trace	1.63
Na (%)	0.09	0.33	0.41	0.47	0.16	0.30
Ca (%)	0.27	2.36	9.20	33.50	0.35	2.08

The leaves were separated from the other aerial parts and then air-dried in shade at ambient temperature, and then cut into small pieces, which were subjected to hydrodistillation with a Clevenger-type apparatus, for 3 h, according to European Pharmacopoeia. After distillation, the essential oils were dried over anhydrous sodium sulfate, filtered and stored in a dark vial at 4°C until Gas Chromatography Analysis (European Pharmacopoeia, 1996).

Soils were analyzed for their physical and chemical properties. The pH (Jackson, 1967), water soluble salts (Anonymous, 1951), CaCO_3 (Çağlar, 1949), texture and organic matter (Black, 1965), total N (Bremner, 1965), extractable P (Bingham, 1949), extractable K, Ca, Na and Mg (Pratt, 1965; Thomas, 1982) were determined (Table 1).

Table 2. Some physical and chemical properties of the experimental soil

Texture	Sand (%)	Silt (%)	Clay (%)			pH	Water soluble salts (%)
Loamy	47.61	29.64	22.75			7.81	0.027
N (%)	Available (mg kg ⁻¹)					CaCO ₃ (%)	Org. matter (%)
	P	K	Na	Ca	Mg		
0.16	2.42	146	44.75	5800	582	30.00	2.04

All data were analyzed statistically with TARIST package program (Acikgoz et al., 1994).

Results and Discussion

Peppermint grown under organic conditions was investigated in terms of dry and fresh herba yields, primary and secondary essential plant nutrients (N, P, K, Ca, Na, Mg, Fe, Cu, Zn, Mn and B), total essential oil yield (%) and oil components (Table 3, 4 and 5).

Table 3. Fresh and dry weights and total oil contents of peppermint in different treatments

Treatments	Fresh weight (kg da ⁻¹)	Dry weight (kg da ⁻¹)	Total oil (%)	Menthone (%)	Menthol (%)
RP + KF (1)	940 e	181 b	3.79	29.87 b	34.18 ab
BM + KF (2)	1696 a	308 a	3.70	29.71 bc	35.78 a
BM+Z (3)	1240 b	213 b	3.80	32.74 a	31.32 c
RP+Z (4)	1181 c	205 b	4.00	29.16 c	32.68 bc
Org.Control (5)	1109 d	211 b	3.95	29.64 bc	33.82 ab
Fertilizer treat. LSD (1%)	3.07	(1%) 59.49	ns	(1%) 0.57	(1%) 2.13

According to our findings presented in Table 3, fresh herba yield changed between 940-1696 kg da⁻¹ and dry yield between 181-308 kg da⁻¹. Results high lighted BM+KF application as the prominent high yielding fertilizer/input combination. Peppermint yield is changeable according to regions and climates. In general, the minimum and maximum dry herb yields are reported between 250-500 kg da⁻¹ on the average (Özgülven and Kırıcı, 1999). In relation to the essential oil contents of the specified peppermints, 1-2 % which could reach to 3.5% is reported. In a parallel study, the fresh herb yields of *Mentha Piperita* variety was found in the range of 1420-3150 kg da⁻¹ in Germany and 670-1350 kg da⁻¹ in Turkey (Özgülven and Kırıcı, 1999). It is also claimed that in both of the countries, the essential oils were found between 2.40-2.85 %. Many of the findings have shown that it is not possible to obtain high quality peppermint oil from *Mentha Piperita* in the regions below 40° latitude due to shorter days and high temperatures which results in lower menthol and higher menthone quantity (Özgülven and Kırıcı, 1999).

Essential oil yield is one of the most important quality parameters for peppermint. In the current study, essential oil yield was determined between 3.70-4.00 % and no

significant differences were detected with respect to treatments. Menthol and menthone were determined as the dominant oil components. Menthol was found high in the BM+KF treatment (35.78%). On the other hand, menthone essential oil component was found higher in the peppermints subjected to BM+Z practice (Table 3). The European Pharmacopoeia established that peppermint oil should contain 30-55% menthol, 14-32% menthone, 2.8-10% menthyl acetate and 1-9% menthofuran (Harris, 2006). Our results are generally in accordance with these reports.

Peppermint herba was analyzed for their N, P, K, Ca, Na and Mg contents and the treatments were found significantly effective on many of these plant nutrients (Table 4). In a study by Ozcan and Akbulut (2007), the chemical composition of mint collected from different local markets were found as: 0.46 for Ca (%), 1.93 for K (%), 0.30 for Na (%), 0.27 for Mg (%) and 0.65 for P (%). The N, P and Mg contents determined in the current study are compatible with these values. However, K and Ca contents were higher than the reports given in literature. Nitrogen is one of the most important nutrients in peppermint herba and in oil yield (Clark and Menary, 1980; Jeliaskova et al., 1999; Kothari and Singh, 1995; Mitchell and Farris, 1996; Piccaglia et al., 1993; Singh et al., 1989). In this regard, the beneficial effect of the combined application of N and P on essential oil in *Mentha piperita* and *Mentha arvensis* was reported by Zheljzkov et al. (2010) and Munsi (1992), respectively. In our study, the impact of different certified fertilizers /inputs on the N content of peppermint herb did not statistically differ. The amount of P is found higher in the RP+Z treatment. Potassium, Na, Ca and Mg contents in the peppermints of the BM+Z treatment parcels had statistically meaningful differences.

Table 4. Primary plant nutrients of peppermint in different treatments

Treatments	N (%)	P (%)	K (%)	Na (mg kg ⁻¹)	Ca (%)	Mg (mg kg ⁻¹)
RP + KF (1)	2.05 a	0.54 c	3.07 ab	433 b	1.22 b	1823 c
BM + KF (2)	1.81 b	0.51 d	2.62 c	396 d	1.46 a	2063 b
BM+Z (3)	1.97 a	0.57 b	3.32 a	456 a	1.48 a	2133 a
RP+Z (4)	1.96 a	0.61 a	2.67 bc	409 c	1.24 b	1525 d
Org.Control (5)	1.67 c	0.46 e	2.54 c	366 e	1.12 c	1505 d
Fertilizer treat.LSD (1%) 0.09	(1%) 0.02	(5%) 0.42	(1%) 5.09	(1%) 0.09	(1%) 69.04	

The secondary essential plant nutrients in peppermint are given in Table 5. The chemical composition of the peppermint (*Mentha Piperita*) studied by Kızıl et al. (2010) in Diyarbakır is given as: Cu 11.52 mg kg⁻¹, Fe 31.5 mg kg⁻¹, Mn 70.82 mg kg⁻¹ and Zn 12.64 mg kg⁻¹. Our research findings were generally consistent with the values reported by Kızıl et al. (2010). In our study, the impact of different fertilizers/inputs highlighted that RP+Z applied peppermints are richer in terms Fe, Zn and Mn while BM+KF in terms of Cu and B.

Conclusion

Results of this study showed that fresh and dry herba yields of peppermints considerably differed by the practiced fertilizer/input treatments. Especially, BM+KF practice notably increased the yield. Statistically no significant differences were found among the treatments in terms of total essential oil yield (%). Menthone and menthol were determined as the dominant oil components. Menthone (%) and menthol (%) contents were found higher in BM+Z and BM+KF applications, respectively. The effect of treatments on the primary plant nutrients once again indicated that the peppermints of BM+Z treatment contained more K, Ca and Mg. Secondary plant nutrients were found higher in RP+Z and BM+KF applications. All of these findings indicate BM as the primary P source in the nutrition of peppermint. Results also indicate that a K source either KF or Z should accompany. In this regard, priority should be given to the NPK requirements of peppermint in order to make a suitable suggestion for an organic fertilization.

Table 5. Secondary plant nutrients of peppermint in different treatments

Treatments	Fe (mg kg ⁻¹)	Cu (mg kg ⁻¹)	Zn (mg kg ⁻¹)	Mn (mg kg ⁻¹)	B (mg kg ⁻¹)
RP + KF (1)	53.28 c	9.63 ab	32.70 bc	49.94 b	35.28 a
BM + KF (2)	48.83 c	10.17 a	35.33 ab	45.55 d	33.90 a
BM+Z (3)	58.41 b	9.16 b	30.67 c	48.08 c	28.75 b
RP+Z (4)	78.34 a	9.60 ab	37.30 a	85.87 a	28.28 b
Org.Control (5)	52.40 c	9.22 b	30.88 c	51.10 b	19.17 c
Fertilizer treat.LSD (1%)	1.26	(5%) 0.62	(1%) 3.41	(1%) 1.31	(1%) 5.11

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