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The effect of ecological conditions on yield and quality traits of selected peppermint (*Mentha piperita* L.) clones

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ABSTRACT

The commercial production of peppermint (*Mentha piperita* L.) depends on the genetic structure and ecological conditions affecting yield and oil composition. To determine yield and quality characters of two peppermint clones (Clone-3 and Clone-8), field experiments were carried out at four different locations (Aydın, Bursa, Izmir and Tokat) in Turkey during 2007 and 2008. Locations with warmer climate gave higher fresh herbage yield (Aydın and Izmir 37.0 t/ha and 36.8 t/ha, respectively). Although vigor canopy caused maximum fresh herbage yield, it decreased dried leaf yield due to the defoliation of leaves near to the ground. The main components menthol and menthone showed significant variation with different ecologies. Menthol contents were higher in temperate locations (Bursa and Tokat), while menthone contents were lower. The differences in oil composition of Clone-3 were lower than that of Clone-8 according to different climates, thus Clone-3 can be grown widely in various ecological conditions for oil productions as compared to the Clone-8. It was also concluded that temperate location was more suitable for peppermint oil production with high menthol contents.

1. Introduction

Mentha genus, a number of Lamiaceae (Labiatae), includes many high-value essential oil crops used widely in perfumery, cosmetic and pharmaceutical industries. Approximately, 2000 tons of world essential oil is obtained from *Mentha* species being the second most important essential oil plants after *Citrus* species (Mucciarelli et al., 2001). Of all mint species, *Mentha canadensis*, *Mentha piperita* and *Mentha spicata* are major mint species having economic importance. Cultivation of *M. canadensis* (syn: *Mentha arvensis* L. f. *piperascens* Malinv. Ex Holmes) (Liu and Lawrence, 2007) is suitable for the tropical and sub-tropical climates, while *M. piperita* for temperate climate. *M. piperita*, named as "peppermint", has wide adaptation ability in different climate and soil conditions while temperate climates are more suitable for high quality. Green (1963) explained that peppermint (*M. piperita*) was cultivated to produce the best quality oil in region situated in north of 40th parallel. However, Zheljazkov et al. (2010) showed *M. piperita* could be grown successfully up to 34th parallel in Mississippi.

Global demand for peppermint oil is increasing in recent year. Major producing countries are Bulgaria, Italy, China and USA, supplying about 90% of total peppermint oil production (Dwivedi et al., 2004). Despite of suitable climate, mint oil is not produced commercially in Turkey. Substantial consumption of the oil and menthol in Turkey results in an estimated economical output of 2.9 million dollars per year (Bayram et al., 2010). Since the production of mint species with high menthol contents are not adequate, Turkey imports peppermint oil and menthol requirements. In addition, the improved varieties of *M. piperita* for menthol and peppermint oil production in Turkey has not yet available, and there is limited commercial farming for essential oil production in mint, except for spice productions.

The climate in the northwestern Turkey is considered suitable for the production of high-quality essential oil in peppermint. Agronomical studies on *M. piperita* showed that the climatic conditions of Black Sea region (Tokat) (Telci and Sahbaz, 2005a) are more suitable than those of Cukurova region (Adana) (Ozguven and Kırıcı, 1999) for essential oil quality. However, there are limited records on peppermint productivity and oil composition in the Marmara and Aegean regions of Turkey with different climate conditions. The aim of this study was to evaluate the yield and quality performance of two clones under different ecological conditions (Aydın, Bursa,

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Table 1
The geographic positions and the climatic data of locations carried out field experiments.

Position and climatic data	Locations			
	Aydın	Bursa	Izmir	Tokat
Coordinates				
N	37 45 55 53	40 13 35 96	38 27 10 57	40 19 46 03
E	27 42 46 17	28 51 45 88	27 13 31 94	36 27 50 55
Altitude (m)	47	120	27	594
Rainfalls (mm)				
2007	618.5	669.1	487.2	425.8
2008	419.2	636.9	427.3	471.2
Mean	518.8	653.0	457.2	448.5
Temperature (°C)				
2007	18.6	15.3	18.8	13.5
2008	18.4	15.3	18.8	12.0
Mean	18.5	15.3	18.8	12.8
Relative humidity (%)				
2007	56.8	66.5	56.1	58.5
2008	56.5	67.6	55.3	62.6
Mean	56.6	67.0	55.7	60.5

Izmir and Tokat). The clones were selected by scanning *Mentha* landraces in Turkey (Telci and Sahbaz, 2005a,b).

2. Materials and methods

2.1. Plant material and field experiments

Peppermint (*M. piperita*), a hybrid of *Mentha aquatica* and *M. spicata*, was the first cultivated commercially in England, and later introduced to the other countries. The results of scanning the cultivated mint landraces in Turkey revealed that *M. piperita* is restrictedly cultivated in two different locations, Elazıg and Gaziantep. The plants were introduced in collection plots of Agriculture Faculty in Gaziosmanpasa University. Plant materials were selected from one plant of the accessions and named as Clone-3 (from Elazig) and Clone-8 (from Gaziantep). They have been maintained in the collection garden of Field Crop Departments of Agricultural Faculty in Gaziosmanpasa University, Tokat, Turkey.

Field experiments were conducted in 2007 and 2008 at four locations. The geographic positions with some climatic data and soil properties of the locations are summarized in Tables 1 and 2, respectively. Izmir and Aydın having typical Mediterranean climate are characterized by long, hot and dry summers and mild to cool, rainy winters. Bursa has intermediate climate between Mediterranean and Black Sea climates, while Tokat has middle Black Sea climate. Soil texture of experiment areas was composed of clay in Bursa and Izmir, while it was sandy clay loam in Aydın and clay loam in Tokat. Other properties of the soils were suitable for mint productions. The crop was fertilized with 50 kg N, and 50 kg P_2O_5 per hectare. Phosphorous as triple superphosphate (TSP) was applied before planting. Nitrogen as ammonium sulphate was applied in two equal splits at one split spring and other after first cutting in both years. Rooted cuttings of clones were planted in plots (4.8–5 m^2) using "randomized block design" with three replications. Field experiments were conducted at all locations in the spring of 2007. Plants were planted 30 cm apart, in 40 cm rows. Plots were irrigated frequently (intervals of 7–10 days) to avoid wilting at any stage of crop growth with drip irrigation system. Plots were kept weed free by hand hoeing. Plants were harvested twice (the first harvest in mid-July and the second harvest lasting of August) at floral initiation by cutting the plants approximately 10 cm above the soil surface. Fresh weights of all plots were taken immediately for fresh herb yield, and dry weights of two 500 g-fresh herb samples were recorded after being dried uniformly at 35 °C in drier cabin for dried herbage yield. Leaves of dried herb samples were separated, and leaf content in the samples was calculated. Dried leaf yield were determined using dried herb yield and leaf content.

2.2. Essential oil isolation

The essential oil was isolated with the distillation process using a Clevenger apparatus. Distilled water (100 ml) was used for the distillation of dried plant samples (10 g). Distillation time was approximately 2 h at boiling point. The oil phase was separated and dried over anhydrous sodium sulphate and kept in dark glass bottle at 4 °C until GC analyses (Telci et al., 2010).

2.3. GC–FID analysis

GC analyses of essential oils were performed by a Perkin-Elmer Clarus 500 model Autosystem GC with built-in-Autosampler. Oil was diluted in acetone (1:10) and injected in BPX5 column (30 m × 0.25 mm × 0.25 μm film) for separation. The carrier gas

Table 2
Soil characteristics (0–20 cm) of trial areas.

Soil properties	Aydın	Bursa	Izmir	Tokat
Sand (%)	45.95	25.95	18.45	33.45
Loam (%)	25.45	15.45	26.70	32.95
Clay (%)	28.60	58.60	54.85	33.60
Texture	SCL	C	C	CL
EC (ds/m)	0.323	0.397	0.255	0.221
pH	7.98	7.76	7.64	7.95
Lime (%)	4.41	2.57	13.58	12.11
Suitable P_2O_5 (kg/ha)	68.7	91.6	45.8	96.2
Suitable K_2O (kg/ha)	896.5	1006.7	985.5	819.6
Organic matter (%)	1.16	2.04	2.21	2.22

S: sandy; C: clay; L: loam.