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Effects of Microelements and Plant Density on Biomass and Essential Oil Production of Peppermint (*Mentha piperita* L.)

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Abstract: Peppermint (*Mentha piperita* L.) is one of the highly demanded aromatic medicinal plants and its essential oil is extensively used in the food, flavor and pharmaceutical industries. A field experiment was carried out during 2005-2006 at the Research Farm of the University of Tabriz. In this research, the effects of four plant densities (8, 12, 16 and 20 plants m^{-2}) and two microelement treatments (non spraying or spraying a mixture of 20 kg ha^{-1} HBO_3, 25 kg ha^{-1} $ZnSO_4$ and 15 kg ha^{-1}Fe) on biomass and essential oil production of peppermint were evaluated at two cuttings. These treatments were arranged in a factorial experiment on he bases of randomized complete block design with three replications. The results of first cutting showed that the foliar application of microelements increased fresh and dry matter and leaf area of plants. Also, in the first cutting, bush and leaf essential oil percentage and essential oil yield increased with spraying of micronutrients. Dry matter and essential oil production of first cutting plants increased by increasing plant density. In the second cutting, the foliar application of microelements had only significant effects on leaf essential oil percentage and essential oil yield of peppermint. The result of two cuttings indicated that peppermint performed better in first than in second cutting. Plants harvested in first cutting had higher height, fresh and dry matter and essential oil yield (20.02 li ha^{-1}), but they had lower bush and leaf essential oil content. Therefore, the highest leaf essential oil percentage (2.96%) obtained with spraying of microelements in the second cutting.

Key words: Essential oil, *Mentha piperita*, microelements, peppermint, plant density

INTRODUCTION

Essential oils extracted from odiferous plants are extensively used as flavoring in food, beverages and as fragrances in pharmaceutical and industrial products. Mints, belonging to Labiatae, are one of the most important sources of essential oil production (Lawrence, 1993). Peppermint is, therefore, cultivated commercially in many countries (Delaluz *et al*., 2002). But mint oil is not produced commercially in Iran and the consumption of peppermint oil was satisfied by importation. The quality of mint oil is dependent upon both climatic factors, such as photoperiod, temperature, drought and biological factors, such as ontogeny and ageing (Voirin *et al*., 1990). Agronomic applications such as planting time, harvest time, plant density, nutrition's and irrigation can also affect essential oil amount and quality (Tyler *et al*., 1988). Plant density is also very important factor affecting growth and yield of crops (Delaluz *et al*., 2002). Arabasi and Bayram (2004) with planting sweet basil in three plant density (20, 40 and 60 plants m^{-2}) and nitrogen fertilizing or not reported that the highest amount of dry matter, percentage and the yield of effective substances produced in 20 plant m^{-2} plant density in fertilized plots. However, Aflatuni (2005) mentioned that planting pattern had no significant effect on essential oil amount and composition of mint. Microelements are used in fewer amounts by plants, but, the deficit of these elements may have important effects on crop growth and yield. Carlos and Kelly (2004) explained that for higher essential oil production in peppermint 3.8 mg kg^{-1} Mg, 3 mg kg^{-1} SO_2, 22 mg kg^{-1} Zn, 145 mg kg^{-1} Mn, 323 mg kg^{-1} Fe and 8 mg kg^{-1} Cu are necessary. This research was aimed to evaluate the effects of plant density and microelements on growth and essential oil production of peppermint.

MATERIALS AND METHODS

This study was carried out in 2005-2006 at the Research Farm of the university of Tabriz (Lat. 38°, 15' N; Long. 46°, 17'E and elevation 1360 m), Tabriz, which is located at the northwest of Iran. The soil was a clay-loam with EC of 0.63 ds m^{-1}, pH of 8.1, 0.6% organic matter and 15.5 ppm available phosphorus.

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In this research, the effects of four plant densities (8, 12, 16 and 20 plants m^{-2}) and two microelement treatments (non spraying or spraying a mixture of 20 kg ha^{-1} HBO_3, 25 kg ha^{-1} $ZnSO_4$ and 15 kg ha^{-1}Fe at 5% flowering) on biomass and essential oil production of peppermint were evaluated at two cuttings. These treatments were arranged in a factorial experiment on the bases of randomized complete block design with three replications.

On April 1st, 2005 rhizomes were planted by hand in the depth of 6 cm at four densities and irrigated immediately. In the growing period plants irrigated as needed. The crops were harvested twice each year, the first cutting was made in the late July and the second one was in early October.

In this study area, fresh weight and dry matter production, essential oil content of leaves and bushes (leaves and stems) and essential oil yield of peppermint were evaluated under different plant density and microelement spraying treatments.

The air dried leaves or bushes of peppermint were hydro-distilled in a modified Clevenger apparatus in 1000 mL round bottomed flask with 600 mL water for 3 h. All data were analyzed using MSTAT-C statistical package (MSTAT-C, 1993).

RESULTS AND DISCUSSION

The results obtained from the first cutting indicated that the foliar application of microelements increased fresh weight and dry matter and leaf area of peppermint. Also, in the first cutting, bush and leaf essential oil percentage and essential oil yield increased with spraying of micronutrients (Table 1).

Dry matter and essential oil production of first cutting plants increased by increasing plant density (Table 2). In the second cutting, the foliar application of microelements had only significant effects on leaf essential oil percentage and essential oil yield of peppermint.

Spraying of microelements leads to more dry matter (1188 kg ha^{-1}) production compare to non-spraying (837 kg ha^{-1}). The essential oil percentage of laves was increased about 0.78% with foliar application of micronutrients. Therefore, the essential oil yield of peppermint was increased from 13.69 lit ha^{-1} to 21.40 lit ha^{-1} by spraying of microelements (Table 1).

The leaves are the most important photosynthetic organs. Application of microelements increases leaf area and photosynthesis of plants (Drazic and Pavlovic, 2005). Also, spraying of microelements due to the better nutrition of leaves and stems can improve growth and dry matter production of plants (Court *et al*., 1993).

Dry matter production of peppermint was increased from 748 kg ha^{-1}at 8 plants m^{-2} to 1422 kg ha^{-1}at 20 plants m^{-2}. Although the essential oil percentage of bush decreased, but the essential oil yield of peppermint increased about 6.45 lit ha^{-1} by increasing plant density (from 14.61 lit ha^{-1}at 8 plants m^{-2} to 21.15 lit ha^{-1} at 20 plants m^{-2}) (Table 2).

The results of two cuttings indicated that peppermint performed better in first than in second cutting (Table 3 and Fig. 1). This maybe resulted from suitable climatic conditions such as more sunny days and appropriate temperature during the first cutting period. More light and suitable temperature can improve photosynthesis and therefore, produce more dry matter in plants (Clark and Menary, 1997). Yonli *et al.* (1997) and Letchamo *et al.* (1995) also reported that essential oil production of medicinal plants are depended to light regimes.

Table 1: Effects of microelements on biomass and essential oil production of peppermint

Microelement	Fresh yield Kg ha^{-1}	Dry yield Kg ha^{-1}	Leaf area (cm^2)	Percentage green cover	Essential oil percentage on leaf	Number of glands	Essential oil yield Li ha^{-1}
Non spraying	2693b	837b	1368b	68b	1.95b	146.1b	13.69b
Spraying	4210a	1188a	2012a	75a	2.73a	188.5a	21.40a

Different letters shows significant difference at p = 0.5

Table 2: Effects of plant density on biomass and essential oil production of peppermint

Plant density (m^2)	Fresh yield Kg ha^{-1}	Dry yield Kg ha^{-1}	Number of leaf	Percentage green cover	Essential oil percentage on bush	Essential oil yield Li ha^{-1}
8	2152c	748.3c	207.3a	63.83d	2.113a	14.61b
12	2754c	842.3bc	205.4a	70.33c	2.146a	16.65ab
16	4010b	1037b	191.9b	74.17b	1.883ab	17.76ab
20	4892a	1422a	186.4b	78.67a	1.604b	21.15a

Different letters shows significant difference at p = 0.5

Table 3: Biomass and essential oil production of peppermint in two cuttings

Cutting	Fresh yield Kg ha^{-1}	Dry yield Kg ha^{-1}	Leaf area (cm^2)	Essential oil percentage on leaf	Essential oil percentage on bush	Number of glands	Essential oil yield Li ha^{-1}
The first cutting	4792a	1298a	1615b	2.06b	1.60b	118.1b	20.02a
The second cutting	2112b	728b	1765a	2.62a	2.28a	216.4a	15.07

Different letters shows significant difference at p = 0.5

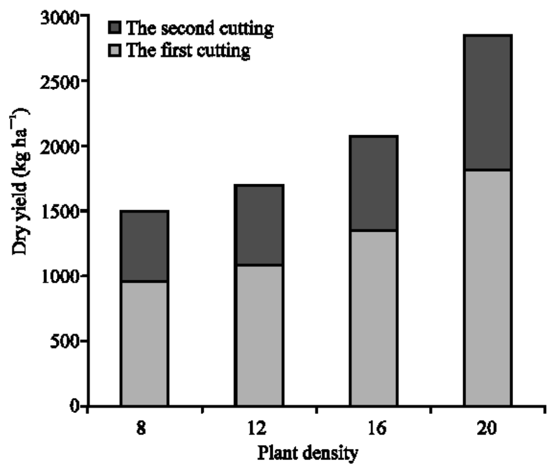

Fig. 1: Effects of plant density on dry yield of peppermint

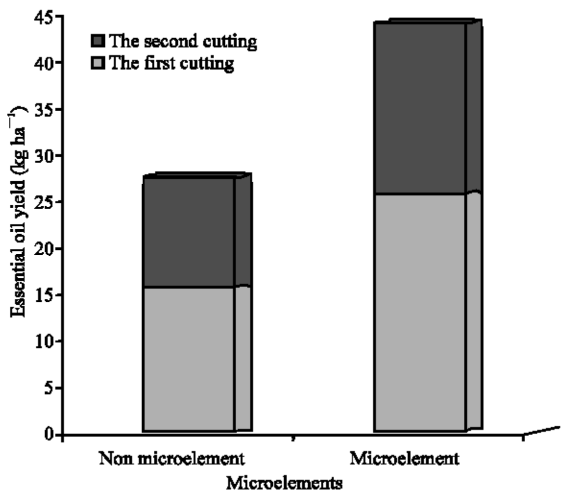

Fig. 2: Effects of microelements on essential oil yield of peppermint

Plants harvested in first cutting had higher height, fresh and dry matter and essential oil yield (20.02 li ha^{-1}), but they had lower bush and leaf essential oil content. Therefore, the highest leaf essential oil percentage (2.96%) obtained with spraying of microelements in the second cutting (Fig. 2).

CONCLUSION

In conclusion, our results suggest that planting in 20 plants m^{-2} and foliar application of microelements can be suitable for improving essential oil production of peppermint.

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