African Journal of Biotechnology Vol. 10(77), pp. 17716-17725, 5 December, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.2462
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

The effect of municipal compost application on the amount of micro elements and their absorption in soil and medicinal plant of mint (Menthas)

Zahra Ahmad Abadi, M. Ghajar Sepanlou* and M. A. Bahmanyar

Soil Science, Sari Agricultural Sciences and Natural Resources University, Sari I. R., Iran.

Accepted 14 November, 2011

The aim of this study was to investigate the effect of municipal compost (MC) application on micro elements concentration in soil and tissues of medicinal plant of mint. This study was carried out in a split plot based on complete randomized block design in three replications in the field of the University of Agricultural Sciences and Natural Resources of Sari, Iran. The main plot was of six fertilizer levels (T_1 = control, T_2 = chemical fertilizer according to soil test, T_3 = 20 ton/ha compost + 1/2 treatments of T_2, T_4 = 20 ton/ha compost, T_5 = 40 ton/ha compost + 1/2 treatments T_2 and T_6 = 40 ton/ha compost) and the sub plot was applied as follows: one year, two non-consecutive years, two consecutive years, three nonconsecutive years, three consecutive years and four consecutive years. The results show that the fertilizer treatments and the years of application had significant effects on the concentration of micro elements in medicinal plant of mint and also in soils. The compound effect of fertilizer treatments and years of application were significant on the concentration of Zn, Fe, Mn, Cu, whereas it was not significant on the concentration of Mn in the plant root and also on the concentration of Cu, Fe and Zn in the plant leaves.

Key words: Mint, municipal compost, micro elements.

INTRODUCTION

Organic cultivation is one of the methods that enjoy a special place in today's agriculture. The aim of organic cultivation is to increase the soil organic matter and maintain soil fertility in the long run. Rich sources of organic matter contain nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) needed to form organic matter and micro elements. Composting process generally include a wide range of livestock, such as poultry, sewage sludge, municipal solid waste, food, paper used alone or a mixture of these elements. Municipal compost as an organic fertilizer can serve as a valuable economic resource in agriculture (Beigi, 1997; Beigi and Hejazi, 2004; Astaraei, 2006). The use of compost in the soil is a suitable method for maintaining organic matter and nutrient elements of the soil needed for plants growth (Mirzaei et al., 2009). Superiority of organic fertilizers, such as compost over other materials is due to their capa-city to produce fertile soil. They act quickly in a short period of time and they have multiple beneficial effects on the availability of micro elements needed for soil and plants (Mamo et al., 1998). Heaf et al. (2007) investigated the effect of compost on the amount of micro elements in the soil and found that compost treated soils demonstrated a greater concentration of zinc (Zn), copper (Cu) and iron (Fe) as compared to chemical fertilizer treated soils. Similarly, other studies investigating the effect of fertilizers and compost on the chemical properties of the soil in the research site of Beheshti University showed that the amount of Fe in the compost treatment was higher than that in control and fertilizer treatment (Mirzaei et al., 2009). Iglesias (1996) also studied the effects of compost on soil micronutrients and conducted an experiment in the Canary region in Iceland. The results of this experiment indicate that samples of soil treated with compost are richer in concentration of Zn and manganese (Mn) as compared to

*Corresponding author. E-mail: sepanlu@yahoo.com.

samples of soil treated with inorganic fertilizers.

The use of medicinal plants and herbal medicines is increasing rapidly all over the world, which shows the importance of cultivation and production of these plants (Akbarinia et al., 2003). One of the important needs of medicinal plants, in order to achieve high performance and quality, is plant nutritional needs; although, correct methods can increase the usage of the input's efficiency (Scheffer et al., 1993; Glyn, 2002). Among the medicinal plants, 50 species belonging to the mint have been identified. Very limited number of these species have medicinal value and are, therefore, consumed by human (Astaraei, 2006). Spicata species *(Mentha spicata)* is a herbaceous perennial plant; although, some have two types of stem (creeping and underground), their leaves are joined together; elliptical and sharp (Glyn, 2002). It flowers in August and September (Heaf et al., 2007). This plant is normally cultivated by different nationals to make essence from the 18th century. The main sites for the cultivation of this plant are located in Britain, North America, Italy and France. The medicinal properties of mint is in its fresh leaves which provide energy and strengthens the stomach, and can be used as anticonvulsants (Glyn, 2002; Heaf et al., 2007). This plant should be grown in fertile lands, with improved soil. In fact, enough water and abundant nutritional elements is essential for the growth of mint (Glyn, 2002; Mamo et al., 1998). Increasing the use of nutrients enhances leaf photosynthesis and then lead to an increase in protein in the plant (Marinuri et al., 2000). The lack of elements, such as Cu, Mn, boron (B) and molybdenum (Mo) play an important role in reducing performance, yield and materials produced by this plant. Therefore, the soils that are under the mint cultivation are tested to remove deficiencies and these elements are added to the soil in each year (Glyn, 2002; Walid et al., 2009). In a study, on the effects of compost on *Clover* plants, it was found that compost application during the plant growth increases uptake of Zn, Cu, Mn, Fe, P and K (Marinuri et al., 2000). Similarly, Akbarinia et al. (2003) also studied pepper plants, and found that increasing municipal compost latex, increased concentration of Fe, Zn, Cu and Mn in the plant's shoot. In general, the experiments that investigated effects of organic fertilizer separately or mixed with chemical fertilizer, are little, but the results review the quantity and improve the quality of these plants under the influence of organic and chemical fertilizers (Khandan and Astaraee, 2004; Mirzaei et al., 2009).

The aforementioned studies and many others indicate a positive effect for municipal compost as an organic fertilizer on the amount of absorbent soil micro elements, and also, the positive effect of these elements is to increase the performance and quality of medicinal plants. Therefore, the goal of this study was to use different levels and frequency of municipal compost to determine the concentrations of these elements in roots and leaves of mint plants and the soil under cultivation.

MATERIALS AND METHODS

This research was conducted in the research field of Agricultural Sciences and Natural Resources University of Sari (with North latitude 13`, 53° and East longitude 42`, 36°) in 2009. This area is 16 m above sea level with a moderate climate. The experiment was carried out in split plot based on complete randomized block design in three replications. The main factor included six levels of fertilizer treatments: (T_1 = control, T_2 = chemical fertilizer (Potasium sulfate 100 kg/ha, super phosphate 100 kg/ha and urea 150 kg/ha), T_3 = 20 tons/ha compost mixed and 1/2 of T_2 treatment, T_4 = compost 20 tons/ha, T_5 = 40 tons/ha compost mixed and 1/2 of T_2 treatment and T_6 = compost 40 tons/ha) and subsidiary factor included six levels of fertilizer application years (one year fertilizer (2006), two nonconsecutive years fertilizer (2006 and 2008), two consecutive years fertilizer (2006 and 2007), three nonconsecutive years fertilizer (2006, 2007 and 2009), three consecutive years fertilizer (2006, 2007 and 2008) and four consecutive years fertilizer (2006, 2007, 2008 and 2009). The main and subsidiary factors were applied in the plots with 1.5 to 3 m dimensions. Table 1 shows some of the characteristics of the control soil (before culture) and used compost. The mint was planted after applying fertilizers in the plots, in three rows with 50 cm apart following agricultural operations which included irrigation and weeding during the growth period. To determine the effect of the applied fertilizers, the samples from root and leaves of the plant were taken in flowering stage. After washing the samples, they were dried in the oven at 70°C temperature for 72 h. After preparing the plant samples, extract was taken by dry burning and digestion by hydrochloric acid (HCl) method (Warman and Termear, 2005). Then, the amount of absorption was determined by atomic absorption spectrophotometer (AAS) (Planquart et al., 1999). Also, soil samples were sampled in 0 to 20 cm depth after harvesting plant of mint. The amount of micro elements absorption in the soil was determined. The concentrations of extractable Zn, Cu, Fe and Mn in the soil were determined by DTPA (diethylene triamne pentaacetic acid) method (APHA, 1998). Finally, the statistical analysis of the data was performed by using both SPSS and MSTAT C software.

RESULTS AND DISCUSSION

Soil

Table 2 presents the analysis of variances obtained for the data related to the soil. It is clear that the use of municipal compost in the soil, the years' of consumption of these treatments and also interactions between treatments and years of application had a significant effect on the concentrations of micro elements in the soil.

The effect of fertilizer treatments on concentrations of micro elements in the soil was significant at 0.01 level. The most effect in this relationship was related to Fe, Zn, Mn and Cu concentration in 40 tons/ha compost, that is, 38.35, 21.30, 11.6 and 11.94 mg/kg. Also, the lowest concentrations were observed in chemical and control treatments (Table 3). It is clear from Table 3 that the combined organic and chemical treatments showed greater concentrations of these elements in the exchangeable form than the chemical fertilizer. This can be attributed to the positive role of these elements in producing organic complex and increasing their absorbency (Kasia et al., 2002). Yearly consumption of

Table 1. Some of the chemical properties of the compost and soil.

Measured parameter	Soil	Compost
pH	7.55	7.41
OC (%)	2.41	22.63
EC (dS/cm)	1.17	10.07
N (%)	0.234	2.03
P (mg/kg)	14.56	45.6
K (mg/kg)	264.86	8485.76
Extractable Zn (mg/kg)	1.02	103.9
Extractable Mn (mg/kg)	7.32	52.41
Extractable Fe (mg/kg)	35.93	273.26
Extractable Cu (mg/kg)	2.21	37.52
Depth (cm)	0-20	-
Texture	Siltyclay	-
C/N	9.57	-

Table 2. ANOVAs for the changes in the rate of concentration of soil micro elements related to the fertilizer and year treatments.

Treatment	Cu	Mn	Zn	Fe
T	7784.12**	1923.25**	1578.31**	1172.92**
Y	56.96**	49.87**	65.95**	254.76**
T × Y	15.20*	20.08*	16.54*	188.55**

T, Fertilizer treatments; Y, year treatment; T × Y, interaction between fertilizer and year treatments; *Level of significant at P < 0.05; **level of significant at P < 0.01.

Table 3. Comparison of the means of concentration of soil micro elements (mg/kg) related to fertilizer treatments.

Treatment	Cu	Mn	Zn	Fe
T1	4.19^{e}	5.34^{f}	13.32^{e}	21.71^{e}
T2	5.15^{d}	6.22^{e}	15.58^{d}	29.85^{d}
T3	7.46^{c}	7.95^{d}	17.37^{c}	34.79^{cd}
T4	7.79^{c}	9.40^{c}	17.92^{c}	38.71^{b}
T5	9.68^{b}	10.22^{b}	19.07^{b}	40.15^{a}
T6	11.94^{a}	11.60^{a}	21.30^{a}	43.35^{a}

In each column related to each element, the means which have at least one common letter do not differ significantly (P < 0.05). T_1 = Control; T_2 = chemical fertilizer; T_3 = 20 tons/ha compost + 1/2 T2; T_4 = 20 tons/ha compost; T_5 = 40 tons/ha compost +1/2 T_2; T_6 = 40 tons/ha compost.

fertilizers had a significant effect on the amount of exchangeable forms of these elements. The highest concentration was observed in three and four years consecutive application, and the lowest concentration was also related to one year fertilizer application (Figure 1). The interaction between fertilizer treatments and years of application had significant effect on the concentration of exchangeable forms of micro elements in the soil. The highest concentrations of Fe, Zn, Mn and Cu were observed in 40 tons/ha compost with four consecutive years' application, that is, 45.54, 21.89, 11.49 and 12.01 mg/kg, respectively (Table 4). By comparing the means (Table 4), it is clear that in every fertilizer treatments, the lowest concentration is related to one year application of fertilizer.

The results of this study on the effect of the application of organic fertilizers on the amount of findings of the exchangeable form of micro elements in the soil are similar to the study conducted in Egypt. It investigated the effect of compost application on the status of soil nutrients of micro-elements and reported that the amount of concentrations of Fe, Cu and Mn in soil significantly

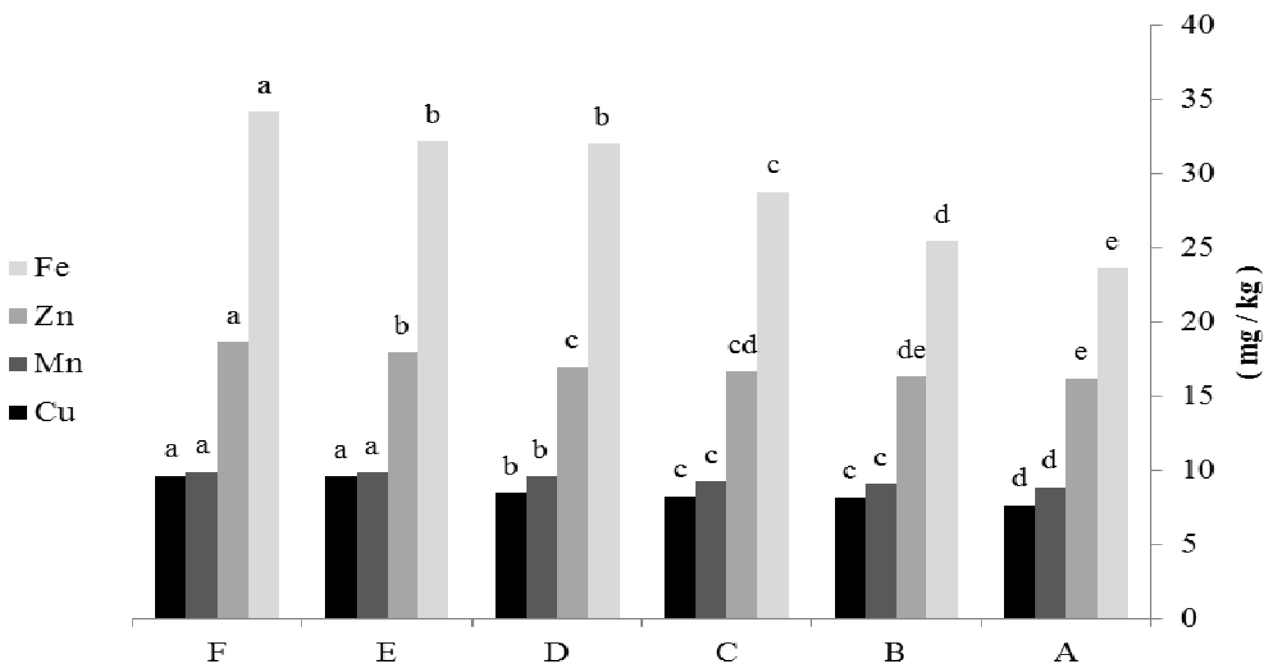

Figure 1. Comparison of the means of concentration of soil micro elements (mg/kg) related to the treatment of consumption years. In each group of column related to each element, the means which have at least one common letter do not differ significantly ($P < 0.05$). A = 2006; B = 2006 and 2008; C = 2006 and 2007; D = 2006, 2007 and 2009; E = 2006, 2007 and 2008; F = 2006, 2007, 2008 and 2009.

increased when combined fertilizer and compost were used than when chemical fertilizer was used alone (Malak et al., 2007). Walid et al. (2009) also used five years 40 tons/ha of compost and reported that the amount of concentrations of micro elements, that is, Zn and Cu in soil and in the control treatment (0 to 20 cm of soil depth) had 67.37 and 35.42% of increase, respectively. They attributed it to the positive role played by organic material in creating an organic complex with these elements which increased their capacity. Planquart et al. (1999) also reported that during their experiments, focusing on the effects of municipal compost on the concentration of nutrient elements, with six months application of 40 tons/ha of compost, the amount of Zn and Cu elements in the 0 to 10 cm soil depth increased to 39%. Xiaoli et al. (2007), similarly reported that with the two years application of organic fertilizer, greater concentrations of Zn, Cu and B in the 0 to 20 cm soil depth was observed when compared with the control. Kasia et al. (2002), according to results of their experiment, found that with the five months application of organic fertilizer in the soil, greater concentrations of elements including Cu, Zn, Mo and Mn in the 0 to 15 cm soil depth were observed which is consistent with the results of this study.

Plant analysis

According to the ANOVAs table on plant data, it was found that the use of municipal compost and the number of years of its application had significant effect on the rate of micro element uptake in plant leaves and roots. The interaction between year and fertilizer about root was significant in all cases except for the absorption of Mn, and in the leaves only the amount of Mn and Zn absorption showed significant difference (Table 5).

Root

The effect of using municipal compost on the rate of absorption of micro elements in the root was significant at 0.01 level. By increasing the use of compost, rates of elements nearly doubled when compared with the control. The highest rate was observed in the 40 tons/ha compost treatment in which Fe, Zn, Mn and Cu elements were: 494.43, 46.22, 50.08 and 27.92 mg/kg, respectively (Table 6). According to the comparison (Table 6), it is clear that among micro elements, the highest amount is related to Fe absorption, in fact, it seems that adding municipal compost to the soil provides exchangeable form of this element for plant uptake more than other micro elements, therefore, the more municipal compost is added, the more absorption is performed by the plant. In fact, combined application of organic and chemical fertilizers had a positive effect on the rate of nutrient absorption in root as compared to when the chemical fertilizer is used alone. The number of years and their

Table 4. Comparison of the means of concentration of soil micro elements (mg/kg) related to the interaction between ferterlizer and years.

Treatment	Year					
	F	E	D	C	B	A
Fe						
T1	22.89^{v}	22.49 ^{v}	21.93 ^{vw}	21.73^{v}	21.88 ^{vw}	21.87^{vw}
T2	29.81^{q}	29.83^{q}	28.74^{r}	28.11^{s}	27.48^{t}	26.97^{u}
T3	36.59^{kl}	36.06^{m}	33.19^{n}	33.15^{n}	32.62^{o}	31.03^{p}
T4	41.10^{d}	40.52^{e}	37.41^{i}	37.45^{i}	37.35^{ij}	36.32^{lm}
T5	40.14^{f}	40.04^{f}	38.94^{g}	38.14^{h}	37.08^{h}	36.97^{jk}
T6	45.54^{a}	45.49^{a}	45.41^{a}	44.48^{b}	42.93^{c}	41.13^{d}
Zn						
T1	13.64^{o}	12.42^{op}	13.01^{p}	12.94^{o}	13.12^{op}	13.22^{op}
T2	15.92^{m}	15.99^{m}	15.36^{n}	15.16^{n}	14.59^{mn}	14.54^{mn}
T3	17.05^{j}	16.72^{k}	16.39^{l}	16.09^{l}	15.89^{l}	15.88^{l}
T4	18.72^{e}	18.75^{e}	17.48^{f}	16.61^{h}	16.51^{h}	16.44^{i}
T5	19.42^{g}	19.27^{i}	19.17^{i}	18.53^{j}	17.96^{k}	17.94^{k}
T6	21.89^{a}	20.39^{b}	20.94^{c}	19.48^{d}	19.09^{de}	19.03^{de}
Mn						
T1	5.51^{m}	5.43^{m}	5.35^{m}	5.45^{m}	4.96^{mn}	5.38^{m}
T2	6.37^{j}	6.32^{j}	5.90^{k}	5.30^{l}	5.15^{l}	5.12^{l}
T3	8.07^{f}	8.05^{f}	7.69^{g}	7.23^{h}	6.86^{hi}	6.81^{hi}
T4	9.56^{d}	9.51^{d}	9.54^{d}	9.43^{d}	9.41^{d}	8.9^{4e}
T5	10.81^{b}	10.51^{b}	10.32b^{c}	10.16^{c}	10.12^{c}	9.13^{de}
T6	11.49^{a}	11.41^{a}	11.32^{a}	10.63^{b}	9.92^{c}	9.83^{c}
Cu						
T1	4.11^{m}	4.08^{m}	3.88^{mn}	4.19^{m}	3.94^{mn}	3.90^{mn}
T2	5.13^{j}	5.21j	5.10^{j}	4.45^{k}	4.15^{kl}	4.09^{l}
T3	7.50^{gh}	7.58^{gh}	7.18^{h}	6.44^{i}	6.39^{i}	6.31^{i}
T4	7.87^{g}	7.96^{g}	7.88^{g}	7.29^{h}	7.19^{h}	6.94^{hi}
T5	9.65^{d}	9.28^{de}	8.76^{e}	8.53^{ef}	8.55^{ef}	8.43^{e}
T6	12.01^{a}	11.54^{b}	11.42^{b}	10.90^{bc}	10.66^{c}	10.41^{c}

In each group of column related to each element, the means which have at least one common letter do not differ significantly ($P < 0.05$). T_1 = Control; T_2 = chemical fertilizer; T_3 = 20 tons/ha compost + 1/2 T2; T_4 = 20 tons/ha compost; T_5 = 40 tons/ha compost +1/2 T_2; T_6 = 40 tons/ha compost.
A = 2006; B = 2006 and 2008; C = 2006 and 2007; D = 2006, 2007 and 2009; E = 2006, 2007 and 2008; F = 2006, 2007, 2008 and 2009.

pattern had significant effect on the rate of micro elements absorption in the roots of mint (Figure 2). As shown in Figure 2, the unconsecutive fertilizer treatments resulted in low absorption as compared to consecutive treatments. The maximum absorption of micro elements was related to the three years of consecutive and more treatment. Also, the lowest absorption for each element was observed in one year application of fertilizer treatment. The interaction between fertilizer and years of treatment was significant in all micro elements except for Mn (Table 7). By comparing, the means of micro elements absorption including Fe, Zn and Cu in the root of mint, it is clear that the maximum absorption of these elements is related to the unriched 40 tons/ha compost treatment with three consecutive years or more consumption for each element in each fertilizer treatment. The lowest amount of absorption was also observed in one year application of fertilizer treatment. The maximum amount of Fe, Zn and Cu absorption in the root were 492.2, 44.73 and 33.7 mg/kg, respectively (Table 7). In fact, it seems that using organic fertilizers resulted in the improvement of the absorption of micro elements, due to the positive effect of these materials on the pore size of the soil, and the increase in the maintenance of nutrient

Table 5. ANOVAs for the changes in the rate of concentration (mg/kg) of microelements in root and leaves of mint related to the fertilizer and year treatments.

Parameter	Leaf				Root			
	Cu	Mn	Zn	Fe	Cu	Mn	Zn	Fe
T	498.11**	1752.1**	141.16**	681.29**	406.20**	726.18**	231.84**	2269.11**
Y	5.22*	41.34**	8.53**	15.47**	44.01**	26.17**	41.15**	31.36**
T × Y	ns	11.06 **	2.49**	ns	5.54**	Ns	3.32**	5.59**

T, fertilizer treatments; Y, year treatment; T*Y, interaction between fertilizer and year treatments; ns, non significant; *level of significant at $P < 0.05$; **level of significant at $P < 0.01$.

Table 6. Comparison of the means of concentration of micro elements in the root of *Mint* (mg/kg) related to fertilizer treatments.

Treatment	Cu	Mn	Zn	Fe
T1	11.96^{f}	27.16^{e}	21.92^{f}	184.41^{e}
T2	18.23^{e}	30.21^{d}	26.64^{e}	273.44^{d}
T3	20.35^{d}	35.22^{c}	35.16^{d}	335.61^{cd}
T4	24.82^{c}	40.17^{b}	39.24^{c}	394.52^{c}
T5	27.82^{b}	49.94^{a}	43.07^{b}	447.13^{ab}
T6	32.92^{a}	50.08^{a}	46.22^{a}	494.43^{a}

In each column related to each element the means which have at least one common letter do not differ significantly ($P < 0.05$ T_1 = Control; T_2 = chemical fertilizer; T_3 = 20 tons/ha compost + 1/2 T2; T_4 = 20 tons/ha compost; T_5 = 40 tons/ha compost +1/2 T_2; T_6 = 40 tons/ha compost.

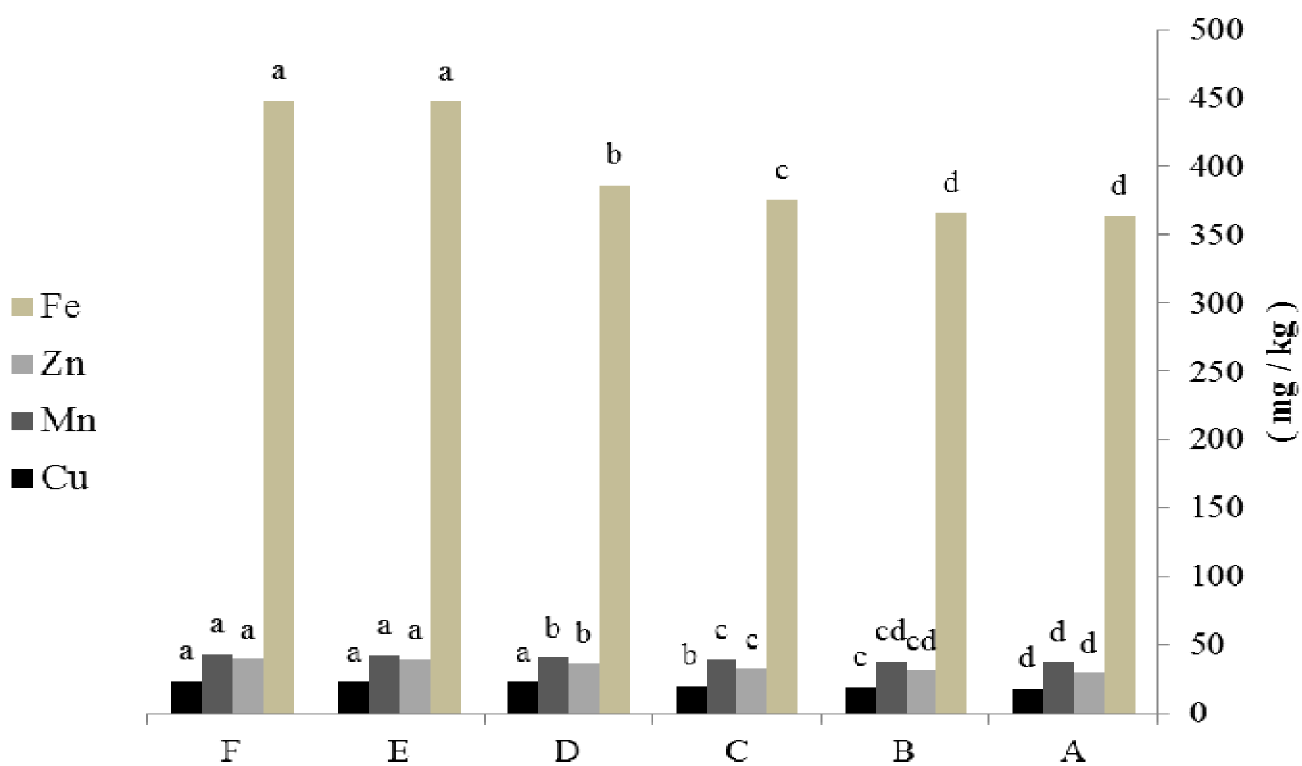

Figure 2. Comparison of the means of concentration of microelements in the root of *Mint* (mg/kg) related to the treatment of consumption years. In each group of columns related to each element , the means which have at least one common letter do not differ significantly ($P < 0.05$). A = 2006; B= 2006 and 2008; C = 2006 and 2007; D = 2006, 2007 and 2009; E = 2006, 2007 and 2008; F= 2006, 2007, 2008 and 2009.

Table 7. Comparison of the means of concentration of micro elements in the root of *Mint* (mg/kg) related to the
interaction between fertilizer and years.

Treatment	Year					
	F	E	D	C	B	A
Fe						
T1	185.3^{l}	186.5^{l}	184.7^{l}	179.9^{lm}	186.1^{l}	184.4^{l}
T2	279.5^{ij}	283.3^{i}	279.2^{ij}	267.2^{j}	251.1^{jk}	250.2^{jk}
T3	345.2^{fg}	345.8^{fg}	343.6^{fg}	31.4^{g}	325.4^{g}	322.4^{gh}
T4	392.8^{de}	369.6^{f}	353.9^{fg}	352.8^{fg}	348.5^{fg}	335.4^{g}
T5	429.2^{cd}	456.5^{c}	454.3^{c}	433.9^{cd}	431.2^{cd}	410.9^{d}
T6	492.2^{a}	484.6^{ab}	474.9^{b}	476.11^{b}	456.1^{c}	449.8^{c}
Zn						
T1	21.11^{n}	20.88^{no}	20.86^{no}	21.15^{n}	21.24^{n}	20.88^{no}
T2	25.30^{j}	24.90^{jk}	24.81^{jk}	24.24^{k}	2295^{l}	22.04^{m}
T3	35.84^{fg}	35.79^{fg}	35.69^{g}	35.59^{g}	34.73^{h}	34.63^{h}
T4	39.95^{d}	39.10^{de}	36.40^{f}	36.43^{f}	34.90g^{h}	34.36^{hi}
T5	42.15^{bc}	42.30^{bc}	41.71^{c}	41.80^{c}	41.74^{c}	39.11^{de}
T6	44.73^{a}	44.51^{a}	42.88^{b}	42.45^{b}	41.70^{c}	39.91^{d}
Cu						
T1	12.13^{n}	11.79^{no}	11.64^{no}	11.96^{n}	1195^{n}	12.18^{n}
T2	19.52^{ijk}	19.43^{ijk}	19.51^{ijk}	18.07^{klm}	16.92^{lm}	15.98^{m}
T3	21.74^{ghi}	21.97^{gh}	21.80^{ghi}	19.40^{ijk}	19.09^{jkl}	18.15^{klm}
T4	25.84^{e}	26.11^{e}	25.06^{ef}	22.75^{gh}	22.24^{gh}	20.87^{ghij}
T5	26.94^{e}	25.74^{e}	25.19^{ef}	23.22^{fg}	22.75^{gh}	20.60^{hij}
T6	33.70^{a}	31.14^{ab}	30.22^{c}	29.49^{c}	28.97^{cd}	27.11^{de}

In each column and row related to each element, the means which have at least one common letter do not differ significantly ($P < 0.05$).
T_1 = Control; T_2 = chemical fertilizer; T_3 = 20 tons/ha compost + 1/2 T2; T_4 = 20 tons/ha compost; T_5 = 40 tons/ha compost +1/2 T_2; T_6 = 40 tons/ha compost. A = 2006; B = 2006 and 2008; C = 2006 and 2007; D = 2006, 2007 and 2009; E = 2006, 2007 and 2008; F = 2006, 2007, 2008 and 2009.

elements in the pore, which subsequently caused more of these elements to be available and transferred to the plant (Alizadeh, 2004).

Leaf

The application of fertilizer treatments had a significant effect on the rate of micro element's absorption in the leaves ($P < 0.01$). The highest value was related to the 40 tons/ha compost treatment and the lowest was observed in the control. Similar to the finding in the root, the leaves treatments with combined organic fertilizer showed greater concentration of micro elements than when chemical fertilizer was applied alone (Table 8). The number of years these treatments were applied had a significant effect on the rate of micro elements absorption. By increasing the number of years' consumption, the rate of absorption increased and the maximum effect was related to the three or four consecutive years' consumption treatments (Figure 3). The interaction between year and fertilizer treatments, unlike root, in the leaves were significant only in the amount of Mn and Zn absorption. By comparing the means of micro elements absorption in the leaves, the interaction effects showed that the maximum absorption of these elements was related to the 40 tons/ha compost treatment with four consecutive years' consumption. This was followed by the 40 tons/ha compost treatment stands with three consecutive years' consumption. The highest amounts of Zn and Mn absorption in the leaves were 124.3 and 91.5 mg/kg, respectively.

Also, in each fertilizer treatment, the lowest concentration of each elements was related to the application of one year fertilizer (Table 9).

Conclusion

In general, findings from studies on medicinal plants

Table 8. Comparison of the means of concentration of microelements in the leaves of *Mint* (mg/kg) related to fertilizer treatments.

Treatment	Cu	Mn	Zn	Fe
T1	31.38d^{e}	65.25^{e}	80.46^{d}	431.74^{e}
T2	35.51^{d}	72.58^{d}	85.31^{c}	521.55^{d}
T3	40.32^{c}	83.68^{c}	90.16^{bc}	613.86^{c}
T4	58.51^{b}	84.12^{c}	96.49^{b}	697.05^{bc}
T5	59.80^{b}	87.99^{b}	100.31^{b}	714.92^{b}
T6	65.13^{a}	91.01^{a}	123.85^{a}	917.39^{a}

In each column related to each element, the means which have at least one common letter do not differ significantly ($P < 0.05$).
T_1 = Control; T_2 = chemical fertilizer; T_3 = 20 tons/ha compost + 1/2 T2; T_4 = 20 tons/ha compost; T_5 = 40 tons/ha compost +1/2 T_2; T_6 = 40 tons/ha compost.

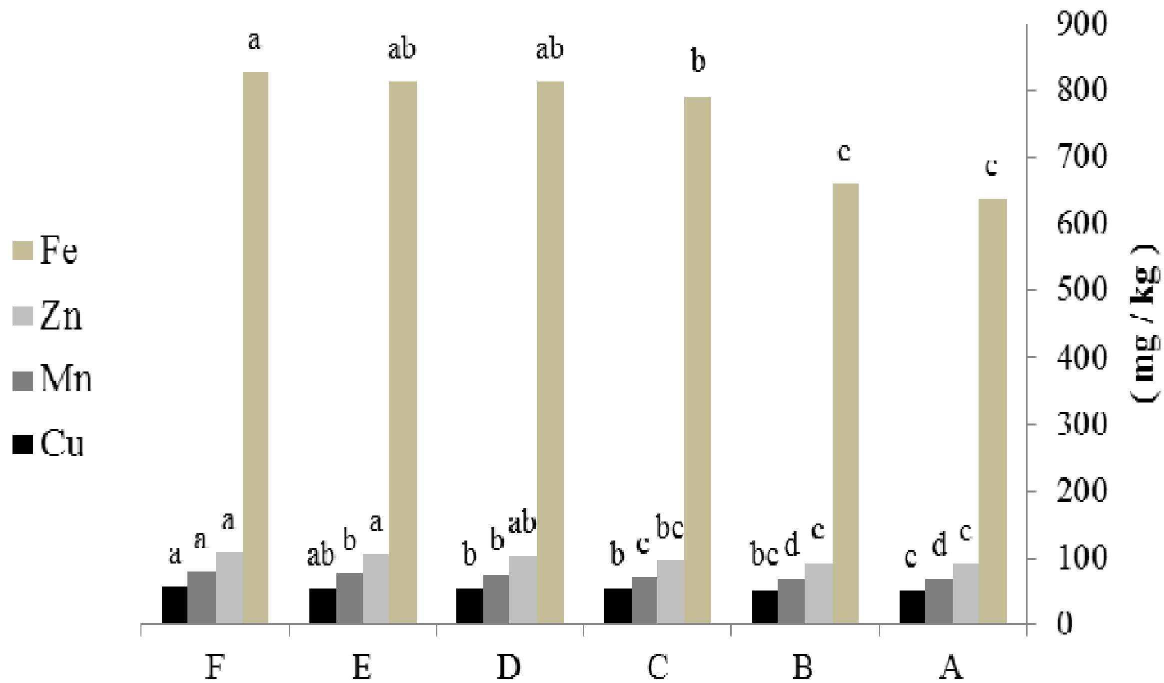

Figure 3. Comparison of the means of concentration of microelements in the leaves of *Mint* (mg/kg) related to the treatment of consumption years. In each group of column related to each element, the means which have at least one common letter do not differ significantly ($P < 0.05$). A= 2006; B= 2006 and 2008; C= 2006 and 2007; D= 2006, 2007 and 2009; E= 2006, 2007 and 2008; F= 2006, 2007, 2008, 2009.

show that using organic fertilizers during the growing stage of these plants leads to a significant increase in soil organic matter and in the absorption of Fe, Zn, Cu, Mn, P, K and N, which have a positive role in producing active materials and yield of the plant (Glyn, 2002). Similar to this experiment, Sains et al. (1998) used organic fertilizers in growing *Clover* medicinal plant and found that these materials include a significant amount of nutrients and micro elements as compared to chemical fertilizers, which resulted in direct plant nutrition and eventually increase its yield. Sobti and Kual (1982), in a study on *Datura* medicinal plant, stated that organic fertilizers influence the quality and quantity of the plant more than chemical fertilizers do and produce active materials. Walid et al. (2009), in an experiment focusing on five years application of compost in the soil, reported that the soils treated with five years application provided more nutrients and microelements to the plant as compared to the control and less than five years application of fertilizer. Zargari (1982) also found that a combination of chemical and organic fertilizer application in *Coriander* medicinal plant increased plant yield, which resulted in increased nutrient absorption by the plant. Similarly, in an experiment on examining the effects of compost and

Table 9. Comparison of the means of concentration of Zn and Mn in the leaves of *Mint* (mg/kg) related to the interaction between fertilizer and years.

Treatment	Year					
	F	E	D	C	B	A
Zn						
T1	80.57^{mn}	78.85^{lmn}	81.34^{m}	78.82^{lmn}	81.45^{m}	81.87^{m}
T2	85.19^{j}	84.81^{j}	84.05^{k}	83.71^{jk}	83.42^{kl}	83.11^{l}
T3	92.07^{gh}	92.05^{gh}	92.64^{gh}	92.48^{gh}	92.02^{h}	91.43^{hi}
T4	97.54^{e}	98.50^{de}	98.25^{de}	95.10^{f}	94.11^{fg}	93.65^{g}
T5	101.28^{d}	101.2^{d}	101.3^{d}	98.37^{de}	98.31^{de}	98.14^{de}
T6	124.30^{a}	122.80^{ab}	122.7^{ab}	119.30^{b}	119.11^{b}	117.72^{bc}
Mn						
T1	63.46^{o}	63.17^{op}	63.63^{o}	62.99^{op}	62.69^{o}	63.15^{op}
T2	71.86^{k}	71.46^{kl}	70.32^{m}	70.17^{m}	68.60^{n}	68.51^{n}
T3	83.25^{gh}	83.14^{gh}	82.44^{i}	81.70^{ij}	81.56^{j}	81.41^{j}
T4	83.83^{fg}	83.51^{g}	83.18^{gh}	82.30^{i}	82.24^{i}	81.74^{ij}
T5	87.38^{gh}	87.11^{e}	86.97^{e}	86.43^{ef}	85.99^{f}	85.93^{f}
T6	91.50^{a}	90.88^{ab}	90.57^{b}	89.99^{bc}	89.78^{bc}	87.92^{d}

In each column and row related to each element, the means which have at least one common letter do not differ significantly ($P < 0.05$).
T_1 = Control; T_2 = chemical fertilizer; T_3 = 20 tons/ha compost + 1/2 T2; T_4 = 20 tons/ha compost; T_5 = 40 tons/ha compost +1/2 T_2; T_6 = 40 tons/ha compost. A = 2006; B = 2006 and 2008; C = 2006 and 2007; D = 2006, 2007 and 2009; E = 2006, 2007 and 2008; F = 2006, 2007, 2008 and 2009.

fertilizer application on the amount of nutrient absorption in a *Geramineous* plant, Soumare et al. (2003), reported that using 50 ton/ha of compost leads to higher levels of nutrient absorption in this plant than 50 ton/ha of compost enriched with nitrogen, phosphorus and potassium (NPK). Also, the results of studies on *Pepper* medicinal plant show that increasing municipal compost latex application increased concentration of Fe, Zn and Cu in shoots of this plant (Akbarinia et al., 2003). According to the results of an experiment on the *Savory* medicinal plant, it can be stated that with application levels of 0, 10, 20 and 30 ton/ha of municipal compost, the highest percentage of essence was observed in 30 ton/ha treatment that increased nutrient absorption in the soil (Duobani et al., 2009). The results of this study is consistent with the results of the previews studies.

According to the results of this study, it can be concluded that the use of municipal compost in the soil as an organic fertilizer increased exchangeable form of micro elements in the soil and also the availability of these elements by medicinal plant of mint. The highest amount of micro elements were observed in the 40 ton/ha of compost treatment. The results also indicate that increase in levels and frequency of fertilizer application leads to increase in the absorption of these elements for plants, and eventually increases their concentration in roots and leaves of mint. Therefore, since there was no significant difference between three years compost application and four-years of compost application, the results suggest that the use of three years of compost in agricultural soils for supplied required elements in plants is a useful and cost-effective source in the majority of soils under cultivation.

REFERENCES

Akbarinia A, Ghalavand A, Sharifi Ashorabadi A, Banj Shfieei S (2003). Effect of different nutrition systems on soil propertis, elemental uptake and seed yield of Ajowan (*Carum Cupticum*). Pajouhesh and sazandegi. 62: 11-29.

Alizadeh A (2004). Soil physic. Imam Reza university press. Iran. pp. 567.

APHA (1998). Standard methods for the examination of water and waste water, 20th edition. American Public Health Association. Washington DC.

Astaraei A (2006). Effect of municipal solid waste compost and vermicompost on yield and yield components of *Plantago Ovata*. Iran. J. Med. Aromatoc Plants, 3: 180-187.

Beigi RO (1997). Findings from the production of medicinal plants. Tarrahan nashr press. Iran.

Beigi RO, Hejazi M (2004). Essential oil and composition of satureja hotrtensis of two different region. J. Essential Oil Bearing Plants, 7(2): 66-68.

Duobani SHZ, Siruos Mehr A , Qanbar A, Tabatabaee J (2009). The effect of difrente levels of Nitrogen and Municipal Compost on the yield and percentage of essence in Savory medicinal plant *(Satureja Hortensis*). The National Congress of Medicinal Plants. Free Islamic University of Birjand.

Glyn MF (2002). Mineral nutrition, production and artemisin content in Artemisia annual. Acta Hortic. 426:721-728.

Heaf C, Weipu X, Junliung L, Qinggian Z, Yanging H, Gang C (2007). Application of Composted Sewage Sludge (CSS) as a soil amendment for Turfgrass Growth, 29: 96-104.

Iglesias JE (1996). City refuse compost as a source of micronutrients for plants. Fertilizers Environ. 5: 517- 521.

Kasia D, Soren OP, Livk K, Ambus P (2002). Evaluating effects of sewage sludge and household on soil physical, chemical and microbiological properties. 19: 237-248.

Khandan A, Astaraee A (2004). Effect of Organic (Municipal Waste Compost, Manure) and fertilizers on som physical properties of soil. J. Agric. Natural Sources Sci. 6(4): 362-370.

Malak AE, Ramandan Am, Bassiony EL, Al-Ashkar E (2007). Behavior of some micronutrients in Clay Loam Soil and the organ of Tomato plants as Affacted by Different Fertikizea Ratios. 3(11): 1615-1621.

Mamo M, Rosen CJ, Halbach TR, Moncrief JF (1998). Corn yield and nitrogen uptake in sandy soils amended with municipal solid waste compost. J. Prod. Agric. 11: 460-475.

Marinuri S, Masciandro G, Ceccanti B, Grego S (2000). Influence of organic and mineral fertilizer on soil chemical, biological and physical properties. 72: 9-17.

Mirzaei R, Kambozia J, Sabahi H, Mahdavi A (2009). Effect of different organic fertilizers on soil physicochemical properties, production and biomass yield of tomato (*Lycopersicon esculentum*). Iran. J. Crops Res. 7(1): 257-267.

Planquart P, Bonin G, Prone A, Massiani C (1999). Distribution, movement and plant availability of trace metals in soils amended with sewage sludge composts: application to low metal loadings. Sci. Total Environ. 241: 161-179.

Sains MJ, Tboada-Castro MT, Vilarino A (1998). Growth, mineral nutrition and mycorrhizal colonization of red clover and cucumber plant grows in a soil amended with composted urban wastes. Plant Soil, 205: 85-92.

Scheffer MC, Ronzelli PJ, Koehler HS (1993). Influence of organic fertilization on the biomass. Yield and yield composition of the essential oil of Achilles millefoliom. Acta Hortic. 331:109-114.

Sobti SN, Kaul BZ (1982). Cultivation of Datura innoxia and D.metel in India. SCIR Jamma Tawi India.

Soumare M , Tach FMG, Verloo MG (2003). Effect of municipal solid waste compost and mineral fertilization on plant growth in two tropical agricultural soils in Mali. Bioresour. Techenol. 88: 15-20.

Walid BA, Gabteni N, Lakhdar A, Laing GD, Verloo M, Jedidi N, Gallali T (2009). Effect of 5-year application of municipal solid waste compost on the distribution and mobility of heavy metals in a Tunisian calcareous soil. Agric. Ecosyst. Environ. 130: 156-163.

Warman PR, Termeer WC (2005). Evaluation of sewage sludge, septic waste and sludge compost applications to corns and forage: Ca, Mg, S, Mn, Cu, Zn and B content of crop and soils. Bioresour. Thechnol. 96: 1029-1038.

Xiaoli L, Shunzhen Z, Wenyong W, Honglu L (2007). Metal sorption on soils as affected by the dissolved organic matter in sewage sludge and the relative calculation of sewage slugde application. Plant Soil, 149: 399-407.

Zargari A (1982). Medicinal plants. Tehran University press. Iran.