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Research article

Iron and magnesium concentrations of mint accessions (*Mentha* spp.)

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Abstract

Plant foods can contribute significantly to human nutrition and health, because they contain almost all essential human nutrients. However, nutrient composition varies among different plant foods. Improvement of nutritional quality of our food supply, especially with respect to essential nutrient minerals, such as magnesium, iron and zinc, could be an important goal of vegetable crops. There is little information available on essential mineral concentration of mint (*Mentha* spp.). This study was conducted to evaluate some micronutrient minerals of twelve Iranian mint accessions, three of which belonging to *Mentha longifolia* (Mzin5, Mzin6 and Mzin11) and the remaining were *Mentha spicata* L species (Mzin1, Mzin2, Mzin3, Mzin4, Mzin7, Mzin8, Mzin9, Mzin10, and Mzin12). This report is assigned to two essential human nutrients, iron (Fe) and magnesium (Mg) concentrations of two mint herbage harvests in 12 mint clones within each of two studied years. Results of analysis of variance indicated a significant difference among accessions and a non-significant difference between species for Mg and Fe concentrations. Mean comparisons showed that Mzin2, Mzin12 (both belong to *M. spicata*) and Mzin6 (belongs to *M. longifolia*) possess the highest Fe concentration. Furthermore, Mzins 5, 6 and 11 belong to *M. longifolia* as well as Mzins 2 and 10 belong to *M. spicata* did not significantly differ and all included the first ranking group for Mg concentration. Fe concentration averaged on the first harvest ranged from 134 mg/kg for Mzin4 genotype (belongs to *M. spicata*) to 210 mg/kg to for Mzin5 genotype (belongs to *M. longifolia*), while Fe concentration at the second harvest varied from 315 mg/kg for Mzin1 to 582 mg/kg for Mzin12. At the first harvest, Mg concentration ranged from 748 mg/kg for Mzin1 to 1174 for Mzin5. At the second harvest, Mg concentration varied from 1171 mg/kg for Mzin9 to 1618 mg/kg for Mzin11. It is hence concluded that the magnesium and iron concentrations of *Mentha* species are comparable to those reported for other leafy vegetable crops. Therefore, this is evidence that this herb is rich in some essential nutrient minerals, especially Fe and Mg which are essential for human health.

Keywords: Mint accessions; *Mentha longifolia*; *M. spicata*; Iron; Magnesium; Herbage; Human nutrition; Breeding

1. Introduction

Mentha is a genus of aromatic perennial herbs belonging to the family of Lamiaceae. This genus is mainly distributed in the temperate and sub-temperate regions of the world [1]. Several *Mentha* taxa, such as *M. spicata* (spearmint) and *M. longifolia* (habek mint), widely distributed and have considerable economic importance [4]. Shoots and leaves of mints are used as condiments in food, and their essential oil components are processed into flavorings and fragrance elements for use in a variety of products [4]. Habek mint (*Mentha longifolia*), known as horse or wild mint, like many other members of this genus, is often used in domestic herbal remedy, being valued especially for its antiseptic properties and its beneficial effects on the digestion [7].

Plant foods contain almost all of the mineral and organic nutrients established as essential for human nutrition. Not all plant foods contain all the essential nutrients needed for human health. For instance, seed foods are good sources of carbohydrates, proteins, lipids, and lipid-soluble vitamins, but tend to have low concentrations of Fe and Ca. Leafy vegetables are good sources of most minerals and vitamins, but are less nutrient dense with respect to protein and carbohydrates [9]. In the developing world, many low-income families exist on a simple diet composed primarily of staple foods such as rice, wheat and maize that are poor sources of some macronutrients and many micronutrients [3]. As a result, 2 billion people (30% of the world's population) are at risk for iron

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deficiency (infants, children, and women of reproductive age are particularly vulnerable) [6].

Plant sources of Fe include both xylem-fed leafy vegetables and phloem-fed seeds [9]. Increasing the Fe concentration of either type usually requires increases in total Fe input to the plant, and may require modifications to whole-plant partitioning.

To ensure an adequate dietary intake of all essential nutrients and to increase the consumption of various health-promoting compounds, researchers have been interested in improving the nutritional quality of plants, with respect to both nutrient composition and concentration [2,8,23]. Improvement of nutritional quality of our food supply, especially with respect to essential nutrient minerals, such as magnesium, iron and zinc, could be an important goal of leafy vegetable crops. There is little information available on essential mineral concentration of mint (*Mentha* spp.). Mineral elements of plants vary with the stage of growth and environmental and genetic factors [5]. Considerable interspecific and intraspecific variations in Fe and Mg concentrations have been observed in a number of plant species [16,18]. The extent of this variation raises the possibility of developing strains exhibiting improved nutrient uptake and utilization.

The primary objective of plant breeding programs over the last several decades has been to increase yields. This has been achieved primarily by selecting for resistance to pests and diseases, increased fruit set and size, specific plant growth status, increased grain size and weight and so on, all of which contributing to enhancement of yield. The quest for increased yield is without a doubt a primary goal for the ever-growing world population. However, equally as important, but often overlooked, are the nutrient composition and density of crops, especially with regard to important nutrients such as Fe and Mg. When nutrient concentration has been assessed in various plants, significant genotypic variation has been observed for minerals. For example, Mg concentration varied among wild-rye [14], wheatgrass [17] and broccoli [15] genotypes. The latter study in broccoli measured Mg during 2 seasons in 27 commercial hybrids and 19 inbred lines and mean concentration of Mg varied about 1.5-fold among both the hybrids and the inbred lines. Genetic variation of Fe concentration has been shown in beans [18], wheat and rice [24]. Among 132 wheat genotypes, both Fe and Zn vary by about 2-fold. In 1000 common beans (*Phaseolus vulgaris* L.), both nutrients range 2.6-fold. Among 939 genotypes of brown rice, Fe and Zn vary by 3-fold and 4-fold, respectively. Genetic differences in Fe concentration of seed in bean (*P. vulgaris*) were expressed over a wide range of environmental conditions [18].

These examples highlight the fact that significant variation in nutrient concentration already exists within the germplasm of these species, and probably exists in many others. Thus, classical breeding approaches can and are being used to provide nutritionally improved cultivars [9]. In addition, genotypes with dissimilar nutrient concentration are helping to identify the genetic [21] or physiological [10,11] basis for nutrient variation. Clearly, more advances will be possible if attention is given to the evaluation of currently available germplasm resources [22].

Although, aerial parts of mint use as condiment and its essential oils processed into flavoring for food, medicine, mouthwash, toothpaste, chewing gum, and confectionery, its leaves is also eaten as fresh, dry and cooked leafy vegetable in certain parts of the world and could be a useful source of dietary nutrients, especially in malnourished populations. Because little information is available on the mineral concentration of this herb, leaf Fe and Mg concentrations in 12 diverse accessions of mints were characterized using leaves from both fully bloomed and before flowering stages.

The objective of this study was to assess the magnesium (Mg) and iron (Fe) concentrations of Iranian mint landraces belonging to *M. spicata* and *M. longifolia* species using two herbage harvests within each of two studied years.

2. Materials and methods

2.1. Plant material and growing conditions

The experiment was carried out during the 2001–2002 growing seasons. Twelve Iranian mint accessions (Mzin1–12) collected as clones from central regions of Iran were used. Aerial parts of fully flowered of these accessions were identified as 9 accessions belong to *Mentha spicata* L. and 3 accessions belong to *Mentha longifolia* (L.) Hudson species (see Table 1) by R. Olson at the W.P. Fraser Herbarium. Voucher specimens were deposited at the W.P. Fraser Herbarium, University of Saskatchewan, Saskatoon, Canada.

The mint accessions were grown at Agricultural Research Station, Isfahan University of Technology, located in Flavarjan (20 km south west Isfahan, 32°32′N and 51°23′E 1540 m asl)) in March 2001 (Table 1). Clones were grown in five-row plots with a row spacing of 45-cm and planting space of 20 cm within the rows. The clones were grown in a 3×2.5 m^2 plots with a density of 10 plants per m^2. The surface layer (0–30 cm depth) of soil had a silty clay loam texture with pH = 7.2–7.4, EC = 1.5–2 dS m^{-1} and 1.4% of organic matter. Fertilizers were applied prior to planting at a rate of 30 kg P ha^{-1} and 50 kg N ha^{-1}. Additional 50 kg N ha^{-1} was top dressed in two split amounts at 30 and 50 days after planting.

The plots were irrigated every 10 days. The first harvest was performed at full flowering and the second harvest was performed before flowering stage (60 days after the first harvest). The net area of 1.5 m^2 of each plot was harvested after discarding marginal borders. The leaves were hand-separated and oven-dried for 24 h at 70 °C. Then, one gram of dry leaves was ashed at 600 °C for 6 h. The resulting ash was dissolved in 10 mL of 2 N HCl. Iron (Fe) and magnesium (Mg) concentrations were measured using Perkin-Elmer (model 3030) atomic absorption spectrophotometer.

2.2. Statistical analysis

Although the field trail was conducted as a randomized complete block design, sample was taken for each genotype only from one replication. Analysis of variance was hence carried out using harvests and years as replicates using PROC

Table 1
The accession number, name, species, origin and source of 12 mint landraces used in this study

Accession number	Landrace name	Species	Origin	Source
Mzin1	American mint	*Mentha spicata*	Kashan, Iran	IARC*
Mzin2	Piperita-1	*Mentha spicata*	Kashan, Iran	IARC
Mzin3	Isfahan poneh	*Mentha spicata*	Isfahan, Iran	IARC
Mzin4	Isfahan mint	*Mentha spicata*	Isfahan, Iran	IARC
Mzin5	Piperita-2	*Mentha longifolia*	Kashan, Iran	IARC
Mzin6	Poneh	*Mentha longifolia*	Isfahan, Iran	IARC
Mzin7	Sosanber	*Mentha spicata*	Mahalat, Iran	IARC
Mzin8	Mahalaty mint	*Mentha spicata*	Kashan, Iran	IARC
Mzin9	Khozestany poneh	*Mentha spicata*	Isfahan, Iran	IARC
Mzin10	Ghazwin mint	*Mentha spicata*	Kashan, Iran	IARC
Mzin11	Spearmint	*Mentha longifolia*	Kashan, Iran	IARC
Mzin12	Badrody	*Mentha spicata*	Isfahan, Iran	IARC

*IARC: Isfahan Agricultural Research Center.

GLM of SAS [19]. Mean comparisons were conducted using Fisher's least significant differences (LSD).

Cluster analysis was performed to differentiate the mint accessions based on Fe and Mg concentrations according to Ward's minimum-variance method by the cluster procedure of SAS computer program [19].

Linear correlation and regression analyses were conducted to determine phenotypic relationship among Fe concentration, Mg concentration, essential oil content, leaf dry weight and herbage yield of the studied mint landraces.

3. Results

Analysis of variance of the data showed that there was no significant difference between the two species for both iron and magnesium concentrations (Table 2). Thus, the data obtained for iron (Fe) and magnesium (Mg) concentrations averaged on two harvests and two years (as 4 replicates) were subjected to the statistical analysis.

3.1. Iron concentration

Analysis of variance showed that there were highly significant differences ($P < 0.01$) among accessions for iron concentrations (Table 2). Variation due to species was not significant in this experiment (Table 2). Hence, mean comparisons of data based on average of Fe concentrations over two harvests and two years were conducted and the results are presented in Table 3. Based on the comparison, accessions were classified into three groups. Accessions Mzin12 (*M. spicata*), Mzin6 (*M. longifolia*) and Mzin2 (*M. spicata*) were ranked as superior group for producing the highest concentrations of Iron. On the other hand, accessions Mzin1 and Mzin4 both belong to *M. spicata* were the inferior for Fe concentration.

In the evaluation of 12 mint accessions a range of 114 for Mzin3 to 244 mg kg^{-1} Fe for Mzin2 (both belonging to *M. spicata*) was found at first harvest of first year, with an average of 171 mg kg^{-1} (Table 4). The iron concentration varied from 228 ppm for Mzin8 (*M. spicata*) to 622 ppm for Mzin6 (*M. longifolia*) at the second harvest of first year (Table 5). The Fe concentration differed from 108 ppm for Mzin7 (*M. spicata*) to 234 ppm for Mzin5 (*M. longifolia*) at the first harvest of second year (Table 5). The iron concentration ranged from 232 ppm for Mzin10 to 656 ppm for Mzin12 (both belong to *M. spicata*) at the second harvest of second year.

Iron concentration of the first harvest averaged on two years ranged from 134 mg kg^{-1} for Mzin4 genotype (belongs to *M. spicata*) to 210 mg kg^{-1} to for Mzin5 genotype (belongs to *M. longifolia*), while Fe concentration at the second harvest averaged on two years varied from 315 mg kg^{-1} for Mzin1 to 582 mg kg^{-1} for Mzin12 (Table 6).

3.2. Magnesium concentration

Analysis of variance showed that there were highly significant differences ($P < 0.01$) among accessions for magnesium concentrations (Table 2). Variation due to species was not significant in this experiment (Table 2). Hence, mean comparisons of data based on average of Mg concentrations over two harvests and two years were conducted and the results are presented in Table 3. Based on the comparison, accessions were classified into five groups. Accessions Mzin5 (*M. longifolia*) and Mzin9 (*M. spicata*) produced the highest and the lowest concentrations of magnesium, respectively. Mzins 5, 6 and 11 belong to *M. longifolia* as well as Mzins 2 and 10

Table 2
Results of statistical analysis (ANOVA) of Iron (Fe) and magnesium (Mg) concentrations using two harvests and two years as replications

Source of variation	Degree of freedom	Mean square	
		Fe (mg kg^{-1})	Mg (mg kg^{-1})
Replications	3	24,872	87,733
Accessions	11	7646**	71,528**
Residual	33	2013	16,520
Contrast:			
Between species	1	4035^{ns}	2696^{ns}

ns and ** not significant and significant at $P < 0.01$, respectively.

Table 3
Mean comparisons of iron (Fe) and magnesium (Mg) concentrations averaged on two harvests and two years (as 4 replicates) of 12 mint accessions

Accession number	Species	Fe (mg kg^{-1})	Mg (mg kg^{-1})
Mzin1	*M. spicata*	229.0^{c}	1023.1^{de}
Mzin2	*M. spicata*	308.6^{ab}	1251.3^{abc}
Mzin3	*M. spicata*	252.6^{bc}	1027.5^{de}
Mzin4	*M. spicata*	228.0^{c}	1070.0^{cde}
Mzin5	*M. longifolia*	282.1^{b}	1354.4^{a}
Mzin6	*M. longifolia*	324.6^{ab}	1235.6^{abc}
Mzin7	*M. spicata*	235.9^{b}	1147.5^{cde}
Mzin8	*M. spicata*	251.0^{bc}	990.0^{de}
Mzin9	*M. spicata*	267.9^{bc}	961.3^{e}
Mzin10	*M. spicata*	265.0^{bc}	1241.3^{abc}
Mzin11	*M. longifolia*	281.9^{b}	1298.1^{ab}
Mzin12	*M. spicata*	376.3^{a}	1048.8^{de}

Means followed by the same letter and in the same column are not significantly different ($P < 0.05$) by a protected LSD test.

Table 4
Iron (Fe) and magnesium (Mg) concentrations of 12 mint genotypes in the first year (2001)

Accession number	Species	Fe (mg kg^{-1})		Mg (mg kg^{-1})	
		1st harvest	2nd harvest	1st harvest	2nd harvest
Mzin1	*M. spicata*	189	347	680	1360
Mzin2	*M. spicata*	244	492	1090	1640
Mzin3	*M. spicata*	114	416	840	1540
Mzin4	*M. spicata*	134	388	1040	1220
Mzin5	*M. longifolia*	180	444	1360	1620
Mzin6	*M. longifolia*	145	622	1050	1760
Mzin7	*M. spicata*	166	364	1130	1460
Mzin8	*M. spicata*	122	228	780	1100
Mzin9	*M. spicata*	211	362	790	1180
Mzin10	*M. spicata*	208	468	1200	1560
Mzin11	*M. longifolia*	174	512	1130	1660
Mzin12	*M. spicata*	169	508	900	1340
Mean		171.3	429.3	999.2	1453.3
CV%		22.6	23.7	20.1	14.6

belong to *M. spicata* did not significantly differ and all included the first ranking group.

Mzin5 possessed the highest Mg concentration (1360 ppm) while Mzin1 had the lowest Mg concentration (680 ppm) at the first harvest of year 2001 (Table 4). At the second harvest of year 2001, Mg concentration varied between 1100 and 1760 mg kg^{-1}, with Mzin6 (*M. longifolia*) and Mzin8 (*M. spicata*) possessing the highest and the least amount, respectively (Table 5). Genotype number 10 (Mzin10- *M. spicata*) possessed the highest concentration of Mg (993 ppm) at the first harvest of second year. At the second harvest of the second year (2002), Mzin11 belongs to *M. longifolia* had the highest concentration of Mg (1575 ppm).

Mean of Mg concentration at the first harvest (905 ppm) was less than mean of Mg concentration at the second harvest (1369 ppm) when averaged on two years. Mg concentration of the first harvest averaged on two years, ranged from 748 mg kg^{-1} for Mzin1 belonging to *M. spicata* to 1174 for Mzin5 belonging to *M. longifolia*. Mg concentration varied

Table 5
Iron (Fe) and magnesium (Mg) concentrations of 12 mint genotypes in second year (2002)

Accession number	Species	Fe (mg kg^{-1})		Mg (mg kg^{-1})	
		1st harvest	2nd harvest	1st harvest	2nd harvest
Mzin1	*M. spicata*	124	256	815	1238
Mzin2	*M. spicata*	149	350	738	1538
Mzin3	*M. spicata*	181	300	705	1025
Mzin4	*M. spicata*	145	245	808	1213
Mzin5	*M. longifolia*	234	265	988	1450
Mzin6	*M. longifolia*	167	365	845	1288
Mzin7	*M. spicata*	108	306	825	1175
Mzin8	*M. spicata*	178	476	743	1338
Mzin9	*M. spicata*	137	362	713	1163
Mzin10	*M. spicata*	152	232	993	1213
Mzin11	*M. longifolia*	116	326	828	1575
Mzin12	*M. spicata*	172	656	743	1214
Mean		155.3	344.9	812	1285.8
CV%		23	34.5	11.8	12.6

Table 6
Iron (Fe) and magnesium (Mg) concentrations of 12 mint genotypes averaged on two years (2001–2002)

Accession number	Species	Fe (mg kg^{-1})			Mg (mg kg^{-1})		
		1st harvest	2nd harvest	Mean of 4 harvests	1st harvest	2nd harvest	Mean of 4 harvests
Mzin1	*M. spicata*	157	315	236	748	1299	1023.5
Mzin2	*M. spicata*	196	421	308.5	914	1589	1251.5
Mzin3	*M. spicata*	147	358	252.5	773	1283	1028
Mzin4	*M. spicata*	134	317	225.5	924	1216	1070
Mzin5	*M. longifolia*	210	355	282.5	1174	1535	1354.5
Mzin6	*M. longifolia*	156	494	325	948	1524	1236
Mzin7	*M. spicata*	137	335	236	978	1318	1148
Mzin8	*M. spicata*	150	352	251	761	1219	990
Mzin9	*M. spicata*	174	362	268	751	1171	961
Mzin10	*M. spicata*	180	350	265	1096	1386	1241
Mzin11	*M. longifolia*	145	419	282	972	1618	1295
Mzin12	*M. spicata*	171	582	376.5	821	1276	1048.5
Mean		163.1	388.6		905	1369.5	
CV%		14	20		15.4	11.4	

from 1171 mg kg^{-1} for Mzin9 to 1618 mg kg^{-1} for Mzin11 when the second harvest averaged on two years (Table 6).

3.3. Cluster analysis

Fig. 1 shows the dendrogram of relatedness among 12 mint landraces based on their Mg and Fe concentrations of first harvests. The results of clustering based on first harvest of two studied years revealed three groups each of which having 5, 2 and 5 accessions, respectively. Accession numbers 2, 4, 6, 7 and 11 grouped into cluster I, 5 and 10 grouped into cluster II and 1, 3, 8, 9 and 12 grouped into cluster III. The clustering pattern of accessions failed to discriminate the accessions of two mint species. On the other hand, clustering pattern of accessions based on the second harvests (average of two years) successfully discriminate between the accessions of the two mint species (Fig. 2). The resultant dendrogram contained four groups each of which having 4, 3, 1 and 4 accessions, respectively. Cluster IV possessed three accessions of 5, 6 and 11 belonging to *M. longifolia* and one accession of 2 belongs

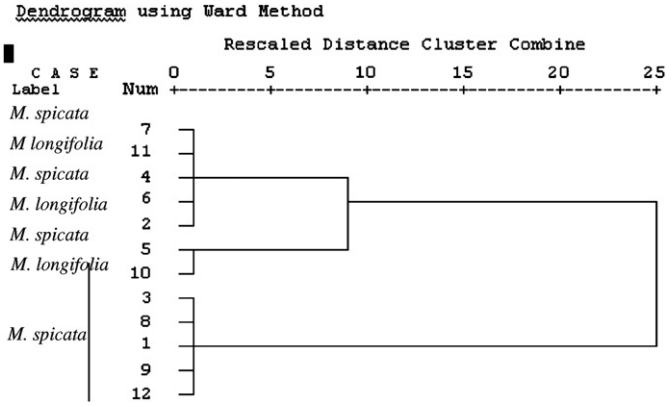

Fig. 1. Cluster analysis of 12 mint accessions using Mg and Fe concentrations of first harvest (mean of 2001 and 2002). The dendrogram was produced using Ward's method of cluster analysis. Accession numbers are based on Table 1.

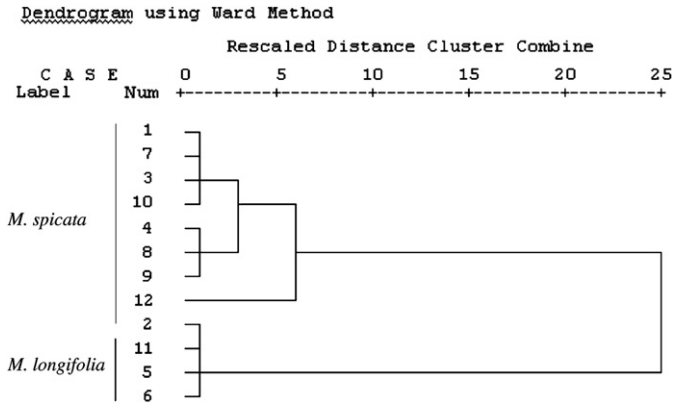

Fig. 2. Cluster analysis of 12 mint accessions using Mg and Fe concentrations of second harvest (mean of 2001 and 2002). The dendrogram was produced using Ward's method of cluster analysis. Accession numbers are based on Table 1.

to *M. spicata*. Cluster analysis on the basis of two nutrient concentrations averaged of the four harvests discriminated the mint accessions into four groups each of which having 5, 1, 1 and 5 accessions, respectively (Fig. 3). Cluster I contained five accessions of 1, 3, 4, 8 and 9 all belonging to *M. spicata* species. Each of clusters II and III possessed only one accession (7 and 12, respectively both belong to *M. spicata* species). Cluster IV contained five accessions of 2 and 10 belong to *M. spicata* and 5, 6 and 11 belong to *M. longifolia* species. Analysis of variance among clusters revealed the significant differences ($P < 0.01$) for both Mg and Fe concentrations (data not shown). On the other hand, there was no significant difference within each cluster for these elements.

3.4. Statistical relationship

The relationship among Fe concentration, Mg concentration, essential oil content, leaf dry weight, herbage yield of the studied mint landraces were assessed and for those with the significant relationship presented in Figs. 4 and 5. There

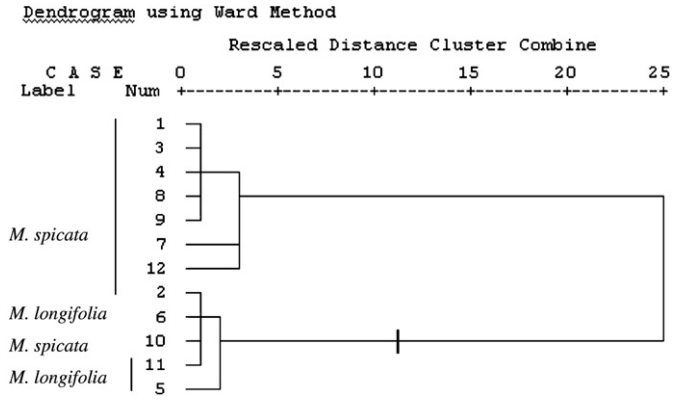

Fig. 3. Cluster analysis of 12 mint accessions using Mg and Fe concentrations of first and second harvest data (averaged on four harvests of 2001 and 2002). The dendrogram was produced using Ward's method of cluster analysis. Accession numbers are based on Table 1.

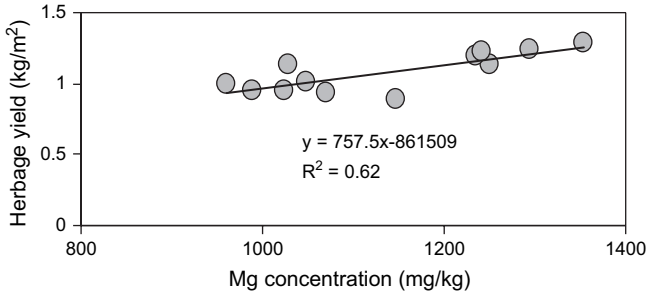

Fig. 4. Relationship between Mg concentration and herbage yield of 12 mint landraces.

was no significant correlation between Fe and Mg concentrations of the mint landraces ($R^2 = 0.06$). Although Mg concentration correlated significantly with both leaf dry weight ($R^2 = 0.6$) and herbage yield ($R^2 = 0.62$), the regression coefficients were not significant neither for Fe concentration and leaf dry weight ($R^2 = 0.02$) nor for Fe concentration and herbage yield ($R^2 = 0.12$). Although no significant relationships were found between Fe concentration and essential oil content ($R^2 = 0.004$) as well as Mg concentration and essential oil content ($R^2 = 0.17$) of the mint landraces, there were an inverse and non-significant correlations between both Fe concentration and essential oil content ($r = -0.06$) as well as Mg concentration and essential oil content ($r = -0.42$).

4. Discussion

Twelve mint accessions were grown under field conditions to assess the Fe and Mg nutritional values of two leaf harvests of two seasons (2001–2002). The data averaged on two years showed that concentrations of Mg and Fe were higher at the second harvest than the first harvest. It should be stressed that first harvest was performed at full flowering while the second harvest was performed before flowering stage. Plants were bigger and were at reproductive stage at first harvest and it is possible that the partitioning of root-absorbed nutrients throughout the larger shoot mass of the older plants including flowering organs may have led to a lower overall delivery of nutrients to the leaves. Ibrikci et al. [13] observed lower mineral concentrations in leaves of chickpea collected at the later harvest date.

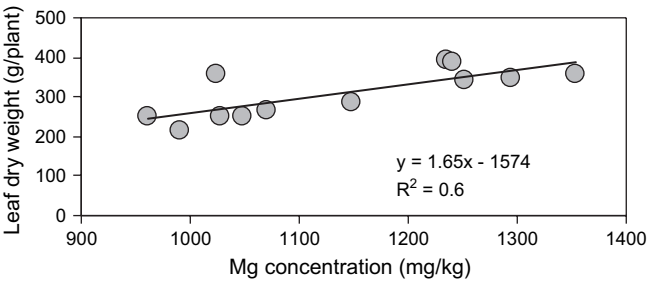

Fig. 5. Relationship between Mg concentration and leaf dry weight of 12 mint landraces.

The results also revealed the genotypes of *M. longifolia* had higher Fe and Mg concentration than genotypes of *M. spicata* species (Table 3). Singh et al. [20] analyzed several vegetables which purchased from market for mineral concentration and among which mint possessing 506 mg kg^{-1} Fe was the second ranked after cauliflower.

A clear relationship between concentration of iron and magnesium and geographical distribution was not evident. This result is in agreement with those of our previous reports on evaluation of morphological diversity and essential oil compositions of the same accessions [25,26]. This may be due to sampling of mint accessions within a relatively small region as central Iran. However, clustering based on second harvests could discriminate the accessions of two mint species more appropriately than the first harvest. Although Mg concentration correlated significantly with both leaf dry weight and herbage yield (see Figs. 4 and 5), the regression coefficients were not significant for Fe concentration with leaf dry weight and herbage yield. These results indicated that breeding for higher leaf weight and herbage yield in mint could increase Mg concentration while it may not lead to the increment of Fe concentration.

To help provide higher quantities of plant-based dietary minerals, researchers have been working to enhance the mineral density of plant foods. This is not proving to be an easy task, as minerals must be acquired from the rhizosphere, and are partitioned to edible tissues via a complex, integrated series of short and long-distance transport events [9]. However, mineral concentrations can differ across tissues within a single plant, across genotypes of a given species, or more broadly across species. Therefore, more advances will be possible if attention is given to the evaluation of currently available germplasm resources.

Our data on the Fe and Mg composition of mints indicated the relatively high Fe and Mg concentration in both *M. spicata* and *M. longifolia*. For example based on average of four cuts in two years in 12 accessions, daily consumption of 350 g mint dry leaves provides sufficient magnesium to meet the recommended daily allowance (RDA) of 350 mg per person, and 60 g mint dry leaves supplies the recommended adult daily allowance of iron (15 mg). To describe the diversity among the mint accessions into a more understandable way, daily consumption of 250 g dry leaves of accession number Mzin5 belonging to *M. longifolia* provides sufficient magnesium while 360 g dry leaves of Mzin9 (*M. spicata*) will provide the same RDA. For iron, daily consumption of 40 g dry leaves of accession number Mzin12 belonging to *M. spicata* provides sufficient iron while 70 g dry leaves of Mzin4 (*M. spicata*) will provide the same RDA. Guil Guerrero et al. [12] suggested the consumption of 220 g per day of a wild plant leaves (*Verbena officinalis*) as having sufficient magnesium to meet the RDA of 350 mg Mg per person.

In summary, our analysis of 12 diverse mint accessions demonstrates that mint leaves contain high levels of two essential minerals (Fe and Mg), comparing favorably with other common leafy vegetables. Mint leaves show great promise as a dietary source of these human essential minerals, especially for populations where malnutrition and micronutrient deficiencies are prevalent. The result of present study also revealed that Mzin2, Mzin12 (both belong to *M. spicata*) and Mzin6 (belongs to *M. longifolia*) possess the highest Fe concentration. Furthermore, Mzins 5, 6 and 11 belong to *M. longifolia* as well as Mzins 2 and 10 belong to *M. spicata* did not significantly differ and all included the first ranking group for Mg concentration. The exploitation of these valuable genetic variations would be greatly enhanced through the breeding programs aimed at improving these two essential nutrients in mint.

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