Catena 165 (2018) 173–177

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

How geographical differences may affect the uptake of nutrients by the wild populations of pennyroyal [*Mentha longifolia.*(L.), Huds]

Mohammad Mohammadi, Hossein Ali Asadi-Gharneh*

Department of Horticulture, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran

A R T I C L E I N F O

Keywords:
Climate
Geographical differences
Height above the sea level
Medicinal plants
Nutrient uptake
Soil properties

A B S T R A C T

How the growth and the nutritional value of medicinal plants are affected by different factors, is an important investigation for the domestication and production of efficient medicinal plants. Accordingly, a research work was proposed to determine how the uptake of nutrients including phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) in pennyroyal [*Mentha longifolia.*(L.), Huds] may be affected by geographical differences such as longitude, latitude, and the height above the sea level as well as the soil properties. One of the wealthiest (medicinal plants) Iranian provinces, namely Ilam, was selected for the experiment using the following 10 ecotypes: Siahkal, Helaesm, Alamdar, Kolm, Mishkhas, Chenarbashi, Jan Jan, Chalimar, Sarab and Sang Sefid Using the standard analytical methods including wet chemistry and the use of atomic absorption spectrophotometer, the concentrations of different nutrients were determined in plant samples. The soil samples were also analysed for acidity, salinity, organic matter, and texture. The results indicated that geographical differences and soil properties significantly affected the concentrations of nutrients in pennyroyal. Chalimar, JanJan, Kolm, Alamdar, and Mishkhas were among the most productive ecotypes with respect to the concentrations of plant nutrients. The concentrations of nutrients were in the following ranges: P (0.24–0.47%), K (1.00–2.49%), Ca (0.91–1.95%), Mg (0.30–0.95%), Fe (587.50–1637.50 mg/kg), Zn (35.00–73.75 mg/kg), Mn (62.50–117.50 mg/kg) and Cu (15.00–22.50 mg/kg). Data were also subjected to cluster analysis, and the similar ecotypes, with respect to the concentrations of the nutrients, were grouped. It is possible to find the most nutritious and productive ecotypes for domestication and production purposes as affected by geographical differences and soil properties. The other important point related to the significance of this research work is that the concentrations of nutrients in pennyroyal can importantly affect its nutritional and medicinal values.

1. Introduction

With respect to the morphological and biochemical properties of medicinal plants, they are widely used for food and medicinal purposes. Pennyroyal [*Mentha longifolia.*(L.)] is a medicinal plant, planted in different parts of Iran and has a wide range of usages. Its wild populations present a wide range of morphological and biochemical characteristics. Different parameters including climate, soil and plant species can affect its growth and its biochemical properties such as the amount and the quality of essences. The biochemical products in pennyroyal can determine its food and medicinal values (Abbaszadeh et al., 2009; Shinwari et al., 2011; Heidari et al., 2016).

It was hypostasized in this research work that the geographical factors such as the height above the sea level, the longitude, latitude and climate as well as soil factors can influence pennyroyal growth and physiology including the concentration of different nutrients (Elmendorf et al., 2012; Chen et al., 2015; Mohammadi and Asadi-Gharneh, 2018). A higher concentration of nutrients in plant can enhance plant growth and its nutritional quality (Ncube et al., 2012). Plant nutrient uptake is determined by the nutrient chemical properties as well as by the soil biological, chemical and physical properties (Mousavi, 2011). Some nutrients such as magnesium (Mg), calcium (Ca) and potassium (K) are more mobile and available under alkaline conditions and some nutrients, especially micronutrients such as iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) are more mobile under acidic conditions (Miransari, 2012).

There is a wide range of physiological and biochemical functions for nutrients in plant including: 1) photosynthesis process, 2) regulation of enzymatic activities, 3) adjusting water uptake, 3) plant signaling, 4) interactions with soil microbes, and 5) improving plant tolerance under stress. It is accordingly essential for plant to absorb suitable rate of nutrients or its growth and yield decreases (Marschner, 1995; Shen

* Corresponding authors.
E-mail address: h.asadi@khuisf.ac.ir (H.A. Asadi-Gharneh).

https://doi.org/10.1016/j.catena.2018.01.019
Received 30 March 2017; Received in revised form 16 January 2018; Accepted 21 January 2018
Available online 06 February 2018

et al., 2011).

Under natural conditions, the combination of environmental and biological properties can determine the availability of nutrients in the soil (Zhenghua et al., 2001; Craine and Dybzinski, 2013). For example, different factors including precipitation, moisture, temperatures as well as soil pH, salinity, organic matter, and soil microbes can affect plant nutrient uptake (Miransari, 2013). Such factors are affected by geographical differences.

It is accordingly, important to evaluate the parameters, which can affect the morphological and biochemical properties of medicinal plants and their subsequent domestication. With respect to the presence of medicinal plants, in this research work, one of the wealthiest provinces of Iran, namely Ilam, was selected, and 10 different wild populations (ecotypes) were used for sampling. The objective was to determine how the geographical differences and soil properties may affect the nutritional uptake and hence the nutritional value of the important medicinal plant, pennyroyal.

2. Materials and methods

2.1. Sampling and evaluating the pennyroyal plants

The region for the research work was first selected at the end of summer, 2014, and during the flowering stage the sampling was done (Mohammadi and Asadi-Gharneh, 2018). Ten different regions (ecotypes) were selected for sampling including Siahkal, Halasem, Alamdar, Kolm, Mishkhas, Chenarbashi, JanJan, Chalimar, Sarab and SangSefid. The populations were sampled randomly and using a GPS, the geographical characteristics of the regions were determined (Table 1). The collected samples (20 samples for each ecotype in three replicates) were then dried using a flat press and were transferred to the Herbarium of the Isfahan (Branch) Islamic Azad University, Iran. Using a loop and the method of plant classification (Jalili and Jamzad, 2013; Jamzad and Hasani-Nejad, 2014) the plant samples were classified. The properties of soils were determined using the following standard methods (Table 2, Miransari et al., 2008).

The acidity (using a pH meter) and the electrical conductivity (using a conductivity meter) of the soil saturated pastes were determined (Rhoades, 1982). The level of organic matter in the soil samples were indicated according to the method of wet oxidation (Nelson and Sommers, 1982). The hydrometer method was used for the determination of soil texture (Gee and Bauder, 1986).

The nutrient concentrations in the plants of the ecotypes were determined using the following methods (Miransari et al., 2009): P was determined using the colorimetric method by acetic acid extraction (Olsen and Sommers, 1982; Prokopy, 1995), K according to Hamada and El-Enany (1994) using the acetic acid extraction and emission flame photometer (using the emission of spectrophotometer, Knudsen et al., 1982), and Ca and Mg using the titration method (Thomas, 1982). The measurement of micronutrients was done using atomic absorption spectrophotometer by the diethylenetriaminepentaacetic acid (DTPA) method (Lindsay and Norvell, 1978; Wright and Stuczynski, 1996).

Table 1
The experimental ecotypes with their geographical properties.

Region	Longitude	Latitude	Height (above the sea, m)
Siahkal	60° 7′ 3″	37° 22′ 92″	892
Helaesm	65° 90′ 14″	37° 29′ 54″	860
Alamdar	61° 27′ 7″	37° 50′ 59″	1072
Kolm	67° 82′ 48″	36° 92′ 49″	929
Mishkhas	64° 19′ 90″	37° 90′ 9″	1260
Chenarbashi	66° 52′ 4″	37° 22′ 54″	1115
Jan Jan	62° 37′ 99″	37° 56′ 5″	1300
Chalimar	63° 3′ 96″	37° 35′ 96″	1410
Sarab	62° 61′ 80″	37° 36′ 45″	1294
Sang Sefid	65° 45′ 77″	37° 33′ 93″	994

Table 2
The properties of the experimental soils.

Region	EC (dS/m)	pH	OM	Sand (%)	Silt (%)	Clay (%)	Texture
Siahkal	7.5	7.7	1.3	52	36	12	Loam
Helaesm	6.5	7.6	1.53	64	21	15	Silt loam
Alamdar	5.2	7.9	5.1	58	25	17	Silt loam
Kolm	7.5	7.3	5.86	42	41	17	Loam
Mishkhas	3.4	7.2	1.1	25	41	34	Sandy loam
Chenarbashi	6.8	7.5	1.27	75	13	12	Silt loam
Jan Jan	2.5	7.8	3.2	27	43	30	Sandy loam
Chalimar	2.9	7.7	1.58	55	28	17	Silt loam
Sarab	4.1	7.4	5.51	41	22	17	Loam
Sang Sefid	5.5	7.6	2.24	44	31	25	Loam

2.2. Statistical analysis

The experiment was a completely randomized design; the means were compared using Dunkan's multivariate test at $P = 0.05$. The statistical parameters including mean, maximum, minimum, standard deviation and coefficient of variation were calculated using SAS. Using the Ward's clustering method the similar ecotypes were grouped according to plant nutrient concentration. The grouping of pennyroyal species was done using the methods of agglomerative and hierarchical (SAS).

3. Results

Analysis of variance indicated the significant effects of regions (ecotypes) on the concentrations of macro- and micro-nutrients in the pennyroyal wild populations (Table 3). Table 4 presents the highest and the least concentrations of nutrients in the ten experimental ecotypes including P (0.24–0.47%), K (1.00–2.49%), Ca (0.91–1.95%), Mg (0.30–0.95%), Fe (587.50–1637.50 mg/kg), Zn (35.00–73.75 mg/kg), Mn (62.50–117.50 mg/kg) and Cu (15.00–22.50 mg/kg). The most variable nutrient was Mg with the C.V. of 34.17% and the least one was Cu with the C.V. of 13.58.

According to the results the highest plant P concentration was resulted by the Chalimar and Sarab ecotypes significantly different from the Chenarbashi with the least P concentration (Fig. 1). The ecotype of Chalimar also resulted in the highest plant K concentration and the ecotype of SangSefid resulted in the least plant K concentration (Fig. 2). The ecotypes of Mishkhas and Kolm had the highest rate of Ca concentrations and JanJan with the least Ca concentration, significantly different from each other (Fig. 3). The highest concentration of Mg was related to the ecotype of SangSefid and the least to the Kolm ecotype, which were significantly different (Fig. 4).

The ecotypes of Alamdar and Chalimar, with significant differences from each other, resulted in the highest and least concentration of Fe, respectively (Fig. 5). The highest concentration of Zn was resulted by Mishkhas and the least was resulted by SangSefid, significantly different from each other (Fig. 6). The highest Mn concentration was related to the JanJan ecotype and the least to Mishkhas and Chalimar with significant differences (Fig. 7). The ecotypes of Mishkhas and JanJan resulted in the highest and the least concentrations of Cu, respectively, significantly different from each other (Fig. 8).

Cluster analysis grouped the following ecotypes: 1) Halasem, Sarab, Kolm, Siahkal and Chenarbashi, which contained less concentration of P compared with the other ones. 2) Alamdar, JanJan and SangSefid with higher Mg, Fe and Mn related to other groups, however, the concentrations of K, Ca, Zn and Cu was less compared with the other groups, 3) Mishkhas and Chalimar with the higher concentrations of P, K, Ca, Zn, and Cu than the other groups, and less concentrations of Mg,