

ELEMENTAL COMPOSITION OF THE AERIAL PART OF PLANTS OF THE GENUS *PYCNANTHEMUM* MICHX.

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Summary. These are the results of the study of plants of the genus *Pycnanthemum* Michx. (Lamiaceae), which were introduced in the M.M. Gryshko National Botanical Garden of the NAS of Ukraine. The characteristics of the soil and climatic conditions of plant growth are given. The quantitative content of 22 chemical elements in the raw materials of plants in the flowering phase is established. It is revealed that some species, in particular *P. californicum*, *P. montanum*, *P. muticum*, are able to accumulate K, Na, Mg to a greater extent than other. Heavy metals Ni and Zn are also found in the raw materials.

Keywords: introduction, genus *Pycnanthemum*, raw materials, chemical elements

Introduction

Introduction studies of plants in botanical gardens of Ukraine have a comprehensive approach, due to which the accumulated experimental and analytical material contributes to the implementation of the main task – the preservation of floristic diversity. At the same time, the polyfunctionality of plants, their adaptive potential and lability, high introduction resistance in the proposed soil and climatic conditions allow individual plant species to be involved in breeding work and recommended for cultivation in cultural phytocenoses.

The practical use of introduced plants has production feasibility and, probably, an economic advantage, given the dynamics of climatic variability, the disturbed ecological balance in the country, the growing demand for natural plant products and their derivatives. Particular attention is paid to the quality of plant raw materials.

In a comprehensive study of plants of a specific species (genus), part of the research is necessarily aimed at biochemical screening of raw materials, assessing their safety and establishing enrichment with certain compounds and elements. The qualitative and quantitative content of chemical elements in plant materials used by humans has a direct impact on their health. All chemical elements in relation to the human body – essential, toxic and neutral – play an important role in regulating water-electrolyte metabolism, in oxidation-reduction reactions, in the processes of transmission of neuromuscular excitation, etc. [4]. In this paper, we propose to publish the results of a study of the elemental composition of raw materials of plants of the genus *Pycnanthemum* Michx. (Lamiaceae), which were first introduced in Ukraine and are of considerable interest both from a scientific point of view and from the practical side of use.

Materials and methods

The following plants of the genus *Pycnanthemum* were used in the research: *P. californicum* Norr. ex Durand, *P. montanum* Michx., *P. muticum* (Michx.) Pers., *P. tenuifolium* Schrad., *P. verticillatum* var. *pilosum* (Nutt.) Cooperr., *P. virginianum* (L.) T. Durand & B.D. Jacks. ex B.L. Rob & Fernald. They are by introduced to the collection of the Department of Cultural Flora of the M.M. Gryshko National Botanical Garden of the NAS of Ukraine (NBG). The collection was carried out in 2023 during the flowering of the plants. A blend of inflorescences, leaves and herbaceous parts of shoots was subject to analysis.

The quantitative content of 22 chemical macro-, micro- and ultramicroelements in the raw materials of plants of the genus *Pycnanthemum* was determined in the experiment was determined

at the Center for Collective Use of Scientific Instruments «Spectrometric Center for Elemental Analysis» of the NBG using the ICP OES method on the ICAP 6300 DUO apparatus (Thermo Fisher Scientific, USA).

The soil analysis was carried out in the laboratory of the Allelopathy Department of the NBG. The samples were collected in accordance with GOST 17.4.02-84, the content of the complex of biogenic macro- and microelements was determined using the colorimetric method, pH was determined using the potentiometric method, and the total humus content was determined using the I.V. Tyurin method [6].

Climatic conditions are analyzed and summarized based on the initial data of the Borys Sreznovsky Central Geophysical Observatory (Kyiv) for 2019-2023.

Results and discussions

For the first time in Ukraine, we primary introduction test of perennial herbaceous plants of the genus *Pycnanthemum* Michx. (Lamiaceae), which are representatives of foreign flora. The natural range of the genus *Pycnanthemum* is in North America. Most species grow in the eastern part of the United States, and the center of diversity of the genus is considered to be the mountains of North Carolina [1]. About 50% of the known species are distributed in the state of Alabama [8]. According to the modern taxonomic processing of «The Plant List», the genus *Pycnanthemum* includes 22 plant species with two varieties inclusive [9]. These are perennial rhizomatous herbaceous plants 30-95 cm high, the aboveground part of which, when rubbed, has a refreshing mint aroma due to the content of essential oil.

In NBG the plants are presented in the collection of Non-Traditional essential oil plants. Examination of the soil of the collection showed that it is dark gray, ashed, weakly washed and compacted. It was established that the soil is rich in humus, the pH value of the soil is alkaline and was within the limits suitable for plant development. The content of mobile elements – N, R, Mg, Fe – had deviations both towards a deficiency (NO_3^- , K) and a significant excess (Mg, Fe). The content of NH_4^+ is within the norm, and the content of NO_3^- is significantly less than the indicated norm (Table 1).

Table 1

Chemical composition of the soil of the collection Non-Traditional essential oil plants

Content of elements, mg/l										
NH_4^+	NO_3^-	P	K	Ca	Mg	Fe	S	Mn	pH	C % humus
14,0	15,0	109,0	121,2	8330,0	2032,0	1250,0	37,5	160,0	6,6	6,2

The analysis of chemical elements in raw revealed a deficiency of K in the soil, which could have a negative effect on the frost resistance of plants, their resistance to diseases, and in growth processes. The Mg content exceeded the norm and could have a negative effect on the absorption of Ca, and the excess of the low-mobility element S – on the physiological functions of plant leaves. A significant excess of Fe was revealed, which could have affected to a certain extent the growth parameters of the experimental plants [2], as well as immobile elements Ca and Mn, which still did not cause interveinal chlorosis of the leaves, but probably affected the process of absorption of elements, in particular K. The P content was close to the norm.

The climatic conditions under which the primary introduction of the *Pycnanthemum* species were carried out are characterized by elevated temperatures and insufficient precipitation in summer, which confirms the general trend of aridization of growth conditions (Table2). The winter period became warmer with a normalized amount of precipitation.

A brief description of the soil and climatic conditions gives an understanding of the environment in which the experimental plants of the *Pycnanthemum* species grow.

Table 2

Average monthly air temperature and monthly precipitation during the growing season of plants for the period 2020-2023 in the city of Kyiv

Climate parameter	Year	Months							
		III	IV	V	VI	VII	VIII	IX	X
Average monthly air temperature, °C	2020	6,5	9,9	12,4	21,7	21,9	21,4	18,4	12,5
	2021	2,7	8,0	14,4	21,3	24,6	21,1	13,6	8,4
	2022	2,6	8,1	14,6	21,7	20,8	22,3	12,7	10,6
	2023	4,8	9,6	16,0	19,6	21,5	23,8	18,8	11,4
average long-term deviation from the norm		2,1	-3,1	-5,2	1,9	1,7	2,2	1,22	2,3
Monthly precipitation, mm	2020	15	39	122	49	47	31	31	101
	2021	17	45	74	24	63	65	23	2
	2022	12	42	33	42	40	60	63	44
	2023	42	102	1	87	136	19	8	66
average long-term deviation from the norm		-18,3	53	-18	-23,3	-1,5	-15,5	-24	10

In the flowering phase of the plants, the content of chemical elements in the above-ground herbaceous part was determined (Table 3).

Table 3

Elemental composition of the raw materials of introduced species of the genus *Pycnanthemum*

Elements	<i>Pycnanthemum</i>					
	<i>californicum</i>	<i>virginianum</i>	<i>tenuifolium</i>	<i>montanum</i>	<i>muticum</i>	<i>verticillatum</i> var. <i>pilosum</i>
macroelements						
Ca	20370.0	10460.0	16720.0	11742.0	18020.0	10643.0
Na	92.51	58.46	87.00	144.00	187.00	87.30
K	9086.0	8941.0	6803.0	10760.0	3419.0	9818.0
Mg	4391.0	1624.0	3668.0	2374.0	4950.0	2331.0
P	3624.0	1873.0	3032.0	2231.0	1487.0	1924.0
S	10570.0	597.2	6547.0	2533.0	2038.0	2129.0
microelements						
Al	407.0	109.0	138.0	251.00	330.5	245.13
B	23.84	16.48	23.26	19.80	49.5	19.53
Cu	11.62	7.02	10.13	2.20	1.15	2.3
Fe	417.0	106.0	165.0	249.0	430.0	340.0
Mn	39.81	18.7	24.79	17.30	7.85	23.3
Sr	71.06	34.05	51.90	33.66	56.2	42.43
Zn	89.01	41.3	57.16	57.16	84.6	35.21
Pb	1.35	0.57	1.19	0.41	0.4	0.53
Cd	0.07	0.04	0.04	<.00	0.05	<.00
Si	1012.0	597.2	961.7	693.7	513.0	876.3
ultramicroelements						
Ba	32.42	80.91	9.04	27.68	34.5	30.62
Ni	1.08	0.46	0.68	2.36	not determined	2.26
Cr	1.43	0.54	0.80	2.23	0.06	1.83
Ti	14.26	10.06	15.5	11.49	12.03	11.91
V	1.52	0.36	0.7	<.00	0.54	0.03

Co	0.27	0.13	0.21	0.16	0.13	0.18
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It was found that among the introduced species, *P. montanum* and *P. verticillatum* var. *pilosum* have the highest K content – 1070 mg/kg and 9818 mg/kg, respectively; Mg – *P. muticum* (4950 mg/kg) and *P. californicum* (4391); *P. californicum* dominates in P (3624), S (10570 mg/kg) and Ca content (20370 mg/kg), and *P. muticum* (187 mg/kg) and *P. montanum* (144 mg/kg) predominate in Na. As for the so-called heavy metals – Pb, Cd and Ni, their content is quite different among the experimental species. The Cd content in the introduced species is normal, however, in one species – *P. californicum* it exceeds the maximum permissible concentration (MPC) by 0.02 mg/kg, and in *P. montanum* and *P. verticillatum* var. *pilosum* it was not detected at all, but the Ni and Cr content in these two species is the highest compared to the indicators of other species. The Pb content in the analyzed samples of raw materials is within the limits not exceeding the MPC, while a significant excess of the MPC of Zn in the raw materials is noted, especially in *P. californicum* (89.01) and *P. muticum* (84.6 mg/kg).

In general, heavy metals – Pb, Cd, Cr, Co, Ni, Cu, Zn – were detected in all samples of *Pycnanthemum* raw materials in different concentrations. We can see the reasons for the pollution of plant raw materials due to the influence of the high level of air pollution in the metropolis of Kyiv has a direct effect on the introducers, and the possible anthropogenic entry of heavy metals into the soil through agrotechnical measures, namely, the application of organic fertilizers. In this way, the content of Co, Cr, Cu, Ni in the soil and then in the raw materials can increase. We assume that species of the genus *Pycnanthemum* are, to one degree or another, concentrators of a certain set of heavy metals.

Note that K contributes to the relief of allergic reactions in humans, equalizes blood pressure, Ca – improves immunity and the process of hematopoiesis, P ensures the functioning of the brain and muscular system, Zn has a positive effect on the activity of certain hormones of the pituitary gland and on the secretory capacity of the liver, etc. Cu, Fe, Mg, Zn, and Mn are capable of forming complexes with substances of an organic nature, are components of or activate up to 300 enzymes in the human body [5, 10]. Using plant raw materials in aqueous medicinal forms – decoctions and infusions, the transition of elements is 8-28%. This process is influenced by both the properties of the elements themselves and the degree of grinding of raw materials [3, 7].

Conclusions

Thus, in the proposed soil and climatic conditions, *Pycnanthemum* introducers have raw materials enriched with macro-, micro- and ultra-microelements. The highest content of K in *P. montanum* (1070 mg/kg) and *P. verticillatum* var. *pilosum* (9818 mg/kg), Ca – *P. californicum* (20370 mg/kg), Mg – *P. muticum* (4950 mg/kg) and *P. californicum* (4391), Na – *P. muticum* (187 mg/kg) and *P. montanum* (144 mg/kg), *P. californicum* dominates in P and S content – 3624 and 10570 mg/kg, respectively. The content of lead in the analyzed samples of raw materials is within limits that do not exceed the MPC. Cd content was not detected in *P. montanum* and *P. verticillatum* var. *pilosum*, in the rest of the species it is normal, except for *P. californicum* (0.07 mg/kg) (8), the Ni content prevails in the raw materials of *P. montanum* and *P. verticillatum* var. *pilosum*. The level of Zn in the above-ground mass of plants exceeds the MPC, particularly in *P. californicum* (89.01) and *P. muticum* (84.6 mg/kg). The presence of heavy metals in raw materials requires clarification of the reasons for their entry into plants, as well as the possible accumulative properties of plants in relation to certain elements.

References

1. Flora of the Carolinas, Virginia, Georgia, northern Florida, and surrounding areas *Pycnanthemum* Michaux (Mountain-mint, Wild-basil), 2008. P.424-426. (924 p.). URL: http://www.herbarium.unc.edu/weakleyflora_2008-apr.pdf

2. Korovetska G., Dzura N., Tsvimenyuk O., et al. Macroelement composition of plants *Carex hirta* L. under the influence of oil pollution of the soil. Bulletin of Lviv University. Biological series, 2009. 50. 182-188.
3. Lovkova M.Ya., Buzuk I.N., Sokolova S.M., Derevyago L.N. On the possibility of using medicinal plants for the treatment and prevention of macroelementoses and pathological conditions. Macroelements in medicine. 2005. 6(4). P.3-10.
4. Pharmaceutical encyclopedia. URL: <http://www.pharmencyclopedia.com.ua>
5. Popova N.V., Bobrytska L.O., Arapetyan M.A. Elemental composition of immortelle and flamin. Herald of Pharmacy. 2013. 3(75). P. 49-51.
6. Rinkis G.Ya., Nollendorf V.F. Balanced nutrition of plants with macro- and microelements. Riga: Zinatne, 1982. 304 p.
7. Rubanka K.V., Zinchenko I.M. Research on the safety of plant raw materials. URL: <http://www.dspace.nuft.edu.ua>
8. Setzer W.N., Duong L., Pham T., Poudel A., et al. Essential Oils of Four Virginia Mountain Mint (*Pycnanthemum virginianum*) Varieties Grown in North Alabama. Plants 2021, 10, 1397. <https://doi.org/10.3390/plants10071397>.
9. The Plant List: *Pycnanthemum* Michaux. URL: <http://www.theplantlist.org/tpl1.1/search?q=Pycnanthemum> (accessed July 16, 2024).
10. Tsurkan O.O., Galembiovskaya O.I., Kolyadych O.P. Micro- and macroelemental composition of above-ground and underground organs of *Prunella vulgaris* L. Zaporizhia Medical Journal. 2012. 4 (73). P. 132-134.