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Variation of macro- and trace elements in organs of the blue honeysuckle subspecies of various environmental and geographic provenance when grown in the Near-Ob forest-steppe (West Siberia, Russia)

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Abstract. The variation limits and organ distribution of macro- and trace elements were determined in plants of the three subspecies of *Lonicera caerulea* L. The leaves, as compared with the stems, were found to accumulate more of B, Ca, Mg, Mo, P and Sr and less of Al, Mn, Ti and Zn. The plants of different subspecies, grown on soils of the similar chemical element composition, showed statistically significant differences in contents and organ distribution patterns of Al, Cr, Cu, Fe, Mg, Mo, Na, Ni, Pb, Si, Ti and Zn. The stems of the subspecies of the Far East provenance (*L. caerulea* subsp. *kamtschatica* and *L. caerulea* subsp. *venulosa*) had abnormally high contents of Al, Cr, Fe, Na, Si and Ti.

Introduction

The subsection Caeruleae Rehd. of blue honeysuckles of *Lonicera* genus in Caprifoliaceae Juss. family includes three endemic diploid species: *Lonicera iliensis* Pojark., *L. edulis* Turcz. ex Freyn, *L. boczkarnokowae* Plekhanova nom. nov and a tetraploid species *L. caerulea* L. The latter is represented by seven subspecies, namely *L. caerulea* subsp. *caerulea*, L. *caerulea* subsp. *emphyllocalyx* (Maxim) Plekhanova comb. nov., *L. caerulea* subsp. *altaica* (Pall.) Plekhanova comb. nov., *L. caerulea* subsp. *pallasii* (Ledeb.) Browich, *L. caerulea* subsp. *stenantha* (Pojark) Hult. ex Skvortsov, *L. caerulea* subsp. *kamtschatica* (Pojark.) Plekhanova comb. nov., *L. caerulea* subsp. *venulosa* (Maxim) Worosh. [1].

Blue honeysuckles are spread in the taiga zone of Eurasia and North America. On most of their growth area their berries are bitter in taste, and till the middle of the 20th century the species of the subsection were not even considered as food plants. Only in the Far East, the north of China and Hokkaido Island in Japan the berriess of *L. caerulea* subsp. *kamtschatica*, *L. caerulea* subsp. *venulosa*, *L. caerulea* subsp. *emphyllocalyx* and *L. Boczkarnokowae* were consumed by humans [2, 3]. The native populations of *L. caerulea* subsp. *kamtschatica* and *L. caerulea* subsp. *venulosa* were used as initial sources for

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breeding the first cultivated varieties. Over the last years the breeding focus shifted towards *L. caerulea* subsp. A*ltaica* as having a combination of economically valuable traits such as high productivity, rapid production, drought resistance, firm berry fixing and high bioflavonoid content.

Numerous studies proved the beneficial effects of blue honeysuckle berries for human health. The fruit medicinal properties are determined by the high content of biologically active substances (BAS). Alongside with high BAS content, the *L. caerulea* organs accumulate high levels of macro- and trace elements [4]. There is an interrelationship between accumulation of certain BAS and trace elements, which often show combined medicinal effect [5]. Species specificity of plants in respect to elemental composition and content is of great interest both from the theoretical point of view, i.e. to get a better insight into the fundamental biochemistry of plants, as well as from the practical angle by using plants as food and medicine source.

Our earlier studies of chemical element contents in plants of *L. caerulea* subsp. *altaica* and *L. caerulea* subsp. *pallasii* growing in natural populations [4, 6] showed substantial variation of macro- and trace element contents in plant organs depending on their growth environment. The aim of this study was to compare macro- and trace elements variation in fruits, leaves and stems of the three *L. caerulea* subspecies of environmentally and geographically different provenances when grown in culture in the forest-steppe zone in the Near-Ob region (West Siberia, Russia).

Material and methods

For measuring chemical elements in the soil-plant system we performed combined collection of soil and phytomass samples. Leaves, berries and stems of *L. caerulea* were collected at the ripening stage on the experimental plot in the Central Siberian Botanical Garden of the Siberian Branch of the Russian Academy of Sciences (54° N, 83° E, Novosibirsk, Russia). The samples were collected from the three plants of the three subspecies differing in environmental and geographical provenances: *L. caerulea* subsp. *altaica* from the Mountain Altai, *L. caerulea* subsp. *kamtschatica* from the Kamchatka Peninsular and *L. caerulea* subsp. *venulosa* from Primorye region. Chemical elements (Al, B, Ba, Ca, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Si, Sr, Ti, Zn) in soil and phytomass were measured by atomic emission spectrometry after dry combustion. The mobile form content of Ca, Cu, Fe, K, Mg, Mn, Na, Ni, Sr, Zn was evaluated by atomic absorption in ammonium acetate extracts with pH 4.8. The results are given per unit of soil mass on the air-dry basis. Statistical analysis was performed with Excel software.

Results and discussion

Elemental composition of soils on the plot where the honeysuckles were grown was rather homogenous both in bulk and mobile form contents of macro- and trace elements (Table 1, 2).

Table 1. Mean content of the mobile macro- and trace elements in soil (mg/kg of the air-dry soil)

***L. caerulea* subspecies**	**Ca**	**Cu**	**Fe**	**K**	**Mg**	**Mn**	**Na**	**Ni**	**Sr**	**Zn**
subsp. *altaica*	3300	0.19	8	46	140	14	21	0.71	14	2.0

subsp. *venulosa*	3800	0.22	10	32	130	17	33	0.74	16	1.7
subsp. *kamtschatica*	2000	0.20	9	57	170	13	22	0.84	14	2.0

Table 2. Mean total content of some macro- and trace elements in plant organs and soil (mg/kg of the air-dry soil)

Chemical element	**Organ**	**subsp. *venulosa***	**subsp. *kamtschatica***	**subsp. *altaica***
ash, %	leaves	6.8±0.1	8.0±0.1	8.9±0.1
	berries	3.9±0.4	3.2±0.1	3.4±0.1
	stem	3.6±0.3	4.7±0.1	4.6±0.3
Al	leaves	207±12	153±8	110±7
	berries	19±2	11±1	17±1
	stem	706±10	1505±305	200±47
	soil	58200±850	43400±1200	48000±520
B	leaves	29±2	48±2	45±3
	berries	13±1	9±1	18±1
	stem	16±2	15±1	20±3
	soil	51±2	55±2	49±2
Ba	leaves	80±7	117±7	60±2
	berries	11±3	11±2	11±1
	stem	79±8	95±7	48±6
	soil	407±13	379±23	373±11
Ca	leaves	19.5±1.1	20.8±0.6	19.0±0.7
	berries	3.8±0.7	2.6±0.2	2.8±0.2
	stem	11.0±1.4	10.9±0.2	9.2±0.9
	soil	12.6±0.5	9.9±0.1	10.2±0.1
Cr	leaves	0.32±0.01	0.36±0.01	0.70±0.11
	berries	0.14±0.01	0.08±0.01	0.16±0.01
	stem	1.14±0.04	2.16±0.11	0.46±0.05
	soil	65 ±1	76±1	71±2
Cu	leaves	11.6±0.2	7.0±0.2	4.3±0.4
	berries	5.0±0.4	4.4±0.4	3.1±0.2
	stem	8.9±1.2	11.2±0.3	4.7±0.4
	soil	14.4±1.0	18.7±1.0	14.7±0.6
Fe	leaves	64±1	65±2	74±7
	berries	10±1	4±1	16±1
	stem	220±2	588±72	84 ±18
	soil	24300±580	23580±710	25780±525
K	leaves	2.8±0.3	7.3±0.3	8.2±1.3
	berries	10.5±3.6	6.2±0.3	9.2±0.4

	stem	3.8±0.3	4.1±0.4	8.6±1.3
	soil	15.6±0.9	19.8±1.1	15.0±0.4
Mg	leaves	4.5±0.3	5.3±0.3	3.2±0.1
	berries	1.1±0.2	0.9±0.1	0.9 ±0.1
	stem	1.7±0.2	1.9±0.1	1.1±0.1
	soil	7.4±0.1	7.4±0.1	7.6±0.1
Mn	leaves	15.7±1.3	39±3	34 ±4
	berries	6.2±1.0	6±1	8±1
	stem	36.8±0.6	58±6	76±22
	soil	685±26	751±11	740±5
Mo	leaves	2.0±0.2	4.6±0.2	0.9±0.1
	berries	0.7±0.2	0.9±0.2	0.3±0.1
	stem	1.1±0.1	0.9±0.1	0.2±0.1
	soil	0.7±0.1	1.5±0.1	1.1±0.1
Na	leaves	103±10	84±1	115±21
	berries	28±8	25±3	20±1
	stem	275±10	552±60	116±23
	soil	15300±185	13630±150	15265±390
Ni	leaves	0.68±0.03	0.88±0.05	1.35±0.10
	berries	0.70±0.02	0.75±0.07	1.56±0.07
	stem	0.58±0.07	1.47±0.12	0.88±0.05
	soil	33.0±0.5	35.5±1.3	35.1±0.4
P	leaves	3215±140	4360±270	2120±20
	berries	1535±390	1275±180	1880±100
	stem	1625±260	1070±135	1080±210
	soil	620±12	940±5	730±6
Pb	leaves	0.17±0.01	0.15±0.01	0.64±0.18
	berries	0.06±0.01	0.05±0.01	0.16±0.01
	stem	1.32±0.02	4.60±0.50	0.87±0.24
	soil	9.0±0.2	10.4±1.8	8.8±1.1
Si	leaves	2100±125	2390±110	2450±120
	berries	168±10	110±5	156±6
	stem	1680±200	4000±800	540±43
	soil	278700±7300	236100±10900	249700±8200
Sr	leaves	196±14	212±10	142±8
	berries	28±6	20±3	17±1
	stem	130±10	120±8	86±11
	soil	164±1	142±1	131±2
Ti	leaves	9.6±0.3	9.3±0.3	7.5±0.4
	berries	1.8±0.2	1.2±0.1	1.1±0.3
	stem	25.0±2.0	55.6±7.4	10.1±2.5

	soil	4180±180	3470±120	3580±120
Zn	leaves	6.1±0.3	9.9±0.6	7.8±0.2
	berries	2.8±0.5	4.0±1.1	6.1±0.1
	stem	21.8±0.8	62.5±4.2	18.3±2.1
	soil	44.6±1.6	63.5±1.5	49.0±1.2

Organ distribution and accumulation of macro- and trace elements showed different patterns (Table 2). The leaves, as compared with the stems, were found to have higher concentration of ash elements (6.8–8.9 *vs*. 3.6–4.7%, respectively). This increased ash content was most likely due to the increased (2–3 times higher) accumulation of Ca, Mg and P, as well as B, Mo and Sr; the stems were found to accumulate Al, Mn, Pb, Ti and Zn more intensively. The berries, as compared with other organs, contained maximal amounts of K and Ni, the other elements being substantially lower in contents. Trace element distribution between the stems and the leaves was either rather homogenous (Ba, Cu) or showed a more complex pattern, being differential for the plant sample provenance.

Statistically significant difference was revealed between the subspecies in the accumulation rate of certain chemical elements. As compared with *L. caerulea* subsp. *altaica*, subspecies of Primorye provenance had extremely high concentrations of Al, Cr, Fe, Na, Si and Ti in their stems, i.e. *L. caerulea* subsp. *kamtschatica* 4.7–7.5 times and *L. caerulea* subsp. *venulosa* 2.4–3.5 times higher.

The found differential accumulation of macro-and trace elements in *L. caerulea* subspecies of environmentally and geographically different provenances, as well as the organ distribution patterns when grown on soil of similar chemical element composition strongly suggest that macro- and trace elements uptake mechanisms by plants had been formed in specific environments and fixed genetically.

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