On the ecological features of leaf ionome of some arboreal Rosaceae in Samara region conditions

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Abstract. Trees and shrubs of Rosaceae family possess a significant resource potential for the Samara region ecosystems. The quantitative study of elemental composition was carried out by X-ray fluorescence analysis (XRF) for leaves of 8 introduced and 3 native Rosaceae species. The features of five elements (K, Ca, Mn, Fe, Zn) levels are shown for them in comparison with the same parameters of two "reference plants" from different geographic locations. A very high Fe content and moderately high Mn and Zn contents were noted for leaves of all studied species. The detected high Ca concentration may be the result of plants development in soil environment with a naturally high Ca content. The revealed differences characterize the regional features of the leaf ionome, that reflecting the specifics of introduces plant species adaptation to new conditions and local species biogeochemical features.

1 Introduction

The study of higher plants elemental composition, stimulated by the instrumental base development, is successfully implemented in the course of identifying the level of elements accumulation in phytomass components in dependence on environmental conditions and clarifying the role of elements in the plant organism (for example, [1]). The accumulation of information contributed to the emergence of important generalizations, including the concept of a “referent plant” ([2]), the calculation of “fingerprints” [2, 3]) for elemental composition comparison of various objects phytomass, as well as the development of ionome concept [4]. The ionom, which reflects the plants elemental composition from subcellular to organismal level, being an elemental profile of phytomass, reflects information on phylogenetic trends, elemental phytohomeostasis features and geographical or geological region specifics [5].

The family Rosaceae is subcosmopolitan and mainly distributed in the northern hemisphere as one of the largest Angiospermae families (19th place according the number of taxa). Between 1987 and 1999, from 95 to 100 genera, from 2830 to 3100 species were indicated for the Rosaceae family. According to the results of modern studies based on the genome sequencing method, the Rosaceae family includes 133 genera and 1966 species [6-8].

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For Samara region, combining the forest-steppe and steppe conditions, arboreal Rosaceae species are important components in various types of ecosystems, taking into account their actual and potential resource potential [9]., The Rosaceae family is represented here by approximately 106 species belonging to 32 genera (5.6% of the species and 5% of genera in region flora). Among 67 species of woody Rosaceae noted in the Samara region, there are 30 native and 37 introduced species. For 2017, 55 species of woody Rosaceae were represented in the dendrological collection of the Botanical Garden of Samara University [9]. For some Rosaceae trees of Samara region, the features of heavy metals accumulation were previously studied [10].

The soil cover of the Samara region, in which chernozems are widely represented, is characterized by an increased Ca and Mg content, as well as neutral reaction and rather high soil solution mineralization, what can partially reduce the availability of some microelements to plants. These features determine the need for introducers - natives of typically forest biomes - to use a set of adaptive reactions to meet fully their demands in mineral nutrition elements in the place where soil conditions do not correspond to their ecological optimum. Modern analytical capabilities have made it possible to obtain new data on the elemental leaves composition for a number of species.

The aim of the study was to evaluate the features of the ionomic leaves profile of introduced and native arboreal Rosaceae under the conditions of the Samara region concerning with the accumulation of some macro- and microelements (K, Ca, Mn, Fe, Zn).

2 Research Methodology

The objects of our study were air dry samples of leaf phytomass taken in July 2015 (with average weather conditions of vegetation period for the Samara region). IThe leaves of introduced species (*Armeniaca vulgaris, Padus virginiana, Padus serotina, Amygdalus hibrida, Prunus sakkhalinensis, Padus mahaleb, Prunus divaricata, Prinsepia sinensis*) were selected in the dendrarium of the Botanical Garden of Samara University, the same of native plants (*Crataegus sanguinea, Amygdalus nana, Cerasus fruticosa*) - in Krasnosamarskoe Forestry (our polygon for educational and scientific ecomonitoring).

The primary preparation of plant samples was carried out by dry ashing in a muffle furnace in order to increase the limits of elements detection. The further quantitative elements determination was fulfilled using X-ray fluorescence analysis (XRF) by Clever C-31 device (ELERAN). The elements concentrations determined by % were expressed in mg/kg of dry mass using the ash content of the samples.

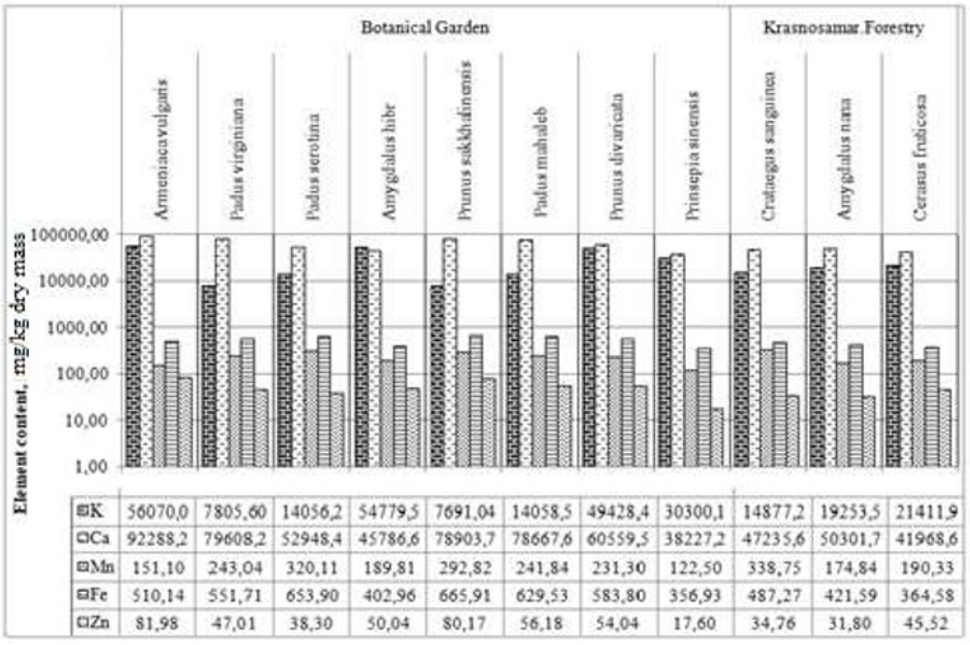
3 Results and Discussion

The established previously features of the ionomic leaves profile for woody plants in the Samara region can be characterized by the following concentration limits of analyzed elements: K - from 5420.0 to 52295.0; Ca - from 1350.0 to 55750.0; Mn - from 1.25 to 1990.0; Fe - from 20.0 to 650.0; Zn - from 1.0 to 179.3 mg/kg of air dry mass [10]. New data on the leaves ionome of arboreal Rosaceae, both introduced and local species, are presented in fig. 1 for 5 elements (K, Ca, Mn, Fe, Zn) using a logarithmic scale. In general, the new objects had data that fit into the previously established regional range of K, Mn, Fe and Zn concentrations for woody plants. On the contrary, Ca content in the leaves of 5 of the 8 introduced species significantly exceeded the maximum regional level of this element.

Among introduced plants, *Armeniaca vulgaris* had the maximum concentrations of K, Ca, and Zn in leaves, as well as a fairly high content of Fe, while *Prinsepia sinensis* had the minimal concentrations of Ca, Mn, Fe, and Zn. Generally, the studied group of introduced

species was characterized by differences of elemental composition among species, which resulted in high variation of all studied elements concentrations. The native species were distinguished by a lower variability level for all the listed elements. The leaves of *Crataegus sanguinea* had the highest concentrations of Mn and Fe, a fairly high content of Ca, *Amygdalus nana* accumulated K and Ca to the maximum extent, and *Cerasus fruticosa* accumulated K and Zn.

From the standpoint of the phylogenetic features, we shall point on some leaf ionome features given recently for Rosales order, to which the Rosaceae family belongs, on the base of significant data amount [11]. The Rosales commonly are characterized by relatively low content of N, P, K, Ca, Mg, moderate accumulation of Fe, high accumulation of Mn, Cu, Zn in leaves. Moreover, for the last two elements, such a feature is indicated only for the Rosales order [11, p.314]. Comparing these features, which demonstrate the "average leaf ionome" resulted under the model experiments conditions, with the concentrations established by us, we can conclude that for all the studied species, a very high Fe content and moderately high Mn and Zn contents were noted. The very high concentration of Ca found by us, which was not noted "in the norm" for Rosales [11], may be the result of plants development in a soil environment with a naturally high level of Ca content (chernozems).



	Armeniacavulgaris	Padus virginiana	Padus serotina	Amygdalus hibr	Prunus sakkhalinensis	Padus mahaleb	Prunus divaricata	Prinsepia sinensis	Crataegus sanguinea	Amygdalus nana	Cerasus fruticosa
K	56070,0	7805,60	14056,2	54779,5	7691,04	14058,5	49428,4	30300,1	14877,2	19253,5	21411,9
Ca	92288,2	79608,2	52948,4	45786,6	78903,7	78667,6	60559,5	38227,2	47235,6	50301,7	41968,6
Mn	151,10	243,04	320,11	189,81	292,82	241,84	231,30	122,50	338,75	174,84	190,33
Fe	510,14	551,71	653,90	402,96	665,91	629,53	583,80	356,93	487,27	421,59	364,58
Zn	81,98	47,01	38,30	50,04	80,17	56,18	54,04	17,60	34,76	31,80	45,52

Fig.1 Some elements content in the leaves of arboreal Rosaceae from Samara region

To identify the specifics of the ionomic spectra of the studied plants, the "fingerprint" method [3] was used, which deals with data comparison with the "reference plant" parameters obtained by averaging for group of species [2] and identified differences visualization using histograms showing deviations from the "reference plant", expressed as a percentage (table).

The performed calculations included a comparison with the levels of elements for plants of Western Europe [2] (Fig. 2), and regional data of local wild Rosaceae [10] (Fig. 3).A characteristic ionome differences in the leaves of all studied Rosaceae in the conditions of the Samara region (Fig. 2) turned out to be a multiple excess of the accumulation of Ca (up to 700 ... 800%), to a lesser extent - Fe (up to 350%), %), a slight decrease in the

accumulation of Zn (up to 50%) was also revealed. The described deviations were most pronounced in introduced plants that developed in soil conditions that were new to them, but were also traced in species of natural flora.

Table 1. - Approximate "reference" levels of some elements in leaves, mg / kg dry mass

Element	«Reference Plant» [2]	Regional data [10]
K	19000	14192
Ca	10000	23240
Mn	200	332
Fe	150	181
Zn	50	20
Sr	50	34
Cu	10	18

These features, as mentioned earlier, we can correlate with the biogeochemical features of the Samara region soil cover, in particular, the high Ca enrichment, which changes the availability and accumulation of other elements for plants. Comparison with previously established regional reference values for woody Rosaceae (Fig. 3) confirmed an increase in Ca and Fe accumulation, expressed to varying degrees, but in all introduced plants, and for some species - in Zn and K accumulation.

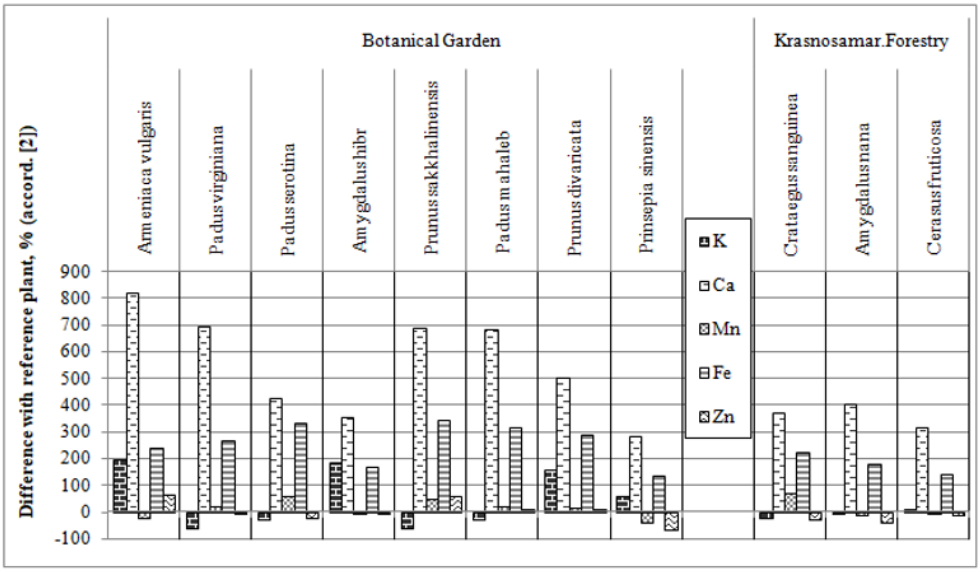


Fig.2. Some features of the ionomic composition of woody Rosaceae leaves in comparison with the "reference plant" according to B. Markert [2]

For this objects group, a slight decrease in the Mn accumulation was found (maximum up to 60%). It is possible that introduced species, under new substrate conditions, activated adaptive reactions of mineral metabolism. For local species, these trends were observed, but less pronounced.

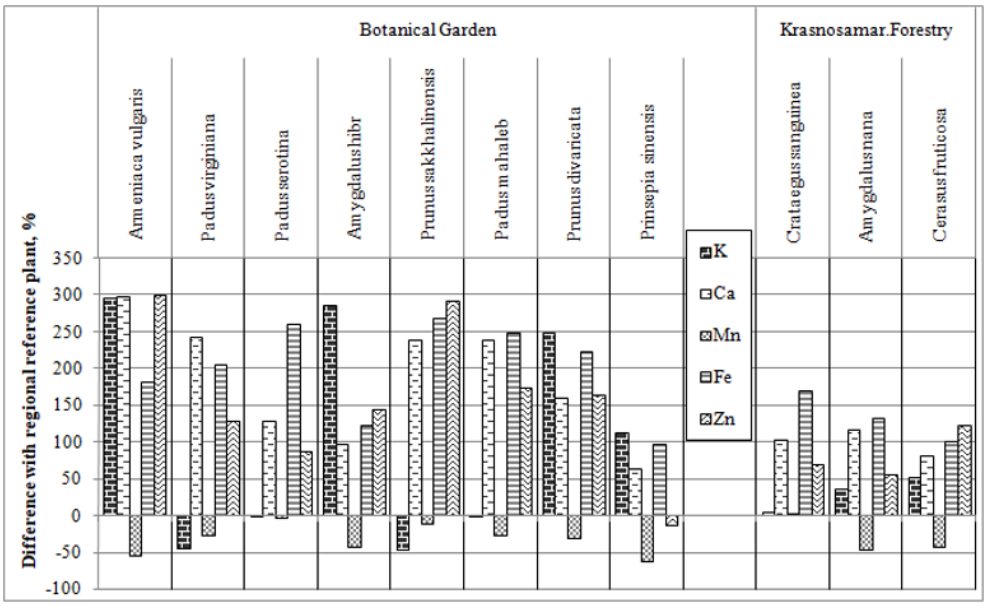


Fig.3. Some features of the leaf ionome of arboreal Rosaceae in comparison with regional reference indicators [10]

4 Conclusions

Thus, the leaves ionom of arboreal Rosaceae (8 introduced and 3 local species) was characterized by indicators fit into to the previously established K, Mn, Fe and Zn concentration range for regionak woody plants, while the content of Ca in the leaves of 5 of the 8 introduced species was significantly above the maximum regional level of this element. The iIntroduced species were characterized by some specificity of the elemental composition, which manifested in higher variation in the concentrations of all the studied elements within a given group of species, whereas native species had a lower level of concentration variability.

A multiple excess of Ca accumulation compared to the Western European level was revealed, to a lesser extent - Fe, K, as well as a slight decrease in Zn accumulation, which is most pronounced in introducers. Compared with the previously established regional reference values for woody Rosaceae, all introduced species showed an increase in the accumulation of Ca and Fe expressed to varying degrees, for some species - Zn and K, as well as a slight decrease in Mn accumulation.

Comparison of the obtained new data with the indicators of two "reference plants" of different geographic location indicates differences in ionomic composition, which in introducers can reflect the actual processes of adaptation to new edaphic conditions, and in local species - to be the result of their evolutionary development.

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