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MORPHOMETRIC ANALYSIS OF *ARABIDOPSIS ARENOSA* (L.) LAW. ON THE WASTE HEAP MAXIMILIÁN IN ŠPANIA DOLINA (STAROHORSKÉ VRCHY MTS.)

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Abstract. The aim of work was to determine of differences in morphometric traits of the model species *Arabidopsis arenosa* (L.) Law. on the heap and neighbour site on the basic of research realized in growing season 2011 on the heap Maximilián in Špania Dolina. We focused on plant height, width of rosette of leaves, width and length of lowest stem leaf, number of seed per one silique, weight of roots and weight of overground parts. The results were subjected of statistical analysis with the assistance of a Student *t*-test, idicators of variability and central values.The results show statistically significant difference at height level of confidence for each of the average of measured traits.The results support the hypothesis about influence of heavy metals on the whole habitus of plant and its evolution.

Key words: *Arabidopsis arenosa*, morphometric analysis, copper waste heap, Špania Dolina, Slovakia

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Introduction

Mine waste heap is the habitat with the specific environmental conditions differing from their environment. It contains elevated to extreme amounts of heavy metals in comparison with natural content in soil unaffected by human activities. That habitats are colonized by plants taxa which can adapt to this conditions by special mechanisms (Banásová 1976). As long ago as Agricola (1494-1555) observed that along ore grow only certain kinds of plant species. Since this point, the research on the impact of heavy metals on the vegetation, flora and physiological processes have been significantly intensified.

The aim of current investigation was to conduct morphometric analysis on *Arabidopsis arenosa* (L.) Law. (Brassicaceae) as one of the typical exponent of the copper heaps. Results of research should indicate specific features which are depended with content of the heavy metals on the heaps.

Material and methods

Field research of *A. arenosa* was realizeted in growing season 2011 on the waste heap Maximilián in Špania Dolina (central part of Slovakia) and neighbour site (near the heap). On both sites we marked 30 individuals by stratified selection. Measures of selected traits we conducted on May, when individuals have fully developed all overground organs. We measured plant height, width of leaves rosette, width and length of lowest leaf on the stem. We also investigated the number of seed per one silique (oldest on the main stem). To determine the dry weight of the overground and underground (roots) biomass we collected and weighed 16 individuals per each site (their number was limited by small population on the neighbour site). The results of calculations were processed through statistical analysis using Student t-test.

The nomenclature of the plant taxa was accepted following Marhold & Hindák (1998).

Floristic-ecological characteristic of the sites

1. Copper waste heap Maximilián in Špania Dolina, Starohorské vrchy Mts., central Slovakia; 653 m a.s.l.; N 48.493141, E 19.075282.

The most occurred species are: *A. arenosa*, *Rumex acetosella* L., *Agrostis stolonifera* L., *Asplenium septentrionale* (L.) Hoffm., *Silene* sp.

Table 1. Central values, variability and result of Student *t*-test for selected measurements on *Arabidopsis arenosa*.

Central values	Leaf length		Leaf width		Plant height		Width of rosette of leaves		Number of seeds per one silique	
	heap	neigh. site	heap	neigh. site	heap	neigh. site	heap	neigh. site	heap	neigh. site
Measurements	30	30	30	30	30	30	30	30	30	30
Average	14.23	49.43	4.6	15.93	10.98	30.58	4.66	10.46	10.67	19.37
Median	12	48.5	4	16	11	29.25	4.15	10.25	9	19
Mode (Modus)	10	38	4	17	11	27	4	9.5	10.5	21
Variance	48.74	127.38	3.35	15.73	7.49	21.2	1.96	5.73	7.47	5.43
Standard deviation	6.98	11.29	1.83	3.97	2.74	4.6	1.4	2.4	2.73	2.33
Coefficient of variation	49.05	22.83	39.78	24.89	24.95	15.06	30.04	22.87	25.63	12.03
t-test (significant level)	0 (99 %)		0 (99 %)		0 (99 %)		0 (99 %)		0 (99 %)	

Table 2. Central values, variability and result of Student *t*-test for weight of roots and overground parts of *Arabidopsis arenosa*.

Central values	Weight of roots (g)		Weight of overground parts (g)	
	heap	neigh. site	heap	neigh. site
Measurements	16	16	16	16
Average	0.12	0.25	0.93	0.74
Median	0.11	0.4	0.88	1.18
Variance	0.003	0.05	0.29	0.51
Standard deviation	0.05	0.23	0.54	0.72
Coefficient of variation	43.24	93.81	57.94	96.9
t-test (significant level)	0 (99 %)		0.026 (95 %)	

The vegetation structure characterized by the prevalence of vascular plants with high content of lichens (e.g. *Lecanora polytropa* (Hoffm.) Rabenh., *Rhizocarpon geographicum* (L.) DC., *Cladonia mitis* Sandst.) and mosses (ASCHENBRENNER *et al.* 2011).

2. Neighbour site Dolný Štúrec, cadaster Staré Hory, Starohorské vrchyMts, central Slovakia; glades above the heap, 949 m a.s.l.; N 48.485329, E 19.085240.

The site are represented by substitutional communities of class *Epilobietea angustifolii* Tüxenet Preising ex von Rochow 1951 with dominance of *Rubus idaeus* L. and relatively abundance of *A. arenosa*.

Results

We reviewed homogeneity and variability of measured traits of *A. arenosa*, which was based on calculated indicators of variability and central values (Tab. 1). These indicators show that individuals of *A. arenosa* from neighbour area were twice or three times bigger than individuals from heap, which had smaller leaves. The plants from neighbour area also had twice more seeds in silique than plants from the heap. As well as the aboveground and underground biomasses were relatively higher in population of neighbour area (Tab. 2). On the base of the values of the coefficient of variation we can confirm relatively higher variability of all features excluding biomass within individuals on heaps. We did not record high values of the coefficient of variation in weight of overground parts and roots of *A. arenosa* from neighbour area. It shows high morphological plasticity of specie on intact habitats. In the stressful conditions which were created by specific habitat features on heap (especially microclimatic, trophic and increased

Table 3. Comparison of selected morphometric features of *Arabidopsis arenosa* from Poland and Slovakia.

Measured attribute	Poland*	Slovakia
	heap Boleslaw	heap Maximilián
Plant height (mm)	125.5±5.6	109.4±27.4
Leaf width (mm)	5.0±0.2	4.6±1.83
Leaf length (mm)	15.8±0.5	14.23±6.98
Number of seeds per one silique	11.9±1.5	10.67±2.73
	NP Kampinos (neigh. site)	Dolný Štúrec (neigh. site)
Plant height (mm)	244.9±13.5	305.8±46.0
Leaf width (mm)	11.7±0.5	15.93±3.97
Leaf length (mm)	35.8±1.1	49.4±11.29
Number of seeds per one silique	22.5±1.8	19.3±2.33

* cited by Przedpelska & Wierzbicka 2007.

Table 4. Content of heavy metals in soil picked from *Arabidopsis arenosa* root system on Maximilián heap.

Element	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	La	Cr
($mg \cdot kg^{-1}$)	0.7	1300.7*	141.9*	510*	1.5	25.2	26.4	813*	15.8	33
Element	As	U	Au	Th	Sr	Cd	Sb	Bi	V	Ba
($mg \cdot kg^{-1}$)	65*	2	<0.1	5.9	106	2.3	114.2	7.8	33	473*

* marks heavy metal excess.

content of heavy metals in the substrate) plants finally showed little difference in production of overground and underground biomasses.

The population of *A. arenosa* from heap Maximilián could be considered as more significantly different (significant differences at $p<0.01$ for each measured morphological traits, except weight of overground parts – significant differences at $p<0.05$) than the population from neighbour area. Nevertheless, individuals from heap are smaller, their leaves are narrower and shorter, as well as they create less number of seeds in silique.

Discussion

Mining dump habitat characterized by very sandy, poor and dry soil, long time dependent upon the direct sun radiation and often winds, with lack of soil nutrients, minimum of water but large content of heavy metals. It is the result of imperfect technology of mining, which is deeply applied, especially on historically older heaps (Banásová 1976). The plants growing in these habitats are more often different from ones growing in natural or semi-natural habitats (Przedpelska & Wierzbicka 2007). Such plants generally marked as tolerant and under the influence of heavy metals are often characterized by high vitality, which resulting from good adaptation mechanisms and ability to eliminate less adaptive species from nutritional competition which sometimes also produce tolerant ecotypes (Lambinon & Auquier 1963; Ernst 1974, Ernst *et al.* 1992).

Similar investigations for *A. arenosa* were conducted by Przedpelska & Wierzbicka (2007) on lead-zinc heap in Boleslaw, Poland. Comparing these results we made the same conclusions, which confirm significant differences in morphometric features between individuals on heap and neighbour site (Tab. 3). Such as Przedpelska & Wierzbicka (2007) we suggest that these attributes are related mainly with the reduction of the evaporation area which is the typical adaptation in xerothermic conditions.

Adaptation of *A. arenosa* to specific

environmental (e.g. xerothermic) conditions depends evidently from its genome plasticity. We suppose that these abilities also have important impact on tolerance to increased content of heavy metals in substrate (Tab. 4). This fact is confirmed in many studies which were realized on other species occurring on mining heaps like *Rumex acetosella, Agrostis capillaris, Deschampsia flexuosa* (L.) Trin., *Silene dioica* (L.) Clairv. (Ernst 1974; Ernst *et al.* 1992; Baker *et al.* 2000; Banásová *et al.* 2006; Przedpelska & Wierzbicka 2007; Čiamporová *et al.* 2009).

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