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MORPHOMETRIC TRAITS OF *PICEA ABIES* L. AND *PINUS SYLVESTRIS* L. ON THE COPPER DUMP-FIELD MAXIMILIÁN IN ŠPANIA DOLINA (STAROHORSKÉ VRCHY MTS., SLOVAKIA)

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Abstract. The main aim of the work was to determine difference in length of needles and annual wood increments of *Pinus sylvestris* L. and *Picea abies* L. on the dump-field and for comparison on referential site. We performed 500 measurements of needles for each tree species and for each study area. The annual wood increments were measured on wood bores from five tree individuals from each species and from both study areas – dump-field and referential site. Student *t*-test and indicators of central values evaluated differences of the measured attributes. The results show statistically significant difference at 99% level of confidence for both attributes – length of needles and annual wood increments. The results support the hypothesis about influence of heavy metals on the plants growing.

Key words: *Picea abies, Pinus sylvestris*, length of needles, annual wood increments, heavy metals, Špania Dolina

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Introduction

Mine waste heap is the habitat with the specific environmental conditions different from their environment. It contains elevated or extreme amounts of heavy metals in comparison with natural content in soil unaffected by human activities. Those habitats are colonized by plants taxa, which can adapt to these conditions by special mechanisms (Banásová 1976). As the heaps are from different time periods, therefore they have developed vegetation in different succession levels. Low cover of vegetation characterizes mine dump-fields, because a species composition is limited by ability of plant adaptation. (Banásová & Hajdúk 2006).

The aim of the current investigation was to deduce morphometric traits of needles and annual wood increments on *Picea abies* L. and *Pinus sylvestris* L. as typical exponents of the copper dump fields. Results of research should indicate specific features, which are depended with content of the heavy metals on the dump-fields.

Material and methods

Field research was realized during growing season 2011 (from June to September) on the copper heap Maximilián and neighbor site (reference site). From arbor species we selected *P. abies* and *P. sylvestris*, because of their domination of arbor flora on heap and reference site. We measured 10 individuals from both selected species. On the each individual we measured 50 needles (10 needles per each of five boughs). We measured two-years or multi-years needles from the middle part of bough. Length of needles was measured from its base to the top. Annual wood increments were measured on the barrel bore from phylum of three. Collection of barrel bore we realized on the 5 individuals from the heap as well as the reference site on *P. abies* and *P. sylvestris*. Annual wood increments were measured by sliding caliper with accuracy of 0.05 mm. On the collect of barrel bore we used increment borer. The results of calculations were statistically processed by Student *t*-test. Basic indicators of variability and middle values were showed graphically by Box and Whiskers plots methods.

Table 1. Central values, variability and results of Student *t*-test for length of needles on *Picea abies* and *Pinus sylvestris*.

Central values	*Picea abies*		*Pinus sylvestris*	
	Heap	Ref. site	Heap	Ref. site
Measurements	500	500	500	500
Average	11.33	19.37	37.2	77.98
Median	11	18	36	76.5
Variance	6.07	15.13	102.37	412.58
Standard deviation	2.46	3.89	10.12	20.31
Coefficient of variation	21.74	20.07	27.2	26.05
t-test (significant level)	0 (99 %)		0 (99 %)	

Table 2. Central values, variability and results of Student *t*-test for the annual wood increments on *Picea abies* and *Pinus sylvestris*.

Central values	*Picea abies*		*Pinus sylvestris*	
	Heap	Ref. site	Heap	Ref. site
Measurements	169	82	137	102
Average	1.69	4.19	2.05	3.61
Median	1.6	4	1.75	3.1
Variance	0.63	1.28	1.56	4.34
Standard deviation	0.8	1.13	1.25	2.08
Coefficient of variation	46.91	26.99	61.06	57.65
t-test (significant level)	0 (99 %)		0 (99 %)	

The nomenclature of the plant taxa was accepted, following MARHOLD & HINDÁK (1998).

Floristic-ecological characteristic of the sites

1. Copper heap Maximilián in Špania Dolina, Starohorské vrchy Mts. is mostly rocky and sandy site, at the top of an emerging initiation vegetation successively passing through the coherent vegetation cover with a high representation of the rocks, about 780 m a.s.l., N 48.483282, E 19.080728.

The lichens growing on the heap belong to the genera: *Rhizocarpon, Cladonia, Cetraria, Lecanora* and *Peltigera*. From the mosses the most frequently genera are: *Dicranum, Hylocomium, Plagiomnium, Pleurozium, Polytrichum, Rhytidiadelphus* and *Thuidium*. The most occurred vascular plants are: *Agrostis capillaris* L., *Arabidopsis arenosa* (L.) Lawalrée, *Acetosella vulgaris* (W.D.J. Koch) Fourr., *Silene dioica* (L.) Clairv., *Picea abies* and *Pinus sylvestris* (ASCHENBRENNER *et al.* 2011).

2. Reference site was the forest over the heap (about 75 meters), 250 meters in length, with well developed undergrowth and the low level of rocks and sandy, about 828 m a.s.l., N 48.483745, E 19.081016.

The most occurred species are: *Picea abies, Pinus sylvestris, Abies alba, Fagus sylvatica* L., *Acer pseudoplatanus* L., *Vaccinium myrtillus* L., *Avenella flexuosa* (L.) Drejer, *Calamagrostis* sp., *Oxalis acetosella* L.

Results

We reviewed homogeneity and variability of length of needles (Tab. 1) and annual wood increments (Tab. 2), which were based on calculated indicators of variability and central

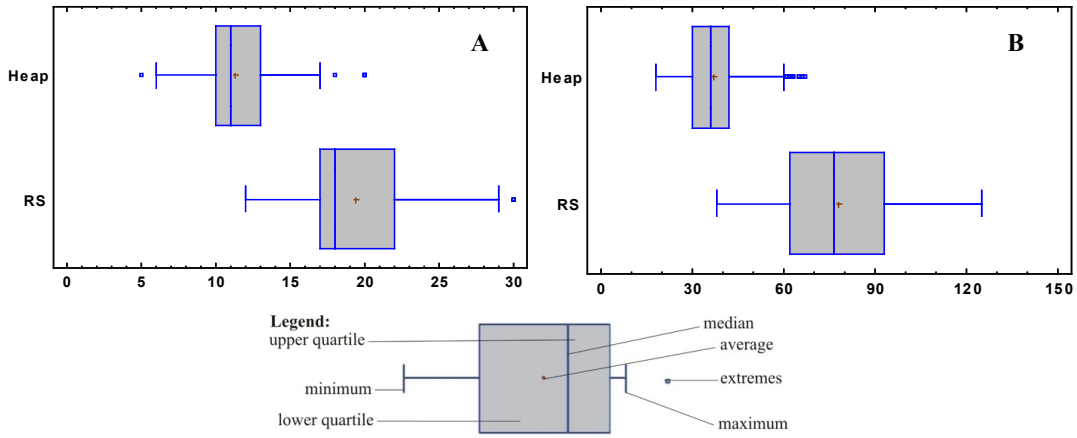

Fig. 1. Graphical comparison of length of the needles from the heap and reference site (**RS**) for the *Picea abies* (**A**) and *Pinus sylvestris* (**B**).

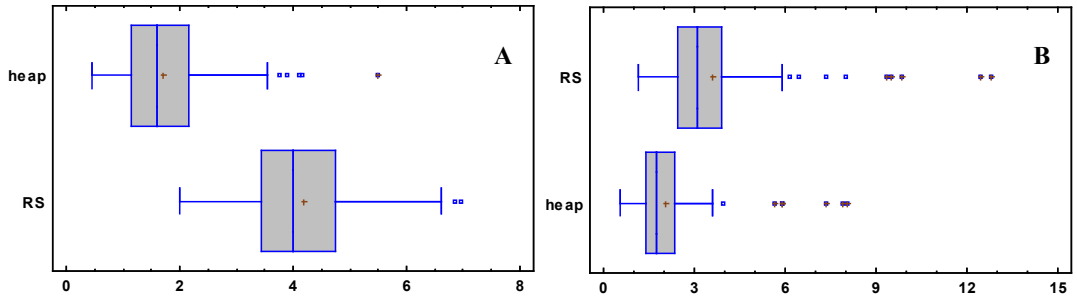

Fig. 2. Graphical comparison of annual wood increments between the heap and reference site (**RS**) for the *Picea abies* (**A**) and *Pinus sylvestris* (**B**). Legend – see Fig. 1.

values. The average length of needles and annual wood increments were significantly higher on the reference site in the case of both species.

Length of the needles

These indicators showed that individuals of *P. sylvestris* from reference site had two times longer needles than individuals from the heap, which had smaller needles; likewise *P. abies* from the reference site had longer needles (nearly two times) than individuals from the dump-fields. On the base of the coefficient of variation we can confirm relatively low variability of the length of needles for both species (Fig. 1). Individuals from the heap had shorter needles, however individuals from reference site had always longer needles. Differences in the length of the needles could be caused by increased content of heavy metals in the substrate of the heap.

Annual wood increments

We recorded relatively increased value of the coefficient of variation in the annual woods increments from the heap (*P. sylvestris* – 61.06; *P. abies* – 46.91) and in the case of *P. sylvestris* from the reference site (57.65). In the case of the *P. abies* from the reference site we did not record relatively high values of the coefficient of variation. Variability of the measured values is showed on Fig. 2. These coefficients of variation confirm increased variability of traits. These differences also could be caused by factors beside the habitats (more rocks, low content of nutrients), increased contents heavy metals in the soil substrate.

Discussion

One of the main characteristics of the mine heap is high content of rocks, particles largest

Fig. 3. Habitus of *Picea abies* (**A**) and *Pinus sylvestris* (**B**) from the copper heap Maximilián.

than 2 cm (up to 80 %) and low content of nutrients. Old medieval mine heaps generally have higher concentration of heavy metals than heaps created in 20th century. This fact can be attributed to advanced technologies of mining and shaping ores (Banasová 1976; Banásová & Hajdúk 2006). Only specific group of species is able to grow in these specific habitats. These plants are more often different from ones growing in natural or semi-natural habitats (Przedpelska & Wierzbicka 2007). The species growing on such specific habitats as mine heaps are often characterized by high vitality, which resulting from good adaptation mechanism and ability to eliminate less adapted species (Lambion & Auquier 1963; Ernst 1974; Ernst *et al.* 1992). Influence of heavy metals on plants could be realized through different actions: necrosis on leaves, dwarfed roots and dwarf looks, dieback and dead organs, the size and shape of leaves (needles), lower thickness of annual wood increments etc (Cannon 1960). Andráš *et al.* (2007) showed, that *P. sylvestris*, as well as the *P. abies*, on copper mine heap Podlipa (Ľubietová village) had significantly smaller needles. It was caused by high level of heavy metals' content (especially Fe) which has a negative impact on the growth of these plants. It was particularly marked also by deformation of top parts of trees up to the stadium called "nest of stork". On the copper mines heaps in Staré hory Banásová (2006) showed shrubby *P. abies*, which shape was caused by low annual wood increments. Such phenomena we also observed in mine heap Maximilián in Špania Dolina (Fig. 3). As a result, we can suggest, that the toxic influence of heavy metals is reflected on the length of the needles and annual wood increments.

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