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Potassium Content in Living Bark, Cambium and Wood in Relation to Electrical Resistance and Tree Condition in the Silver Fir (*Abies alba* Mill.)

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Summary

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The concentrations of potassium were determined in: (a) the last formed wood, (b) the vascular cambial zone with conductive (noncollapsed) phloem, (c) the youngest nonconductive (collapsed) phloem and the (d) oldest nonconductive phloem, by atomic absorption flame spectroscopy in three unaffected and three heavily affected silver fir (*Abies alba* Mill.) trees. The relationship between the electrical resistance (ER) of living tissues and K content was investigated. The tissues of unaffected trees were generally characterized by a higher K content and correspondingly lower ER. In all trees the K content was highest and ER lowest in the vascular cambial zone with conducting phloem, followed by nonconducting phloem and youngest xylem.

Introduction

On some locations in Slovenia silver fir (*Abies alba* Mill.) continues to decline (TORELLI & ČUFAR 1994a, ČUFAR & al. 1994). Different methods were used to monitor tree condition. Among them a bioelectrical method of measuring electrical resistance (ER) of living tissues had some advantages. It proved to be sensitive, objective, nondestructive, and the results were easy to obtain (e.g., TORELLI & ČUFAR 1994b). ER measurements are generally related to tree vigour or its physiological state (e.g., BLANCHARD & al. 1983, TORELLI & KRIŽAJ 1991). In general, adult, healthy and vigorous trees with a wide vascular cambial zone (VCZ) and physiologically active and wide conducting and nonconducting phloem show

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lower ER readings and vice versa, affected or suppressed trees show higher ER readings (TORELLI & KRIŽAJ 1991, OVEN & al. 1995).

The objective of the present study was to determine: (a) the differences in K content of living tissues between unaffected and heavily affected silver fir trees, (b) the relationship between K content and ER readings, (c) the contribution of each tissue contacting the electrodes to ER readings and (d) the relationship between the seasonal variation of ER and K content.

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Materials and Methods

From a selection of 440 adult, 120-200 year old, dominant or codominant silver fir (*Abies alba* Mill.) test trees, continuously observed since 1987, six trees of comparable age were selected according to the visual assessment of tree crowns and ER readings. Three of them were unaffected, the others heavily affected.

At breast height and from the two opposing sides of the stem of each test tree where ER-measuring electrodes were applied, test pieces with outside dimensions of 5 cm trans. and 10 cm ax., consisting of bark, VCZ and 2 to 4 wood annual growth rings, were taken. Sampling dates were February 28, April 25, July 25 , September 19 and December 15, 1994. Determinations of K concentrations were made of the last formed wood, VCZ with conductive phloem, the youngest and the oldest nonconductive phloem. Measurements were performed with a VARIAN AA-5 model atomic absorption flame spectrophotometer using standard techniques.

The ER measurements were carried out with a Conditiometer, a portable kiloohmmeter (Bollmann Elektronik-Systeme, Rielasinger, Germany), and with our own measuring instrument Tree Tester designed in cooperation with Iskra, Measuring Electronics, Slovenia (TORELLI & ČUFAR 1994b).

The statistical methods used were: ANOVA, LSD test, and regression analysis.

Results and Discussion

In all analyzed tissues of unaffected trees, the K content was significantly higher ($p<0.001$) than in corresponding tissues of heavily affected trees (Tab. 1). The K content was highest in the vascular cambial zone and conducting phloem, followed by the nonconducting phloem and the youngest sapwood.

The seasonal variation in K content with a marked increase at the height of the growing season was significant in the cambium and youngest xylem of unaffected trees. The K content increased at the end of April, reached the maximum in July and dropped to a minimum in December. In nonconducting living bark the K concentration varied only slightly in both tree groups. Contrary to healthy trees, in heavily affected ones the seasonal variation in K content was not substantial in any analyzed tissue, probably due to the fact that heavily affected trees showed almost no cambial activity during the growing season.

The horizontal ER of combined bark, cambium, and wood was significantly different between unaffected and heavily affected trees all year around (Fig. 1). ER was lower in unaffected trees then in affected ones regardless of its seasonal variation. Similar results were obtained when comparing the vertical ER readings (Fig. 2).

The K content of analyzed tissues was strongly inversely correlated with the vertical ER of individual tissues ($r=0.76$, $p<0.001$). Those of unaffected trees with higher K concentrations had a correspondingly lower ER and *vice versa*, the tissues of affected trees with lower K concentrations had higher ER readings.

In all test trees, vertical ER was lowest in the VCZ and conducting phloem, where the K content was highest, followed by the nonconducting phloem and the youngest sapwood. Thus the cambial zone and the youngest phloem determine the lower limits of ER. The results are physiologically and anatomically supported, for the path of lowest resistance to an electrical current is believed to be through interstitial fluid of living tissues composed primarily of thin-walled living cells (FENSOM 1966).

Generally, the measured ER depends on the thickness of living tissues penetrated by the measuring electrodes and the ion (mainly K) content. But it should be pointed out that the seasonal variation in ER cannot be affected only by the thickness of living tissues and ion content. This is especially true for heavily affected trees. Many physiological changes, which probably affect the electrical conductive path, happen in living cells when they pass from the active to the dormant state and vice versa, such as changes of cell wall and protoplast properties, quality and quantity of reserve materials. These and other physical changes, such as tissue hydration, osmotic properties, water potential, temperature of conductive path, affect the electrical conductive properties and they most likely play an important role in seasonal ER variation.

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Tab. 1. Mean total concentrations of K in µg/g oven-dry tissue of: the youngest xylem (Xy), cambial zone + conducting phloem (CZ+ CPh), the youngest nonconducting phloem (NCPh1), and the oldest living bark immediately below the periderm (NCPh2) of three unaffected and three heavily affected test trees for 5 sampling dates. Averages are based on 6 measurements.

tissue:	Xy		CZ+CPh		NCPh1		NCPh2	
date	K (µg/g)	SD	K (µg/g)	SD	K (µg/g)	SD	K (µg/g)	SD
unaffected								
28.2.	951	106	9018	998	3747	998	1116	148
25.4.	2794	274	10056	953	4564	756	1613	178
25.7.	4967	1057	13319	1449	4779	605	1774	215
19.9.	1771	315	10112	949	4280	579	1899	288
15.12.	965	246	7866	842	4116	915	1486	257
affected								
28.2.	776	92	4479	399	1386	432	561	79
25.4.	799	104	4632	299	1655	146	595	71
25.7.	914	64	5130	722	1666	219	580	103
19.9.	534	102	3957	1107.	1254	468	561	162
15.12.	533	78	3485	704	1156	223	449	104

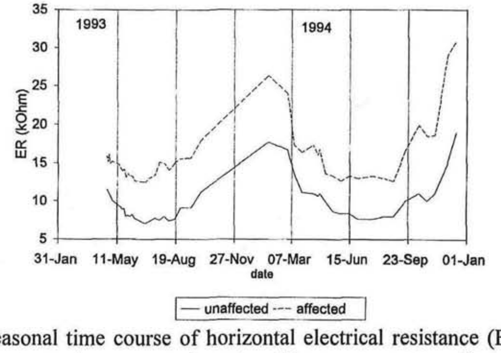

Fig. 1. Seasonal time course of horizontal electrical resistance (ER) in three unaffected and three affected test trees. Averages are based on 12 measurements performed with Conditiometer.

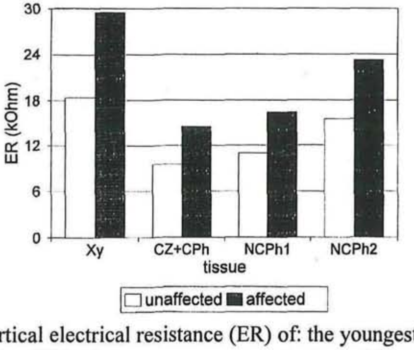

Fig. 2. Mean vertical electrical resistance (ER) of: the youngest xylem (Xy), cambial zone + conducting phloem (CZ+ CPh), the youngest nonconducting phloem (NCPh1), and the oldest living bark immediately below the periderm (NCPh2) of three unaffected and three affected test trees. Averages are based on 30 ER measurements performed with Tree tester.