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Bioelectrical Characterization of Tree Conditions and Slime Cells in the Bark as Possible Symptoms of Silver Fir Decline

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Summary

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The condition of silver fir (*Abies alba* Mill.) trees was monitored 1988-1994 by measuring electrical resistance of living tissues at breast height. High mortality and a tendency towards worsening tree conditions has been observed. It has been shown that occurrence of slime cells and traumatic resin canals cannot be interpreted as a symptom of silver fir decline.

Introduction

Slovenia is in those regions showing severe silver fir (*Abies alba* Mill.) decline (TORELLI & ČUFAR 1994, ČUFAR & al. 1994). To determine the tree condition the symptoms of crown decline are usually observed (TORELLI & al. 1986), although they are subjective and difficult to apply in natural forest stands from beneath the crown. We searched for a method to objectively determine and monitor tree vigour and condition; the one based on electrical resistance (ER) proved to be promising.

In few heavily affected silver firs FINK & BRAUN 1978 observed numerous slime cells in the nonconducting phloem and traumatic resin canals in the xylem "without noticing any mechanical injury or pathogene releasing factor". This led to the formulation of a virus hypothesis.

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The objective of this paper is (a) to report on monitoring tree conditions by measuring electrical resistance and (b) to investigate the occurrence of slime cells in bark and traumatic resin canals in wood as possible symptoms of silver fir decline.

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Materials and Methods

In two representative silver fir-beech forests, Bistra and Ravnik, in the Slovenian Karst 440 trees were selected in 1987 for long term observations.

The electrical resistance was measured between 1988 and 1995. To this a portable ohmmeter - Conditiometer (Bollmann Elektronik Systeme, Rielasingen, FRG), fitted with a No. 2E Delmhorst moisture detector electrode, was used. ER was measured at breast height. Pins oriented one above the other were pushed through the bark perpendicularly to the tree axis, penetrating living bark and the vascular cambial zone, stopping at the recent latewood. By inserting the electrodes through bark and cambial zone, membranes of living cells are disrupted allowing release of monovalent mobile ions, predominantly potassium, into the apoplastic solution (BLANCHARD & al. 1983). The measurements were taken several times during the growing period.

Blocks containing wood, cambium, and bark were excised at breast height in 57 living trees. Fixed samples were mycrotomed, cross-sections stained with safranin and fast green and the number of slime cells in the nonconducting phloem as well as the occurrence of the traumatic resin canals in the xylem determined.

Results and Discussion

In unaffected, mature, dominant or codominant trees the ER below 10 kOhm at the height of the growing season indicated the maximal width of the cambium zone and the maximum number of ruptured live cells. The trees with ER 10 - 13 kOhm were intermediate in this respect, and those with an ER above 13 kOhm revealing irreversible damage (TORELLI & al. 1990).

The bioelectrical characterization of silver fir in two typical forest stands of Bistra and Ravnik had shown a tendency towards worsening tree conditions. In 1988 the percentage of apparently healthy trees with an ER below 10 kOhm was 32% in Bistra and 47% in Ravnik. In 1994 the comparable values were 28% and 35% resp. By 1994, 25% of all test trees in Bistra and 17% in Ravnik had died and had been removed.

The ER values varied with the season and were lowest at the height of the growing season (Fig. 2). Unaffected and unsuppressed mature trees generally showed lowest ER values with most consistent seasonal variations. These were less pronounced than those in younger healthy, unsuppressed trees with a vascular cambium zone of comparable thickness but with substantially thinner living bark. In declining trees, the ER was generally higher due to a thinner vascular cambial zone (OVEN & al. 1995) and lower concentration of ions (KRIŽAJ & ŠTUPAR 1996). Preliminary analyses of K concentration in outer sapwood, vascular cambial zone, inner and outer living bark of an unaffected and affected silver fir, proved the highly significant relationship between the concentration of soluble K+ ions and ER. It should be pointed out that the concentration of soluble K+ ions was always lower in affected silver firs than in unaffected ones. Generally, seasonal variations in ER are a consequence of the variable thickness of the vascular cambium zone, and possibly variations in ion concentrations.

The wounds caused by the needless were small (1 - 2 mm) and were effectively compartmentalized in a short time as follows: (1) living bark responded with the formation of wound periderm via the formation of a ligno-suberized layer (OVEN & TORELLI 1994); (2) injured cambium responded by the formation of barrier zone consisting of undifferentiated tracheids, traumatic parenchyma and traumatic resin canals. (3) The small hole in the current xylem increment was occupied by the proliferated ray parenchyma.

The method could be considered to be nondestructive and well suitable for long-term monitoring tree condition in polluted areas or tree suppression intensity in forest undergoing competition (e.g. ROBIČ 1994).

Slime cells developed from marginal parenchyma cells of phloem rays almost exclusively in nonconducting phloem. They were found in the bark of 38 trees, irrespective of the tree condition as determined with ER and increment analyses. Traumatic resin canals were found only in xylem of 6 trees, regardless their condition. The relations between the number of slime cells and (a) the width of the last growth ring, (b) visually assessed tree conditions, and (c) ER, were not statistically significant. This indicates that occurrence of slime cells and traumatic resin canals cannot be interpreted as a symptom of silver fir, but might occur due to mechanical wounding (TORELLI & al. 1992).

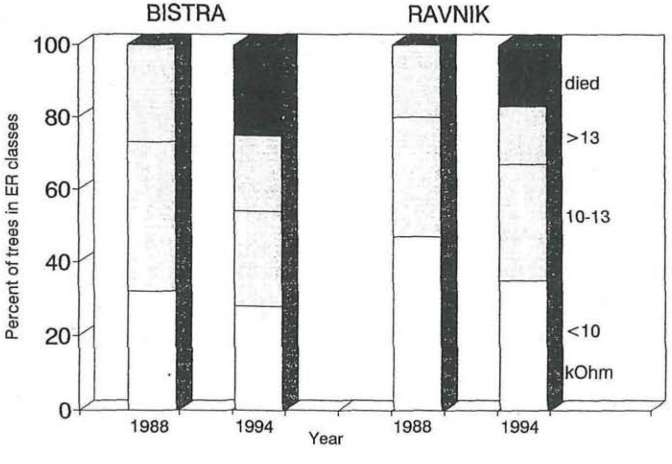

Fig. 1. Proportions of apparently healthy (ER below 10 kOhm), intermediate (ER 10 - 13 kOhm), declining (ER above 13 kOhm), and dead trees in the forest stands of Bistra and Ravnik in 1988 and 1994.

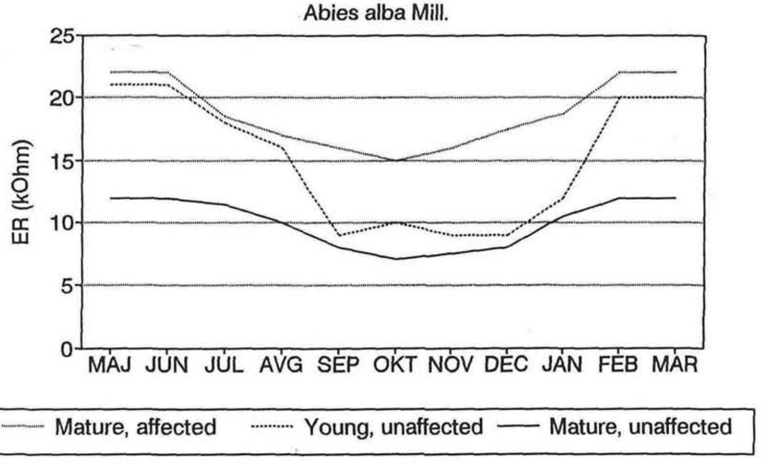

Fig. 2. Seasonal variation of ER in (a) mature, unaffected and unsuppressed trees, (b) mature, affected trees and (c) younger, unaffected and unsuppressed trees.

References

BLANCHARD R.O., SHORTLE W.C. & DAVIS W. 1983. Mechanism relating cambial electrical resistance to periodic growth rate of balsam fir. - Canadian Journal of Forest Research 13: 472-480.

ČUFAR K., LEVANIČ T. & TORELLI N. 1994. Growth characteristics of silver fir from three test plots in Slovenia. Ecology and silviculture of European silver fir. - IUFRO WP: S 1.01 - 08, Altenstieg, Germany: 331-335.

FINK S. & BRAUN H.J. 1978. Zur epidemischen Erkrankung der Weißtanne *Abies alba* Mill. I. Untersuchungen zur Symptomatik und Formulierung einer Virose-Hypothese. - Allgemeine Forst- und Jagdzeitung 149: 145-150.

KRIŽAJ B. & ŠTUPAR J. 1996. Potassium content in living bark, cambium and wood in relation to electrical resistance and tree condition in the Silver fir (*Abies alba* Mill.). - Phyton 36 (3): 39-42.

OVEN P. & TORELLI N. 1994. Wound response of the bark in healthy and declining silver firs (*Abies alba*). - IAWA Journal 15:407-415.

--, -- & ZUPANČIČ M. 1995. Anatomy of cambial zone and living bark as related to electrical resistance readings in healthy and affected silver fir (*Abies alba* Mill.). - Acta Pharmaceutica 2, suppl. I: 375-377.

ROBIČ D. 1994. Determination of the coenotic status by measuring the electrical resistance of living tissues. Ecology and silviculture of European silver fir. - IUFRO WP: S1.01 - 08, Altenstieg, Germany: 336-338.

TORELLI N. & ČUFAR K. 1994. Investigations of the response of the silver fir to air-pollution and mechanical injuries in Slovenia. Ecology and silviculture of European silver fir. - IUFRO WP: S1.01 - 08, Altenstieg, Germany. 316- 326.

--, -- & ROBIČ D. 1986. Some xylotomical, physiological and silvicultural aspects of silver fir dieback in Slovenia (NW Yugoslavia). - IAWA Bulletin n.s. 7: 343-350.

--, OVEN P., ZUPANČIČ M., KRIŽAJ B. & ČUFAR K. 1992. Schleimzellen in der Rinde und traumatische Harzkanale sterbender Tannen. - Holz als Roh- und Werkstoff 50: 180.