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Spatially Resolved Plant Physiological Analysis Using LA-HR-ICP-MS

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Investigations of elemental distribution in trees are interesting in plant physiological and environmental research. Seasonal element variations within single tree rings would provide important information on metabolism studies but they have not been accessible so far. Thus, a direct micro-analytical method involving laser ablation (LA) coupled to high-resolution double-focusing magnetic sector field inductively coupled plasma mass spectrometry (HR-ICP-MS) was developed. Particularly challenging aspects in method development were the high background levels of certain elements and the lack of appropriate calibration standards.[1,2]

Seasonal element profiles of macronutrients in Norway spruce trees from different sampling sites, altitudes and environmental conditions could be established for the first time. The method allows the measurement of low concentrations even in narrow year rings. Table 1 shows typical element concentrations. Table 2 presents wood density and seasonal profiles of sulphur, phosphorus and potassium in a tree in Düdingen (CH). Depending on the tree ring width, the number of laser spots per ring varied between four and eight. For discussion purposes, each ring was divided in four distinct zones commonly used in dendrology: early earlywood (EEW), late earlywood (LEW), early latewood (ELW) and late latewood (LLW).

Elements	Literature Values [mg/kg]				Frieswil 46° 58' 60" N, 7° 16' 0" O	Düdingen 46° 51' 0" N, 7° 12' 0" O	St. Moritz 46° 29' 40" N, 9° 50' 45" O
	Average	Median	Min	Max			
S	344	79	56	896	24–80	34–72	50–93
P	31	38	9.2	47			
K	810	390	15	2570	269–566	169–430	266–884
Ca	855	809	100	1800	458–1406	433–1085	622–957
Mg	113	113	95	131	253–357	98–356	237–578
Mn	159	65	32	566	88–386	47–248	
Zn	18	12	6.4	48	5–17	2–18	6–12

Table 1. Typical element content in Norway spruce stem-wood [mg/kg]. Background picture: Norway spruce.

The sulphur profile displayed seasonal variations with decreasing contents in LEW and ELW, which leads to the assumption that stem sulphur is used for seasonal growth. When accrescence stops in autumn, sulphur reserves are stored in preparation for next year's growth. Nabais *et al.* support this seasonal hypothesis, since methionine in tree sap was found to increase in March until July and decrease in August.[3]

A seasonal pattern was also found for phosphorus. This contradicts the hypothesis of a constant supply by mycorrhizal fungi and implies that reserves are stored towards the end of growing season for use the following spring. The linear relationship between P and S underlines a strong biochemical coupling of both elements.

Other macronutrients like potassium show different profiles. K is of particular importance in needles and probably mostly needed during the growing season, which explains the decrease from EEW to LEW and a higher accumulation in LLW. These seasonal profiles reveal new aspects of Norway spruce metabolism.

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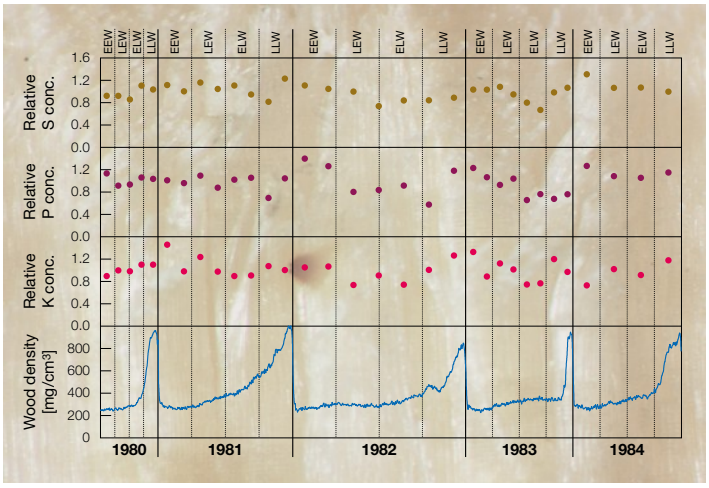

Table 2. Seasonal sulphur, phosphorus and potassium profiles and wood density in single tree rings of a Norway spruce tree in Düdingen. Background picture: Laser spot in wood with a typical spot size of about 100 µm.

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