COMPARATIVE TIME-COURSE MINERAL CONTENT STUDY BETWEEN HEALTHY AND DISEASED PICEA TREES FROM POLLUTED AREAS

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Abstract. In connection with our previous biochemical comparative study on healthy and diseased Picea trees from polluted areas we have now measured the nutrient contents in the same needle samples. 540 small samples were processed in a very short time (25 min for each sample) using microwave digestion in HNO₃. Al, Ba, Ca, Cu, Fe, K, Mg, Mn, Sr, and Zn were then simultaneously determined by ICP-AES analysis. This rapid and simple micromethod is briefly described and results of the comparison between healthy and diseased Picea trees are presented and discussed in the light of our previous results, particularly that of putrescine and polyamines which have been reported to accumulate in response to cell mineral deficiencies.

1. Introduction

SO₂, NOₓ, CO₂, NH₃, O₃, are the major atmospheric pollutants resulting from human activity. They are discharged into the atmosphere from sources such as smelters, commercial and industrial power plants, private houses, incinerators and from certain chemical processes. A major source is the transportation industry. These compounds will react in the atmosphere with water vapor to form dilute solutions of strong mineral acids which are thereafter incorporated into clouds. All acidic aerosols are, ultimately, rained down from the atmosphere, and may release metals from sediments and soil, increasing their geochemical mobility (Fontan and Servan, 1973).

The negative impact of industrial pollution on vegetation is now a well documented and recognized phenomenon (Rennenberg, 1984; Schütt and Cowling, 1985). In the case of forest decline, the diversity of pollutants seems to be more important than their concentration (Miller, 1986). This could be due to their interaction, multiplying in this way their action by a synergistic effect (Ziegler, 1986).

Over the past few years, acid rains became a significant environmental problem. The deleterious effects of acid rain to soil, vegetation, aquatic life and also to stones, monuments and buildings are of wide concern (Acidification today and tomorrow, 1982), and damage to plants by gaseous pollutants and acid rains has received widespread public attention during the last few years in connection with forest decline (Hinrichsen, 1986).

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The role of nutrition has been involved in forest decline processes, due to acid rain leaching out ions both in the soil and in the leaves/needles (Nilhgard, 1986; Mengel et al., 1986).

We have recently carried out a time-course biochemical comparative study of cell metabolite contents in needles of healthy and diseased *Picea* trees living in the polluted area of the Donon range (Vosges, France). Clear differences in the content of the various metabolites studied, according to the physiopathological state of the tree, were demonstrated (Villanueva et al., 1987; Villanueva and Santerre, 1988, 1989).

We present our results concerning a mineral content study carried out on the same samples, in order to check possible correlations between deficiencies or excesses of nutrients and differences in cell metabolite levels – particularly putrescine and polyamines – caused by the biochemical action of the atmospheric pollution on forest trees.

2. Materials and Methods

2.1. Sampling

A detailed description of sampling material has already been given, as the samples used here were those collected for our previous work (Villanueva and Santerre, 1989). Briefly, thirty young *Picea* trees selected in the polluted area of the Donon range (Vosges, France) were, according to their apparent physiological state (yellowing and needles loss), grouped into three classes; ten healthy trees, ten diseased trees and ten very diseased trees.

Seven times from March to August, needles from the third whorl were randomly collected on each of the 30 trees and immediately frozen in dry ice for transport to the laboratory. Needles of three different ages were collected: two yr old and 1 yr old needles were collected seven times, and needles of the year were only available during the four last samplings.

2.2. Sample Preparation

Before mineralization, needles were powdered and let dry in a dessicator (on KOH) to constant weight.

Considering the large number of samples to prepare, and the small quantities of material for each sample, mineralization was performed by concentrated HNO₃ digestion (Santerre et al., 1990a) in a microwave apparatus (Microdigest 300, Prolabo, France): 50 mg of dry needle power was digested in 4 mL of HNO₃ (15 min. at 20% of maximum Microdigest 300 power), the liquid residue was transferred and adjusted to 10 mL with de-ionized water. ICP-AES analysis (Mermet et al., 1988) was then performed directly without dilution. Calibration was achieved with an ICP multi-element standard solution of 19 elements (Merck), to which known amounts of NaNO₃, KNO₃, Ca(NO₃)₂, had been added to complete it with all the