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Investigation of Physiological Responses in Norway Spruce Needles to Natural and Anthropogenic Factors

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Summary

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Among the various stress indicators for early identification of Norway spruce (*Picea abies* (L.) Karsten) decline, sulphur content, photosynthetic pigment content, activity of the enzyme peroxidase, content of water-soluble thiols and ascorbic acid were analysed in four age classes of spruce needles sampled from five trees. Ten sampling sites were selected according to the degree of forest decline, site conditions and air pollution from the Šoštanj Thermal Power Plant.

Introduction

The most acceptable theory about the causes of forest decline is the theory of multiple stress (COWLING 1989). Vegetation in the field is exposed to different stress conditions such as temperature extremes, drought, lack of mineral nutrients in the soil, and the pollution of air and soil.

Such growing conditions enhance the development of several stress responses in plants which are partly of a common nature and partly specific to

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stress in action. Oxidative stress is a part of several stress impacts in which plants react with an increase in the level of activity of the antioxidant scavenging system, with an increase in water-soluble thiols, ascorbic acid and increased activity of several enzymes, eg. peroxidase, as one of the general stress response mechanisms (BERMANDINGER-STABENTHEINER 1995).

The content of total sulphur in spruce needles was analysed as an indicator of sulphur pollution and represents biomonitoring of sulphur pollution related to the operation of thermal power plants and other sources of air pollution with sulphur compounds. Chlorophyll content was measured as a non-specific indicator of the general plant condition (TAUSZ & GRILL 1995).

Material and Methods

Sampling sites were based on an altitude gradient above sea level. They included Zavodnje (760m), Veliki vrh (570m), Kope (1400m), Brneško sedlo (1030m), Graška gora (730m), Topolščica (400m), Lajše (400m), Laze (460m), Kramarica (1070m) and Smrekovec (1550m). Five apparently healthy spruce trees, about 80 years old, were selected for sampling in early September 1993. Branches with needles were cut from the seventh whorl counted from the top of the crown and let stand during the night covered with a dark piece of polyethylene. The following day, current, one, two and three year old needles were cut off and quickly frozen in liquid nitrogen. They were then lyophilised, ground into powder and stored in a deep-freeze (–20°C). Photosynthetic pigments were determined by HPLC according to the procedure of PFEIFHOFER 1989. Ascorbic acid was also determined by HPLC procedure using the method of BUI-NGUYEN 1980 and WIMANLASIRI & WILLS 1983. Water-soluble thiols and enzyme peroxidase were analysed spectrophotometrically according to GRILL & ESTERBAUER 1973. Total sulphur was determined by Sulmhomat AD 12 aparature, at the Slovenian Forestry Institute.

Results and Discussion

Only the results of ascorbic acid and thiols content analysis are presented in the article. These biochemical markers were chosen as bioindicators of stress impact of Norway spruce caused by sulphur air pollution and natural stresses. Total sulphur content in needles was high in all sampling sites, the highest value was determined in needles from the sampling site at Zavodnje. Sulphur content decreased with distances from TEŠ and with increasing altitude. Age pattern of photosynthetic pigments in analysed needles showed a typical disturbed pathway in very polluted sites, e.g. a strong decrease in content of pigments in second and third age class of needles. That is consistent with the results from previous investigations (BATIČ & al. 1995).

The highest amount of ascorbic acid (Fig1.) was determined in needles from Kramarice (1070m) and Smrekovec (1555m) at high altitude, but also in those needles from the most polluted site, Zavodnje. The lowest value was determined in needles from sites in lower altitudes, which are also heavily polluted. As ascorbic acid usually decreases with sulphurous pollution impact and increases with high altitude stress conditions, our results are in agreement with

findings of already cited authors. The results of water-soluble thiols content analysis (Fig. 2.) are consistent with the prevailing stress condition on sampling sites. Generally, the content of thiols increases with the altitude of the sampling site but there is also a slight increase in their content in a very polluted low altitude site, Veliki vrh.

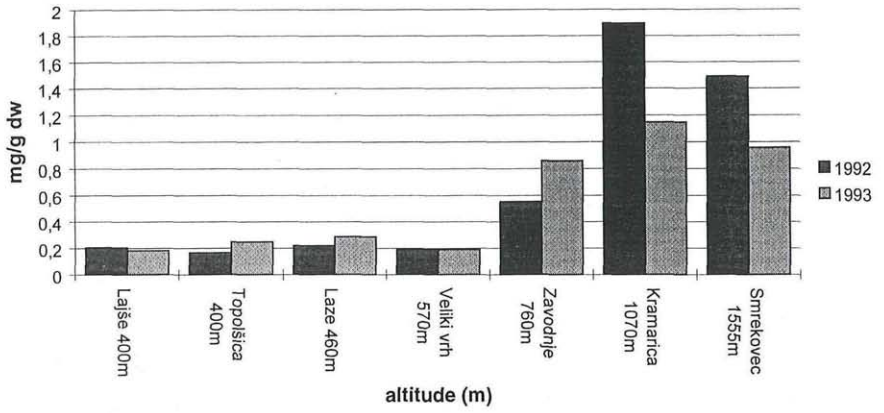

Fig. 1. Ascorbic acid content in two needle age classes of Norway spruce needles (*Picea abies* /L./ Karst.) sampled in a profile over Šaleška valley in autumn 1993.

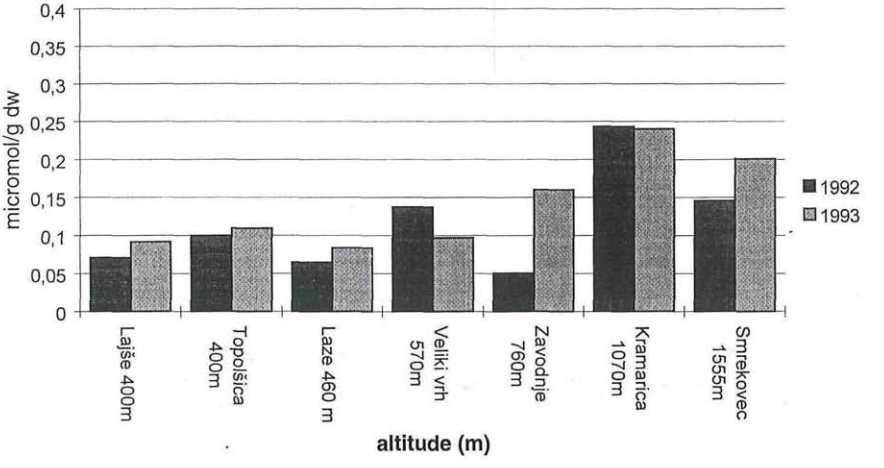

Fig. 2. Water soluble thiols content in two age classes of Norway spruce needles (Picea abies /L./ Karst.) sampled in a profile over Šaleška valley in autumn 1993.

According to the results of the investigated biochemical parameters, it can be concluded that there are various signs of metabolic disturbances in Norway spruce needles sampled from sites with different growing conditions (altitude, air pollution). Some of them can be clearly regarded as consequences of sulphur dioxide (high sulphur content, changed age pattern of pigment content, low level of ascorbic acid), and photooxidants impact (increase of ascorbic acid and thiols, decrease in the chlorophylls/carotenoides ratio).

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