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Studies on the Effects of Radio-Frequency Fields on Conifers

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Introduction

Apart from the steadily increasing presence of electromagnetic fields at various frequencies and concerns about their possible biological effects, so far only few studies have been performed in plants. However, conifers are possibly rather good candidates for such interactions since their leaves (needles), or the whole plant are oriented more or less one-dimensionally. In addition, the plants or their needles are surrounded by isolating material (air, wax), so that such biological structures may in fact work as antennas at technically relevant resonance frequencies (Fig. 1).

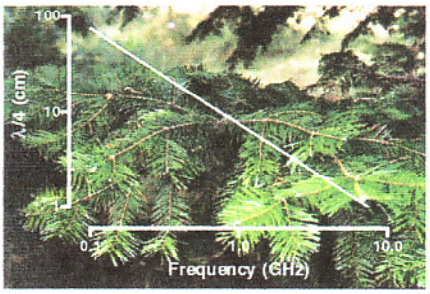

Fig.1: Resonance frequencies of conifer needles. The picture shows branches and needles of *Abies grandis*.

The aim of the present investigation was therefore to study the effects of long-term exposure of three representative conifers to electromagnetic fields (EMF) at 383 MHz.

Material and Methods

One year old seedlings of three species were obtained from a local dealer: Japanese dwarf pine (*Pinus pumila*, n= 182), European silver fir (*Abies alba*, n = 170), and grand fir (*Abies grandis*, n = 99). After randomization, plants were divided into exposed and sham-exposed ones. Plants were watered whenever necessary.

Two identical waveguide systems were used which provided uniform and linearly polarized fields with the electrical vector being parallel to the plants' vertical axes. The segments of the units were made of metal mesh allowing the penetration of both gas and light (approx. 3000 lux at the level of the plants; see also poster p-64). A pulsed signal corresponding to the TETRA standard at 383 MHz and a total power of 50 W was used; exposure was 24 hr/ day except for periods of measurements.
The study was performed in a shelter within Münster, Germany, and started in October 1999.

During the experiment temperature inside the shelter rose from approx. 10 °C to 22°C at the time when the experiment was finished (May 2000). Illumination periods were adjusted according to the seasonal fluctuations.

Plants heights were measured with an electronic caliper (accuracy < 0.1 mm). Chlorophyll content and relative proportions (Chl a/b) were estimated spectrophotometrically. Due to the limited number of needles, this was not done in *Abies alba*. At the end of exposure, all plants were inspected visually, and any abnormalities (e.g., discolouration of leaves) were noted.

Results

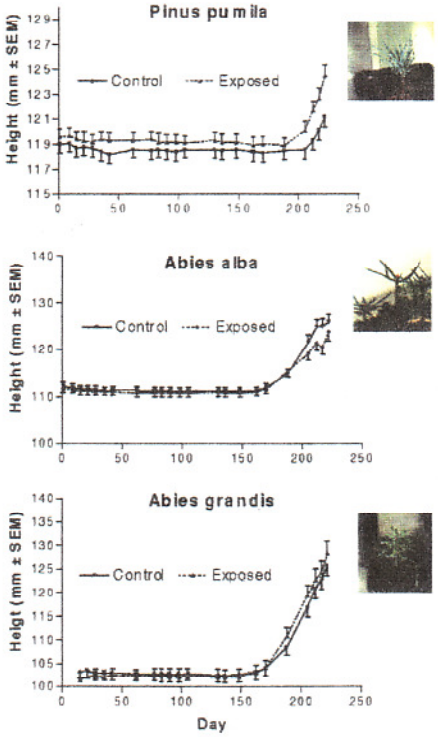

Fig. 2: Growth of all plants during the exposure for 222 days. Means ± SEM.

The three conifer species grew with considerably different rates during the experiment, as could be expected. *Pinus pumila* reacted to exposure with a slightly enhanced growth rate and a reduced chlorophyll a/b ratio (Table 1 and 2, Fig. 2). The numbers of dead plants at the end of the experiment was increased in all three species (Table 3).

Table 1: Relative growth rates of the three conifer species after 222 days of exposure, compared to 100% = mean height at the start of the experiment. *, p<0.05 vs. Control. Means ± SEM.

Species	Control	Exposed
Pinus pumila	101.9% ± 0.7%	104.1% * ± 0.7%
Abies alba	112.1% ± 1.6%	111.0% ± 1.8%
Abies grandis	121.6% ± 2.1%	126.3% ± 2.5%

Table 2: Chlorophyll ratios (Chl a/b) of exposed needles of *Pinus pumila* and *Abies grandis*. *, p<0.05. Means ± SEM.

Species	Control	Exposed
Pinus pumila N = 6 / 7	3.04 ± 0.09	2.81 ± 0.02 *
Abies grandis N = 10 / 11	2.86 ± 0.03	2.81 ± 0.04

Table 3: Numbers of dead plants after exposure for 222 days. *, p<0.05 (χ^2-test)

Species	Control	Exposed
Pinus pumila	6.0 %	20.4% *
Abies alba	17.9%	38.4% *
Abies grandis	6.7%	16.3% *

Discussion

Despite marginally altered growth due to exposure, the physiology of exposed conifers seems to be negatively influenced by exposure to EMF at 383 MHz, causing a decline in the photosynthetic system which may be the first indication of a decline in the plant's overall status.

It is interesting to note that the most prominent effects were seen in *Pinus pumila*. In young plants of this species, needles are more vertically oriented, as compared to the two other species investigated here. It may therefore be possible that the electric component of the EMF is responsible for the observed effects.

Acknowledgements

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