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UPTAKE OF NO_X IN SCOTS PINE

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Information on input of acidifying compounds like SO_2 and NO_X is necessary to understand effects of acidification. The uptake of NO and NO_2respectively was studied on seedlings and shoots of Scots pine. Experiments were conducted both in laboratory (NO and NO_2 respectively) and in the field (NO_2) under light and dark conditions. In all three cases there was a linear relationship between the uptake rate and the NO_X-concentration. The uptake follows a diurnal pattern i.e. the uptake rate was strongly correlated with the stomatal movements. Uptake rates were converted to deposition rate and the results showed that field exposure with NO_2 gave the highest deposition rate.

INTRODUCTION

Among environmental problems in Scandinavia today acid precipitation is regarded one of the most serious. In Sweden the National Board of Environmental Protection has put 15 million Swedish Crowns, in a five-year-period, into research to study effects of acid precipitation in water systems and terrestrial systems.

In our group at the Swedish Water and Air Pollution Research Institute we started to study deposition of NO_2 in 1977.

Today the total antropogenic emissions of sulphur and nitrogen oxides in Europe are fairly equal on a molar basis. However, while emissions of sulphur oxides have remained more or less constant during the seventies, the emissions of NO_X have been increasing. In the OECD countries a 50 % increase in NO_X emissions has been estimated for the period between 1972 and 1985[1]. Since the main oxidation product from NO_X is nitric acid, a strong acid, this implies that it is necessary to include NO_X in our investigations on acid deposition.

It is of great importance to know the input of acidifying compounds to different ecosystems like forests. We need this information to be able to understand the effects of acidification. These effects might include effects on tree growth. Therefore, in the future it will be of particular importance to improve knowledge on long-term effects of low doses over large areas.

[1] The Long Range Transport on Photochemical oxidants; Report from a planning conference on future research cooperation, Oslo, 1214 Sept. 1978.

MATERIAL AND METHODS

Measurements of NO_X-uptake were carried out in the laboratory and in the field. In both cases "perspex" chambers with enclosed seedlings and shoots were used. NO_X-uptake, transpiration and photosynthesis were measured semi-continuously.

In the two *laboratory* experiments 1-year-old seedlings of Scots pine (cultivated according to ANDERSSON et al. 1977) were exposed to five concentrations of NO_2 (100 to 600 μ g · m^{-3}) and four concentrations of NO (125 to 550 μg · m^{-3}). Each experiment lasted for about one week. Three repetitions were made both with NO_2 and NO, i.e. all uptake and deposition figures given represent the mean of six seedlings. The loss of NO_2 and NO in the systems was determined; less than 1 % was lost.

The *field* experiment was performed during August and September 1979 at Jädraås (lat. N 60° 48' and long. E 16° 30', altitude 180 m), which is the field site of the Swedish Coniferous Forest Project. (For a description of the gas exchange system see LINDER et al. 1980.)

One shoot of current needles (on the third whorl) from two 18-year-old pine trees were exposed to three concentrations of NO_2; 50, 125 and 225 μ g · m^{-3}. About 1 % of the NO_2 was lost in the systems e. g. due to reactions with the chamber walls, but there are no indications in the results of losses due to photolysis of NO_2.

RESULTS AND DISCUSSION

The NO_2- and NO-uptake in light from laboratory measurements and the NO_2-uptake in field measurements are summarized in Figure 1. In all three cases there was a linear relationship between the uptake rate and the NO_X-concentration. This gives support to what have been found by others (HILL 1971, ROGERS et al. 1977). In contrast with those experiments, however, the present investigation, especially the field experiment, describes long-term exposures. In Figure 1 uptake of NO_2 in the field from only one of the chambers is presented. For the other shoot there was a tendency of a reduced capacity for NO_2-uptake at the end of the exposure (i.e. when the highest NO_2-concentration was used). The effect appeared as an internal resistance in the needles against NO_2-uptake and might be due to an "exhaustion" of the NO_2 metabolic pathways. The effect will be investigated in more detail. The NO_2-uptake in the laboratory measurements was three times higher than the uptake of NO but it was less than one third of the NO_2-uptake during field conditions. Compared with the NO_2-uptake the uptake rate of NO was surprisingly high. For alfalfa the NO_2-uptake was 10 to 15 times higher than for NO (HILL 1971). One explanation might be differences between species.

The difference in the NO_2-uptake between laboratory and field conditions is probably partly due to the lower light intensities achieved in the laboratory leading to a reduction in stomatal opening. There might also be differences between the two types of plant material used.

The results show that the uptake follows a diurnal pattern. This means that, although the NO_2-concentration of the incoming air was fairly constant, the uptake rate due to a reduction in stomatal opening was reduced with about 85 % during the nights.

One typical example, from the field measurements, of diurnal changes in stomatal conductance for CO_2 is shown in Figure 2. The figure also shows that there was a linear relationship between the stomatal conductance for NO_2 and the stomatal conductance

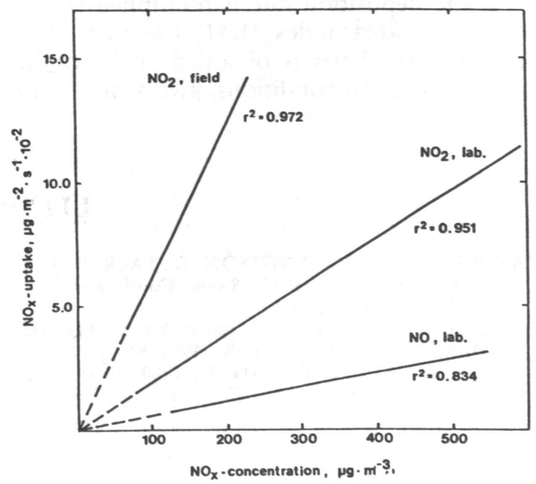

Figure 1 NO_X -uptake in Scots pine *versus* NO_X -concentration.

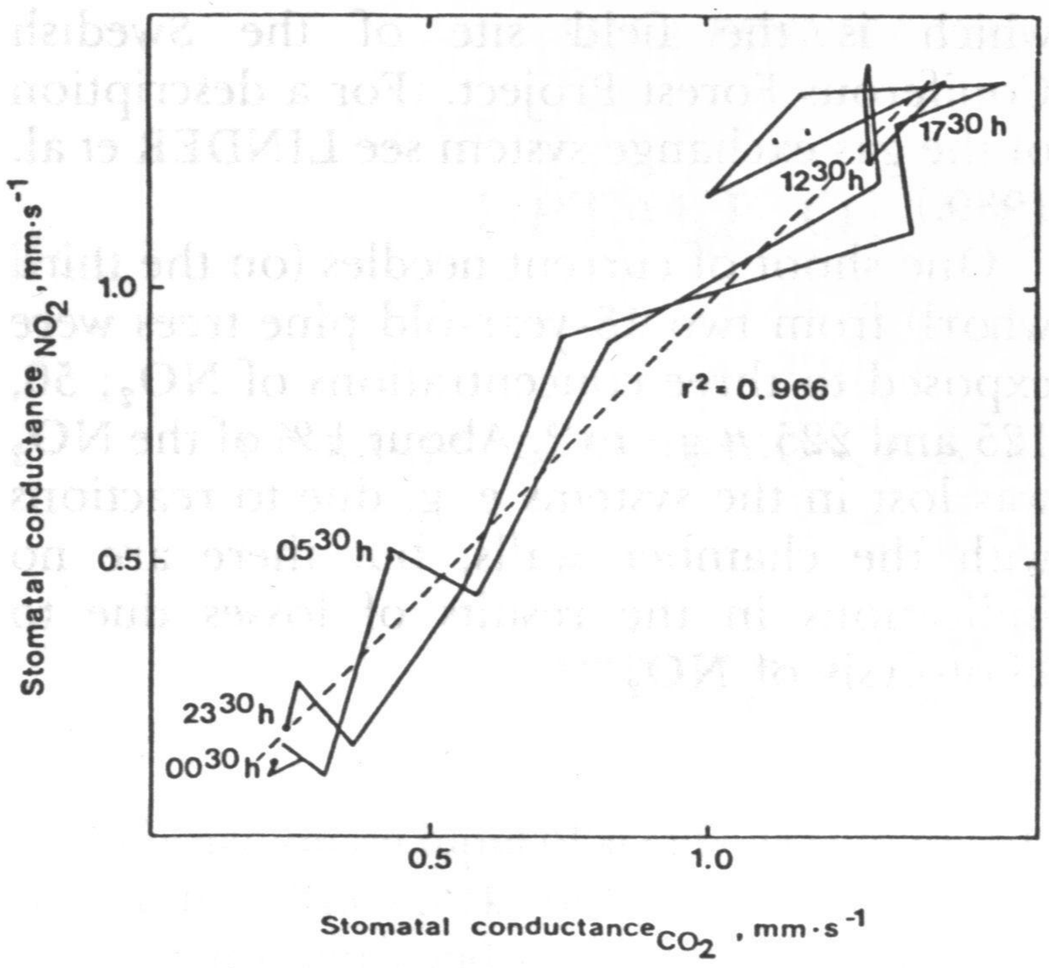

Figure 2 Stomatal conductance for NO_2 in a shoot of Scots pine *versus* stomatal conductance for CO_2. The data represent one typical day and night (from 00.30 h on August 3 to 23.30 h on August 3) of the field measurements. NO_2 -concentration of incoming air; 50.7±2.2 ug· m^{-3}.

for CO_2. Thus the internal resistance in the needles did not limit the uptake of NO_2. However, in one of the shoots an internal resistance was indicated when it was exposed to the highest NO_2 concentration (cf. above). Moreover, the cuticular uptake of NO_2 could probably be ignored for a dry shoot of Scots pine.

As could be expected (cf. Fig. 1) the field exposure with NO_2 gave the highest deposition rate (Table 1).

If the deposition rate is multiplied by the total leaf area index (LAI) the rate on a ground area basis is obtained. This would, under the given conditions, give a mean rate

Table 1 Deposition of NO_x to Scots pine (*Pinus sylvestris* L.) in light. N.B. the deposition rate is calculated per needle area.

Deposition rate, mm·s^{-1}		
NO_2 field	NO_2 lab.	NO lab.
1.10±0.15	0.20±0.01	0.07±0.02

in the day-time of approximately 5 mm·s^{-1} to the Scots pine stand at Jädraås.

It should be pointed out that due to the weather conditions during the experimental period the stomatal conductance was rather low both in the exposed shoots and the controls. In the earlier part of the summer the mean values during the day was at least 50 % higher. If this would mean a proportional increase in NO_2-uptake the result should be a 50 % increase in deposition rate.

To study this hypothesis field measurements on current and 1-year-old needles from two 18-year-old pine trees were continued in 1980. NO_2 of 100 μ g·m^{-3} was introduced continuously for four weeks in July-August. Results evaluated so far show a tendency of quite a higher deposition rate at this time of the year compared to August-September.

From the *field* measurements 1979 there were no indications of any physiological effects of the used NO_2-concentrations. In the *laboratory* experiments the only effect found was a reduction in the transpiration rate in darkness when the seedlings were exposed to the highest NO_2-concentration.

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