Effects of tropospheric ozone on Scots pine and Norway spruce in relation to critical levels

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Abstract

Two characteristic aspects in the research concerning the effects of ozone on conifers are highlighted. The first one is the identification of important plant responses using different exposure techniques and the second one is the continuous international work within the UN/ECE (the United Nations Economic Commission for Europe) to define a critical level for ozone in order to protect Europen forests from negative effects. In Scots pine (*Pinus sylvestris* L.), current year needles, exposed in branch chambers, took up ozone through the stomata in day-time. At high concentrations the uptake continued also during the night-time. The night-time stomatal conductance was also increased, indicating that ozone disturbed the stomatal function. The respiration rate increased and was 60% higher than the control shoot in the end of the exposure period, possibly indicating a consumption of carbon at the expense of lipids and proteins. Young trees of Norway spruce (*Picea abies* (L.) Karst.) were exposed to ozone in open-top chambers during four growing seasons. The earliest sign of an effect of ozone was a change in the ultrastucture of the chloroplasts, followed by a decrease in chlorophyll content with increasing needle age and ozone exposure. The increase in net photosynthetic capacity in current-year shoots and decrease in older shoots was interpreted as an accelerated rate of development and/or a sign of premature senescence in the needles, possibly due to a reduced activity of Rubisco. The increase of the net photosynthetic rate in the young shoots can also be a result of a compensation reaction for carbon loss and/or a defence reaction. After four seasons of exposure to ozone and drought, a disturbed coupling between stomatal conductance and photosynthetic rate was manifested in Norway spruce, resulting in decreased water use efficiency in one-year old needles. In order to test whether these physiological effects were reflected in a reduced growth of young trees, one short-term and one long-term experiment was initiated, again using open-top chambers. In the short-term experiment two clones were studied, among which one was fast growing and one slow growing. Effects of ozone were detected in the fast growing clone only. In the long-term experiment the total biomass of one clone of Norway spruce trees was significantly reduced by 5-8% compared to trees grown in filtered air, after ozone exposure during four growing seasons. A dose-response model predicts a significant reduction in biomass in this clone of 1% at the current critical level set for forest trees in Europe, an AOT40 of 10 $\mu l\ l^{-1}$ h per season. A dose-response model using data from several other European experiments with Norway spruce predicts a 6% growth reduction in the most sensitive trees at this critical level. These results indicate that the most sensitive spruce trees can be negatively affected at or below the current critical level.

Key words: Scots pine, branch chambers, Norway spruce, open-top chambers, stomatal conductance, net photosynthesis, biomass, ozone, critical levels, AOT40.

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