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Effect of ozone and aluminum on pitch pine (*Pinusrigida*) seedlings: needle ultrastructure

Carolyn J. McQuattie and George A. Schier

Abstract: Newly germinated pitch pine (*Pinusrigida* Mill.) seedlings inoculated with a mycorrhizal fungus (*Pisolithustinctorius* (Pers.) Coker & Couch) were grown for 13 weeks in sand irrigated with nutrient solution (pH 4.0) containing 0, 12.5, 25, or 50 mg/L aluminum in growth chambers fumigated with 0, 50, 100, or 200 ppb ozone. Cytological changes in needles of seedlings stressed by ozone and aluminum, singly and in combination, were determined by light and electron microscopy. The most pronounced changes in needles exposed to ozone occurred in the outer mesophyll, whereas major changes in the presence of aluminum occurred in the stele and inner mesophyll. At lower levels of either ozone or aluminum, the cytoplasm became more densely stained. Accumulation of dense materials appeared at intermediate treatment concentrations, and at high concentration localized cell collapse and deterioration became evident. Ozone or aluminum caused similar changes in the chloroplasts, for example, increase in number of plastoglobuli, accumulation of starch, formation of electron-dense stroma, and swelling or disruption of thylakoid membrane system. Ozone and aluminum in combination generally caused histological and cytological damage in needles to occur at lower concentrations than either aluminum or ozone alone.

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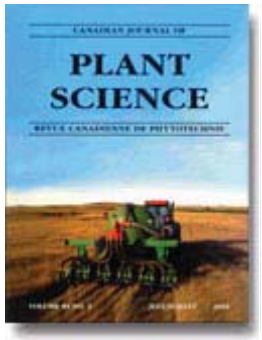

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