INFLUENCE OF O$_3$, RAINFALL ACIDITY, AND SOIL Mg STATUS ON GROWTH AND ECTOMYCORRHIZAL COLONIZATION OF LOBLOLLY PINE ROOTS

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Abstract. Root biomass, length, and branching frequency, and number and type of mycorrhizal short roots were determined for loblolly pine seedlings grown at two levels of soil Mg and exposed to chronic levels of O$_3$ and simulated acidic rainfall. Seedlings were planted in a sandy loam soil having approximately 15 or 35 mg kg$^{-1}$ Mg and were exposed to subambient, ambient, or twice ambient concentrations of O$_3$ in open top chambers from May through October. Seedlings also received ambient amounts of simulated rainfall at pH 3.8 or 5.2. Root biomass, length, and branching frequency were not significantly affected by O$_3$, rainfall acidity, or soil Mg treatments. Seedlings grown in the subambient O$_3$ treatment had a greater number of short roots infected with mycorrhizae than seedlings grown in ambient or twice ambient O$_3$ treatments, but trends were not statistically significant. Increasing rainfall acidity and soil Mg concentration resulted in a significantly (P = 0.07) greater number of mycorrhizal short roots, due primarily to an increased occurrence of one coralloid mycorrhizal type. Results suggest that mycorrhizal fungi differ in their response to O$_3$, rainfall acidity, and soil Mg status, and suggest that mycorrhizal infection is more sensitive than seedling root growth to O$_3$, acidic rainfall, and soil Mg status.

1. Introduction

The chronic deposition of atmospheric pollutants is commonly offered as a major factor contributing to accelerated rates of forest tree mortality or growth reductions (Johnson and Siccama, 1983; Kraus et al., 1983; McLaughlin, 1985). Ozone and acidic precipitation are the two pollutants most frequently mentioned as causal agents in the forest decline problem (Johnson and Siccama, 1983; Tomlinson, 1983). Ambient levels of O$_3$ have been reported to affect the growth of pollutant-sensitive forest trees (McLaughlin et al., 1982; Benoit et al., 1982; Duchelle et al., 1982), and to induce alterations in processes involved with foliar gas exchange, CO$_2$ fixation, and photosynthate allocation (Mann et al., 1980; McLaughlin et al., 1982). Growth reductions with artificial O$_3$ exposures have also been reported in seedlings of several pine species (Willour and Neely, 1976; Kress and Skelly, 1982).

The effects of acidic precipitation on forest tree species are still largely unknown. Leaching of essential nutrients, especially Mg, from foliage has been reported for Norway spruce (Picea abies L. Karst) trees exposed to combined acidic precipitation (pH 3.5) and elevated levels of O$_3$ (Krause et al., 1983). Gradual depletion of foliar Mg may reduce photosynthetic capacity, while sustained Mg deficiency could induce general needle chlorosis and affect patterns of C allocation (Krause et al., 1983; Prinz, 1987).

While the aerial portion of the plant is generally considered the principal site of phytotoxic effects, the rhizosphere may also be affected by atmospheric pollutants. Recent studies have suggested that the physiological mechanism underlying the growth response of forest tree species to acidic precipitation may be attributed, in part, to a direct toxic effect of Al and trace metals on root growth and physiology (Taylor et al., 1986; Matzner et al., 1986). Calcium and Mg deficiencies have also been observed in the fine roots of diseased silver fir (Abies alba Mill.) and Norway spruce trees which have been influenced by pollution (Bauch, 1983). Other studies have shown alterations in carbohydrate partitioning and reductions in root reserve carbohydrates for ponderosa pine (Pinus ponderosa Laws) (Tingey et al., 1976) and white pine (P. strobus L.) (McLaughlin et al., 1982) seedlings exposed to elevated levels of O$_3$.

Only recently has it been recognized that an important factor in forest decline may be the effect of atmospheric pollutants on mycorrhizal fungi which occupy the rhizosphere. Stroo and Alexander (1985) reported reduced mycorrhizal colonization of white pine seedlings after applications of simulated rain at pH 3.5, at three times ambient rates. Mycorrhizal infection of roots of red oak (Quercus rubra L.) seedlings increased at elevated levels of O$_3$, but decreased with decreasing pH of simulated acidic rain treatments (Reich et al., 1985). Dighton and Skeffington (1987) found a significant reduction in the occurrence of two corallloid mycorrhizal morphs on Scots pine (Pinus sylvestris L) seedlings exposed to simulated acid rain treatments of pH 3.0. In contrast, Shafer et al. (1985) found greatest mycorrhizal infection of loblolly pine (Pinus taeda L.) seedlings occurred when seedlings were exposed to simulated rains of pH 5.6 and 2.4, and reduced infection occurred at rain pH's of 4.0 and 3.2.

The species composition of mycorrhizal populations may also be important in determining growth responses of forest trees to pollutants, because of differences in physiological attributes among fungal species (Dighton, 1983; Dighton et al., 1987). Any limitation to the development of the mycorrhizal associations or changes in species composition would prompt physiological and morphological changes within the root system, and could result in reduced tree vigor, or alternatively, could result in increased resistance of the plant to the stress. The objective of this research was to determine the effects of atmospheric O$_3$, acidic rainfall, and soil Mg status on root growth characteristics and ectomycorrhizal associations of loblolly pine seedlings. This research is part of a project designed to determine the growth response of loblolly pine to the above-mentioned factors and to investigate the physiological and edaphic basis underlying observed growth responses.

2. Methods

2.1. Soil and seedling preparation

Soil used in the study was collected from the A horizon of a fine loamy silicious,