CHANGES IN FOLIAR ELEMENTS IN RED SPRUCE SEEDLINGS AFTER EXPOSURE TO SULFURIC AND NITRIC ACID MIST

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ABSTRACT. Red spruce (Picea rubens Sarg.) seedlings were exposed repeatedly at a field site or in a greenhouse to acidic mist containing the major sulfur and nitrogen pollutants of wet deposition in the eastern U.S.: sulfate alone, nitrate alone or with ammonium ion, and a combination of these ions. Acidities and ion concentrations ranged from below the mean to above the maximum concentration for cloudwater in the eastern U.S. Effects on elements in current-year foliage were examined after continuous or intermittent overnight exposures to mist performed over periods of 6 to 19 weeks. Principal findings from five experiments conducted over a three-year period were that acidic mist 1) increased the foliar S and/or N content when exposures were intermittent with repeated opportunities for drying of liquid on foliage; 2) decreased foliar calcium, and/or magnesium content, especially when exposures to acidic mist were continuous rather than intermittent; and 3) gave inconsistent results for foliar iron and aluminum probably because of deposition of soil particles and contamination with metals from the mist delivery system. These results indicate that long-duration exposures to cloudwater with pH below 3 may alter foliar nutrient composition and change relationships between N, S, Ca, and Mg, with potential consequences for growth and resistance to natural stress factors.

1. INTRODUCTION

Foliar levels of elements are affected by 1) uptake from soil and atmosphere; 2) translocation to and from other tissues within the plant; and 3) loss by leaching or volatilization (van den Driessche, 1974; Miller, 1984; Johnson et al., 1985). Some non-woody plant species are highly responsive to the deposition of S and N from the atmosphere, with significant consequences for their growth and longevity (Woodin et al., 1987). High elevation forests of eastern

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North America receive unusually high rates of deposition of S and N (Scherbatskoy and Bliss, 1984; Mueller and Weatherford, 1988; Weathers et al., 1988). There is concern over the consequences of excess S (Rennenberg, 1984) and N (Aber et al., 1989) particularly for northern forests where plant growth usually is limited by N supply (Lindberg et al., 1984). Accumulation of S and N from sulfuric and nitric acids in wet deposition has been demonstrated for conifers (Westman and Temple, 1989). Depletion of K, Ca, and Mg in needles of red spruce exposed to acidic clouds has been reported (Joslin et al., 1988). However, no information is available on the influence of the acidity, S and N components of wet deposition on foliar elements in red spruce despite the well-documented decline of this species (Scott et al., 1984; Adams et al., 1985; Battles et al., In Press). The objective of this study was to determine the effects of foliar elements in red spruce produced by continuous and intermittent exposures to mist containing different acidities and concentrations of the major S and N pollutants of cloudwater and rain of the eastern U.S. Three experiments were performed to examine the effects of ions (S, N, and S/N) and acidity; one experiment examined the effects of continuous and intermittent exposures; and one experiment investigated the effects of ions, provenance, and wind during the drying period. This report is part of a larger study that included effects of acidic mist on foliar injury and shoot growth (Jacobson et al., In Press), phenology and cold tolerance (Jacobson and Lassoie, In Press).

2. MATERIALS AND METHODS

2.1. Plant Material and Culture

Availability and age of seedlings of red spruce (Picea rubens Sarg.) varied from year to year (experiment 1: 3 year old seedlings from New Hampshire; experiment 2: 2 year old seedlings from New York; experiment 3: 1 year old seedlings from Nova Scotia; experiment 4: 1 year old seedlings from New Hampshire and Nova Scotia; and experiment 5: 2 year old seedlings from Nova Scotia, New Hampshire, and Maine). When exposures to mist were initiated, seedlings were: actively growing in experiments 1, 2, and 4; at the budswell stage in experiment 3; and dormant in experiment 5. Healthy, uniform seedlings were selected and randomly assigned to treatment groups. A rain exclusion canopy prevented ambient rain and dew from contacting plants treated at the field site. Seedlings were irrigated with deionized water by hand or with an automated system. Care was taken to avoid wetting foliage during irrigation. Plastic covers were used to prevent mist or throughfall from entering the rooting media in experiments 2 through 5. Additional information on cultivation conditions have been presented elsewhere (Jacobson et al., In Press).