BORON TOLERANCE AND POTENTIAL BORON REMOVAL BY BOTTOMLAND TREE SEEDLINGS

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Abstract: Boron is present in many household, industrial, and municipal products and by-products. Uncontrolled release of boron-containing materials into wetland environments could cause toxicity in bottomland and swamp tree species. To test this hypothesis, boron was added to 10-liter pots containing seedlings of Betula nigra, Nyssa sylvatica var. biflora, Nyssa aquatica, Platanus occidentalis, Taxodium distichum, Quercus alba, Q. falcata var. pagodaefolia, Q. nigra, Q. michauxii, and Q. phellos at rates of 0, 2, 4, 8, and 16 mg/L, and the seedlings grown for four months. Elemental leaf concentrations, growth, and biomass were determined. Boron concentration in leaves was linearly related to boron addition. The highest boron treatment significantly decreased growth for B. nigra, N. aquatica, P. occidentalis, and T. distichum. Platanus occidentalis had the highest boron recovery (23% at 4 mg/L), while T. distichum had the most consistent recovery (11-13%) over all treatments. Although leaf damage was severe in the oaks, there were no significant differences in growth parameters between the control and boron treatments. This is attributed to the determinate growth of the oaks and possibly the short duration of the study.

Key Words: boron, remediation, elemental concentration, biomass, Betula nigra, Nyssa sylvatica var. biflora, Nyssa aquatica, Platanus occidentalis, Taxodium distichum, Quercus alba, Quercus falcata var. pagodaefolia, Quercus nigra, Quercus michauxii, Quercus phellos

INTRODUCTION

Boron is unique in that it is the only essential plant micro-nutrient that is not also considered an essential nutrient for animals (Markert 1992). However, evidence for the essential nature of boron in animal nutrition is growing (Nielsen 1997). The functions of boron in plants are not well-understood (Gupta et al. 1985, Power and Woods 1997) but possibly include the regulation of thiocyanate precursors (Bible et al. 1981), carbohydrate regulation (Atalay et al. 1988), and flavonoid metabolism (Arles et al. 1984). There is a narrow range of soil boron concentration in which normal plant growth and development occurs. When soil boron deviates from this range, characteristic deficiency or toxicity symptoms will appear (Stone 1990). Symptoms of boron toxicity in trees are generally marginal chlorosis or necrosis and/or necrotic spotting within the leaf (Gilliam and Smith 1980, Sposito 1988). American sycamore (Platanus occidentalis L.) seedlings grown in excess boron solutions had yellow-green chlorotic patches on their leaves that later turned necrotic with yellow/yellow-green margins (Vimmerstedt and Glover 1984).

Boron is present in many materials, including glass, metal alloys, detergents, plastics, municipal sludge, fly ash, wood preservatives, and pesticides. Release of boron into the environment could cause toxicity in some plants (Nable et al. 1997). Boron toxicity concerns have arisen from increases in soil boron after sewage sludge application, use of ash material (Stone 1990), irrigation with water from geothermal areas, irrigation in arid/semiarid areas (Van Mensvoort et al. 1985), and overfertilization with boron fertilizers (Gilliam and Smith 1980). In addition, boron leaching from fly ash and coal piles can enter wetland systems (Wilcox and Hardy 1988). Uncontrolled release of boron-containing materials into wetland environments could cause toxicity in hydrophytic tree species. Although boron tolerance has been well-studied in agricultural crops and fruit trees, research on bottomland tree species is lacking (Sposito 1988).

On the Department of Energy’s Savannah River Site (SRS), large quantities of sodium tetraphenylboron are used in the processing of high level radioactive waste, which might enter the environment through accidental releases. In addition, boron can enter nearby stream systems after leaching from coal fly ash and coal piles on the SRS. Our objective was to determine boron
uptake and relative tolerance of ten bottomland tree species to increased boron concentrations in soils.

**MATERIALS AND METHODS**

Ten bottomland tree species were germinated from seed obtained from Sheffield Seed Company, Locke, NY, USA. Species requiring stratification to break dormancy were overwintered outside in tree tubes, while the others were germinated in flats in a greenhouse. During early June of 1991, seedlings were transplanted into individual 10-L black plastic pots lined with plastic bags and filled with Metro Mix 300 potting soil. Transplanted seedling age, depending on species, ranged from 3 to 8 weeks. Species were river birch (*Betula nigra* L.), swamp tupelo (*Nyssa sylvatica* var. *biflora* (Walt.) Sang.), water tupelo (*N. aquatica* L.), American sycamore (*Platanus occidentalis* L.), bald-cypress (*Taxodium distichum* (L.) Rich.), white oak (*Quercus alba* L.), cherrybark oak (*Q. falcata* var. *pagodaefolia* Ell.), swamp chestnut oak (*Q. michauxii* Nutt.), water oak (*Q. nigra* L.), and willow oak (*Q. phellos* L.). A plastic tube with four holes near the bottom, covered with a woven material, was inserted into the soil as an observation well for determination of water needs. Ten days after transplanting, boron as boric acid solution was added on the soil surface at rates of 0, 20, 40, 80, and 160 mg B /pot (i.e., 0, 2, 4, 8, 16 mg/L, wt soil volume basis) and watered with 600 ml of tap water. There were six replicates per species/treatment. When no water was observed in the well (checked once or twice per day as needed), pots

![Figure 1. Biomass (g) of tree seedlings as affected by boron treatment. Asterisk indicates significant difference (p < 0.05) between that treatment and the control within a plant part (top section = leaves, middle = stem, bottom = roots). Asterisk above column indicates significant differences in total plant biomass.](image-url)