EXCESS MANGANESE REDUCES CHLOROPHYLL IN SUGAR MAPLE LEAVES

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INTRODUCTION

In the northeast United States, significant declines in forest health have been observed over the past several decades. Exonomically valuable species such as sugar maples are in many places being replaced by much less valuable, but more resilient tree species such as striped maple. Several factors have been linked to decline symptoms, but soil acidification and the disruption of nutrient cycles appears to be a central factor that weakens sugar maple resistance to both nonbiological and biological stresses. The majority of research on this topic has focused on aluminum toxicity to roots and foliar calcium and magnesium deficiencies. Manganese (Mn) toxicity is another important, but less well understood component of soil acidification.

Mn availability to plants increases as soils acidify below pH 5.5

Kogelmann and Sharpe (1999) reported a five-fold increase in the Mn concentrations of sugar maple leaves growing on extremely acid vs. moderately acid soils in northern Pennsylvania. Sap Mn concentration differences between sugar maple on these sites were even greater with differences up to 10 times as great on the extremely acid site. Mn uptake by sugar maple increases as acidic soils Preduce Mn to a more available form. Soil acidification also increases calcium (Ca) and magnesium (Mg) cation leaching thus making it easier for Mn to bind to root surfaces. The result is nutrient imbalances, which likely impair leaf function.

Little is known about how excessive Mn affexts sugar maple health. The published range of Mn in leaves of healthy sugar maple trees is 632-1630 ppm (parts per million) (Kolb and McCormick, 1993). However, on the Allegheny Plateau where declines in sugar maple have occurred in the last two decades, leaf Mn concentrations averaged 3100 ppm (Drohan et al., 2002). This is much higher than the toxicity threshold of most crop species, and higher than the previously published maximum.

In crop plants, excessive leaf Mn is known to decrease leaf chlorophyll content, resulting in premature leaf yellowing, a symptom of health decline in sugar maple stands of the eastern deciduous forest. The objective of this study was to examine leaf chlorophyll responses of sugar maple seedlings exposed to excess Mn.

METHODS

Second year bare-root seedlings of sugar maple (Acersaccharum) grown from seed were studied. Six seedlings were cultivated in one of four, 100-liter hydroponic tanks filled with nutrient solution. Each tank had one of four Mn concentrations from adequate to excessive: 5uM (microMolar), 125uM, 250uM and 500uM. The solution was aerated continuously and changed every seven days. The experiment was performed in a greenhouse on the Penn State campus from August 1st to September 1st, 2001. At the end of the experiment, chlorophyll was extracted from disks punched from the tip and side of leaves.

RESULTS AND DISCUSSION

Excess manganese reduced chlorophyll concentration in a dose dependent manner. The 125, 250 and 500 uM Mn treatments decreased leaf chlorophyll content by 10%, 20% and 35% relative to the adequate (5 uM) Mn treatment. It is possible that this response was the result of Mn preventing uptake of Mg and iron (Fe) at the root surface. Excess manganese can also interfere with magnesium and iron nutrition in the leaf. Adequate concentrations of these nutrients are important for the production of chlorophyll. Low foliar Mg/Mn and Fe/Mn ratios may be a particularly good indicator of susceptibility to leaf yellowing. The 20% and 35% reductions in leaf chlorophyll observed in this study were occurring at leaf Mn concentrations of 2300 and 4900 ppm, Mg/Mn ratios below 1 and 0.5 and Fe/Mn ratios below 0.1.

Reduction in chlorophyll significantly decreases the photosynthetic capacity of leaves, as it is the primary pigment involved in harvesting light energy for photosynthesis. Tree health and vitality are dependent upon optimal levels of photosynthesis. As sugar is the direct product of photosynthesis, factors that interfere with this process may also decrease sap quantity and quality. These results are preliminary and additional research is underway. Other factors that may act together with manganese toxicity to reduce sugar maple health are being studied. These include light intensity, ozone, and ultraviolet radiation.

WORK CITED

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