Journal of Ecological Research, **5**, 58-64 (2003)

THE EFFECT OF SOIL-PORE WATER CHEMISTRY ON THE PRESENCE OF SUGAR MAPLE BORER *(GLYCOBIUS SPECIOSUS)*

Cheryn L. Courtney

ABSTRACT

Sugar maple (*Acer saccharum*) populations have been on the decline in North America. One symptom this decline is increased infection by the sugar maple borer (*Glycobius speciosus*), which only attacks trees that are under physiological stress. One of the factors related to stress in sugar maples is soil nutrient levels. I compared pH, Al, Ca, and Mg in soil pore water at trees with and without the maple borer infection. The pH of the pore water of infected trees (6.5 ± 0.21) was not significantly different from that of non-infected trees (6.5 ± 0.18) (t = 0.32; df = 8; P = 0.39). The Al concentration of the pore water of infected trees (0.0032 ± 0.00303 mg/l) was not significantly different from that of non-infected pore water (0.00060 ± 0.00089 mg/l). Similarly the Ca of the pore water of infected trees (0.93 ± 0.20 mg/l) and non infected trees (1.046 ± 0.1988 mg/l) was not significantly different (t = 0.91; df = 8; P = 0.194) and the Mg concentration of the pore water of infected trees (0.200 ± 0.020 mg/l) and non infected (0.194 ± 0.0288 mg/l) was also not significantly different (t = 0.38; df = 8; P = 0.356). I conclude that there is not a relation between the soil pore water nutrients and the presence of the sugar maple borer at the Raystown Field Station.

Keywords: Acer saccharum, Glycobius speciosus, *pore-water chemistry, sugar maple borer, sugar maple tree, and tree stresses*

Figure 1. The natural distribution of the sugar maple in the northeastern United States

INTRODUCTION

The sugar maple's (*Acer saccharum)* natural range in North America extends over the north east corner of the United States and into Canada (Fig 1). It is most common in the Great lakes states, Ohio, Pennsylvania and New York (Luzadis 1996). Beginning in the early 1980's, sugar maple populations in these areas experienced impaired forest health or decline (Hutchinson et al. 1997). Decline is characterized by gradual deterioration of trees over time due to biotic and abiotic factors (Bauce and Allen 1991). One such biotic factor that can be used to determine stress and decline is the presence of certain sugar maple insects such as the maple borer (*Glycobius speciosus)* (Bauce and Allen 1991).

The sugar maple borer is a wood-boring beetle which only infects the sugar maple. During the 2-year life cycle the larva eats away at sapwood under the bark, leaving a horizontal and vertical scar (USDA 1978) (Fig 2). The sugar maple borer usually only attacks trees that have low vigor (Bauce and Allen 1991) and is therefore found significantly more often in declining than in healthy trees (Bauce and Allen 1991). Infected and non-infected trees may occur in the same forest (Pers obs). A deficiency of soil nutrients is a potential stress contributing to maple declines in Massachusetts, Quebec, northern New York, Vermont and Pennsylvania (Horsley et al 2000). Sharpe (2002) did studies of soils nutrients of sugar maple stands and found that there was significantly less Ca, Mg and K in declining stands when compared to healthy ones. He attributed this phenomenon to acidification (Flynn 1995) which is often measured by the amount of exchangeable Al species (Cronan and Grigal 1995).

The goal of this study was to determine if soil nutrients affect the occurrence of the sugar maple borer. I compared pH, Al, Ca, and Mg in soil pore water at trees with and without the maple borer infection to see if there was a correlation between soil pore water chemistry and the presence of the sugar maple borer.

Figure 2. The horizontal and vertical scars caused by the larva of the sugar maple borer.

FIELD SITE

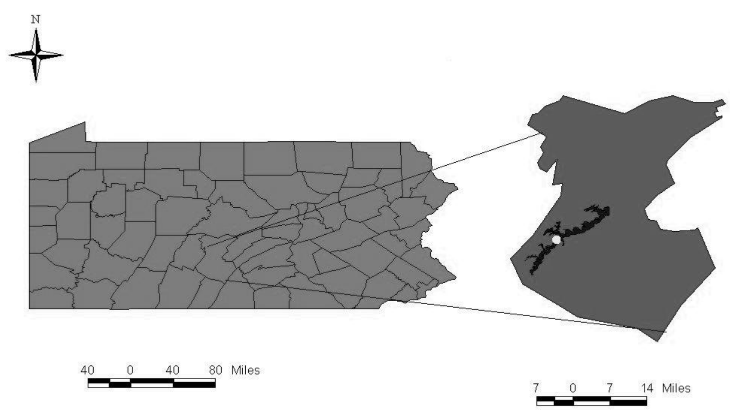

Figure 3. Location of the Raystown Lake Field Station in Huntingdon County, PA

I conducted the study in the sugar maple grove located within the Ernest silt loam soil formation (Molesevich 1977) at Juniata College Raystown Lake Field Station near Entrinken Pennsylvania (USGS Entrinken PA Quadragle) (Fig. 3). The Ernest silt loam soil is located along the lake access road and northwest of the stream and is about 22.5 meters wide and 400 meters long (Fig. 4). I chose the site because of the high incidence of sugar maple borer (Pers Obs). I conducted the study during late October and early November of 2002.

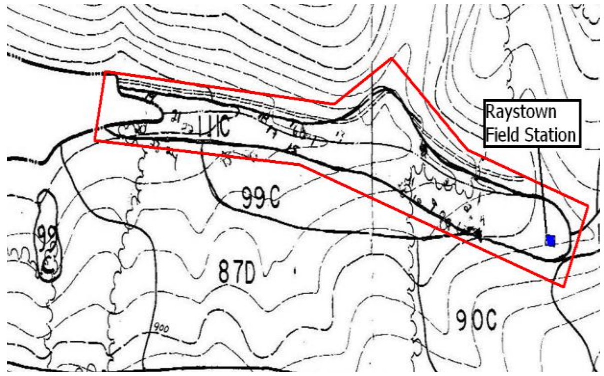

Figure 4. Location of Ernest Silt Loam at the Raystown Field Station in Entrinken PA.

METHODS AND MATERIALS

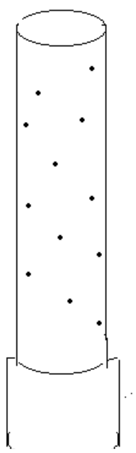

Figure 5. Lysimeter used for collecting pore water

I randomly selected 20 trees of the two different types: 10 trees with no visible sugar maple borer infection and with no infected trees within 5 meters, and 10 trees with sugar maple borer infection and no uninfected trees within 5 meters. The trees that had a visible maple borer scar were considered to be infected, and those with no scar were considered to be non-infected. I collected pore water in lysimeters that were 30 cm in depth by 1.8 cm in diameter with 24 drill holes in them (Fig 5). These lysimeters were placed in the ground, covered with parafilm and left for a week to collect pore water.

I tested the pH of the pore water using a HACH EC10 pH meter while the water was still in the lysimeters (HACH 1996) and then I extracted the water using a pipette. I used the Calmagite Colorimetric Method to asses Calcium and Magnesium concentrations and an Eriochrome Cyanine R Method was used to measure Al (HACH 1994).

I checked the data for normality using an Anderson Darling test (Hampton 1996) and heterogeneity of variances using a Levene's test (Hampton 1996). I compared the pH of the pore water of non-infected trees to that of infected using a two- sample t-test (Hampton 1996). I used an alpha level of 0.05 and considered the difference to be significant if $P \leq 0.05$. I repeated this process for Ca and Mg. I compared the results of the Al levels of infected to non-infected trees using a Mann-Whitney test (Hampton 1996). Again I considered results to be significant if $P \leq 0.05$.

RESULTS

Out of the 20 lysimeters only 10, 5 of each treatment, contained enough pore water to be tested. The pH of the pore water of infected trees (6.5 ± 0.21) was not significantly different from that of non-infected trees (6.5 ± 0.18) (t = 0.32; df = 8; P = 0.39). The content of Al in the infected pore water (3.2 ± 3.03 µg/l) was not significantly different from the non- infected pore water (0.60 ± 0.89 µg/l) (W = 33.0, df = 8, P = 0.148). The Ca concentration of the infected pore water (0.93 ± 0.2024 mg/l) was not significantly different from the non- infected pore water (1.046 ± 0.1988 mg/l) (t = 0.91; df = 8; P = 0.194). Similarly the Mg concentration of the infected pore water (0.200 ± 0.0200 mg/l) was not significantly different from the non-infected pore water (0.194 ± 0.0288 mg/l) (t = 0.38; df = 8; P = 0.356).

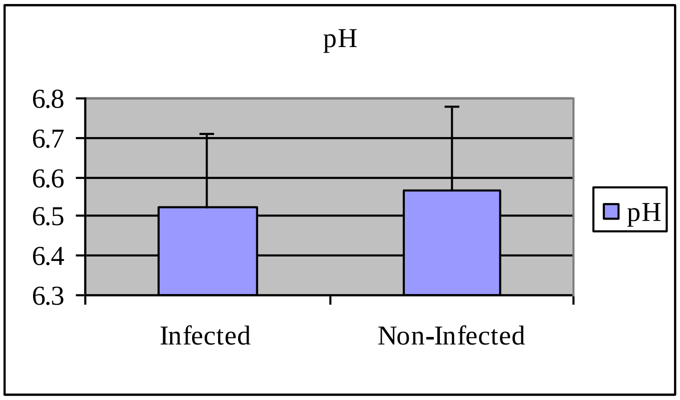

Figure 6. Mean pH of pore water from the maple borer infected and non-infected sugar maples at the Raystown Field Station, fall 2002.

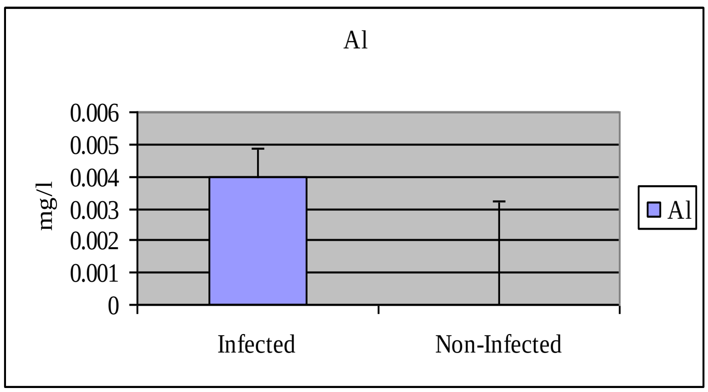

Figure 7. Mean (mg/l) of Al concentration in the pore water for maple borer infected and non-infected sugar maples at the Raystown Field Station, fall 2002.

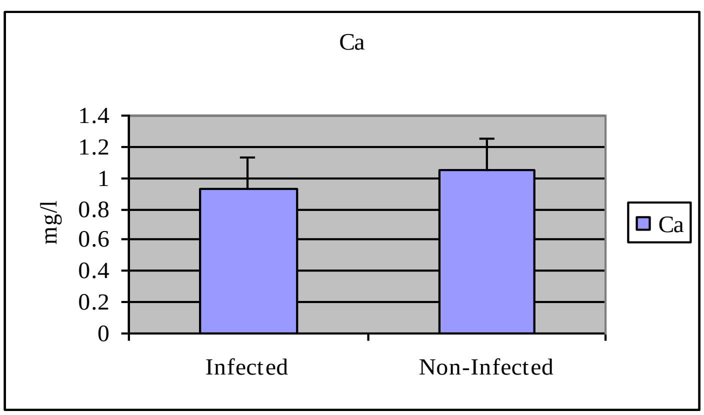

Figure 8. Mean (mg/l) of Ca concentration in the pore water from maple borer infected and non-infected sugar maples at the Raystown Field Station, fall 2002.

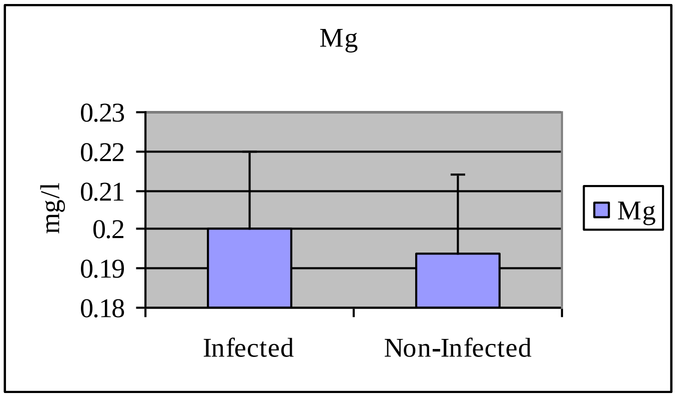

Figure 9. Mean (mg/l) of Mg concentration in the pore water of maple borer infected and non-infected sugar maples at the Raystown Field Station, Fall 2002.

DISCUSSION

The pH is an indicator of soil acidification. Acidification predisposes the soil to deficiencies of Mg, CA, and K, increasing the chances of toxic acidity in the root system (Ulrich and Matzner 1988). The soil pore water in this study was only slightly acidic (pH = 6.6) and falls within the normal soil pH range for sugar maples (3.7-7.3) and in the most common range for sugar maple soils (5.6-7.3) (Luzadis 1996). My results may not reflect the true soil pH because of heavy rain fall during this study and the typically lower pH of typically lower pH of rain in central PA (Personal Communication). However, if this is the case then the real soil pH would be more basic, further indicating that acidification is not in the soils. Differences in soil pH are not as clearly associated with tree conditions as are foliar nutrient levels (Sharpe et al. 2002).

Acidification is often measured by the amount of exchangeable Al species (Cronan and Grigal 1995). When Al competes with Ca and Mg for absorption sites on the roots the energy transformation, cell balance and division, nutrient accumulation and other Mg and Ca dependant processes can be affected (Cronan and Grigal 1995). My levels of Al in pore water of infected (0.0032 mg/l) and non-infected trees (0.0006 mg/l) are below the Mg dependent Al toxic levels that Cronan and Schofield found for some southern Inceptisols and Ultisols (< 0.0269 mg/l) (Cronan and Grigal 1995). However my results are at the low end of concentrations they found because some German Inceptisols were greater than 6.45mg/L. These wide ranges place the Ernest silt loam, which is an Ultisol, within the range of levels found elsewhere.

Ca is important to maple trees because it stabilizes the prectate in the cell wall, bridges phospholipids and other proteins in the plasmalema that are important for the functioning of membrane bound enzymes for control of phytohormones (Cronan and Grigal 1995). Ca comes into the tree through absorption sites in the roots and has to compete for these sites with Al. If Al binds to the absorption sites the Ca dependant processes become deficient (Cronan and Grigal 1995). Al stress has a 50% chance of occurring at a Ca/Al ratio of 1.0, a 75% chance of occurring at 0.5 and a 95-100% chance of occurring at 0.2 (Cronan and Grigal 1995). The Ca/Al molar ratios for pore water of infected (189) and non-infected (76) trees in the study are above any reported Ca/Al ratios that put a tree at risk for Al stress and toxicity (Cronan and Grigal 1995).

Mg is important to tree health because it is incorporated into the chlorophyll (Cronan and Grigal 1995). It is also found in the cytoplasm and plays a role in cell replication, respiration, and protein synthesis (Cronan and Grigal 1995). Mg, like Ca, is absorbed through the roots and is in competition with Al. Because Mg and Ca can both be affected by Al, the same scale for Al ratios can be used for Mg as for Ca to determine stress. The Mg/Al ratio's of my infected (67) and non-infected (23) pore water are lower than the Ca/Al ratios reported above but are still large. Although my Mg/Al levels are high they do not appear to be a source of stress because it is low Mg/Al ratios that put a tree under stress (Cronan and Grigal 1995). However these ratios are less studied than Ca/Al.

The pH and nutrients such as Al, Ca, and Mg play an important role in the health of the sugar maple. However, these nutrients do not seem to be the cause of the stresses that lead to the occurrence or absence of the sugar maple borer at the Raystown Field Station.

ACKNOWLEDGMENTS

A sincere thank you to Chuck Yohn for helping with my project set up, editing and the gathering of information, and to Kimberly Campanaro for helping with research.

LITERATURE CITED

Bauce, E. and D. Allen. 1991. Etiology of a sugar maple decline. Canadian Journal of Forest Research. **21**:686-693.

Cronan, C. and D. Grigal. 1995. Use of calcium/aluminum ratios as indicators of stress in forest ecosystems. Canadian Journal of Forest Research 24: 209-226.

Drohan, P.J., S.L. Stout and G.W. Peterson. 2002. Sugar maple (*Acer saccharum* Marsh.) decline during 1979-1989 in northern Pennsylvania. Forest Ecology and Management **170**:1-17.

Flynn, John. 1995. Is the Allegheny Forest Coming Apart? American Forests **101**: 13

HACH DR/2000 Spectrophotometer Procedures Manual. 1994. HACH Company: Loveland, CO.

HACH EC10 Portable pH/mV/Temperature Meter Model 50050. 1996. HACH Company: Loveland, CO.

Hampton, R.E. 1994. Introductory Biological Statistics. WCB McGraw-Hill, Boston, Massachusetts, USA.

Horsley, S., R. Long, S. Bailey, R. Hallett and T. Hall. 2000. Factors associated with the decline disease of sugar maple on the Allegheny Plateau. Canadian Journal of Forest Research. **30**:1365-1378.

Hutchinson, T., S. Watmough, E. Sager and J. Karagatzides. 1998. Effects of excess nitrogen deposition and soil acidification on sugar maple in Ontario, Canada: an experimental study. Canadian Journal of Forest Research **28**: 299-310.

Luzadis, V.A. and E.R. Gossett. 1996. Sugar Maple. Forest trees of the Northeast. 157-166. http://maple.dnr.Luzadis 1996.edu/tree.asp

Molesevich, M.M. 1977. Soil Study of the Raystown Field Station. Unpublished Independent Study. Juniata College, Huntingdon Pennsylvania, USA.

Newton, W.G. and D.C. Allen. 1982. Characteristics of trees damaged by sugar maple borer, *Glycobius speciosus* (Say). Canadian Journal of Forest Research **12**: 738-744

Sharpe, W., C. Driscoll, Charles and G. Lawrence. 2002. Acid deposition explains sugar maple decline in the East. BioScience **52**:1.

Ulrich, B. and E. Matzner 1988. Solling. Pg 42-47. Krahl-Urban, B. Papke, H. Peters, K. Schimansky, C. The Cause and Effect Research in the United States of North America and Federal Republic of Germany, Forest Decline. Assesment Groups of Biology, Ecology and Energy of the Julich Nuclear Research Center for the U.S E.P.A.and the German Ministry of Research and Technology, Koln, Germany.

United State Department of Agriculture. 1978. How to Identify and Control the Sugar Maple Borer. Forest Service. http://www.na.fs.fed.us/spfo/pubs/howtos/ht_mapleborer/mapleborer.htm, accessed Nov 2,2002.