WINDELS, CAROL E.[1]*, JASON R. BRANTNER[1], ALBERT L. SIMS[1] and CARL A. BRADLEY[2], [1]University of Minnesota, Northwest Research and Outreach Center, Crookston, MN 56716 and [2]University of Illinois, Crop Sciences Department, Urbana, IL 61801. **Long-term effect of a single soil application of factory lime on Aphanomyces root rot and sugar beet yield.**

ABSTRACT

Aphanomyces cochlioides infests over 50% of sugar beet fields in Minnesota (MN) and North Dakota (ND). Factory lime is a by-product of the process where calcium carbonate is used to extract sucrose from beet juice by precipitating impurities (inorganic and organic compounds). Factory lime is stockpiled because it can not be re-used, but recent observations and preliminary research indicate soil application of the material reduces Aphanomyces root rot and also increases sugar beet yield and quality (even when the pathogen is inactive). Experiments were established in growers' fields near Hillsboro, ND (pH = 7.02) in October, 2003 and Breckenridge, MN (pH = 6.3) in April, 2004. The Hillsboro site had a history of moderate Aphanomyces root rot and the soil index value (SIV) averaged 48 (0 to 100 scale, 0 = no disease, 100 = potential for severe disease). The Breckenridge site had a history of severe Aphanomyces root rot and the SIV averaged 98. At each site, four, 1-acre experiments were established. Each experiment included four rates of factory lime (referred to as lime throughout this abstract) and a non-limed control replicated four times in a randomized block design. Treatments at Hillsboro were 0, 5, 10, 20 and 30 tons wet weight lime A^{-1} (= 0, 3.3, 6.5, 13 and 19.5 tons dry weight, respectively) and at Breckenridge were 0, 5, 10, 15 and 20 tons wet weight A^{-1} (= 0, 2.7, 5.3, 8 and 10.6 tons dry weight, respectively). Each plot measured 33 x 60 ft. To allow treatments to stabilize in 2004, corn and spring wheat were sown across all experiments at Hillsboro and Breckenridge, respectively. Sugar beet was planted in one experiment each year from 2005 to 2008 to represent two, three, four, and five growing seasons after application of lime, respectively; the three other experiments were planted with the same crop grown in the field by the grower-cooperator.

Objectives included determining effects of a single soil application of factory lime on sugar beet in 2008 (fifth growing season after application) and overall, in 2005-2008 on: soil pH, Aphanomyces root rot, yield and quality of sugar beet, and Aphanomyces populations (by SIV).

Hillsboro: In 2008, soil pH in the non-limed control was 7.49 and was significantly higher in limed plots (average pH = 8), regardless of rate. Soil pH values were slightly higher in all plots since first measured in 2004 (9 months after lime applied), but overall, remained similar every year. Emergence was slow because of dry weather but by 5 weeks after planting, there was a significant (P = 0.05) linear effect of lime rate on stand; these differences disappeared about 1 week later. By harvest, *A. cochlioides* caused minimal disease and root rot ratings (RRR, 0 – 7 scale, 0 = healthy, 7 = root completely rotted and foliage dead) were significantly (P = 0.01) lower in limed plots (average RRR = 2.1) than in the control (RRR = 2.6). There were no significant differences among limed and control plots for root yield, percent sucrose, pounds of sucrose per ton, pounds of recoverable sucrose and gross return A^{-1}. There was a general trend for root yield, pounds of recoverable sucrose and gross return to be higher in limed plots than in the control.

Summary for Hillsboro, 2005-2008: When data were combined for 4 years of sugar beet production, all rates of lime (applied in October, 2003) significantly (P = 0.01) decreased

Aphanomyces root rot compared to the control. Plots treated with all rates of lime also resulted in significant ($P \geq 0.05$) increases in seedling stands, number of harvested roots, root yield, percent sucrose, pounds of sucrose per ton and pounds of recoverable sugar A^{-1} compared to the control. For instance, sucrose yields increased incrementally in a linear fashion with increasing rates of lime ($R^2 = 0.9191$). Lime had no effect on loss to molasses (LTM). From 2003 to 2008, SIVs fluctuated, but tended to be lower in limed than in control plots. At 9 months after lime was applied, SIVs averaged 20 in limed plots and 45 in the control. By 2008, SIVs had increased and averaged 55 in limed plots and 73 in the control.

Breckenridge: In 2008, (49 months after lime was applied), soil pH was 6.58 in the control and was significantly ($P = 0.01$) higher (average = 7.57) in all limed plots. Soil pH values in 2008 were slightly higher in all limed and control plots compared to October, 2004 (5 months after lime was applied) but overall, remained stable from year-to-year. Cold weather in May and June, 2008 delayed emergence and onset of Aphanomyces damping-off and there were no differences in seedling stands among limed and control plots. As the season progressed, warm temperatures and rainfall favored activity of *A. cochlioides*. By harvest, numbers of harvestable roots were significantly higher ($P = 0.05$) in plots treated with all rates of lime compared to the non-limed control. Aphanomyces RRR was significantly ($P = 0.01$) lower in limed plots (average = 2.9) compared to the control (= 3.8). All rates of lime significantly ($P = 0.01$) increased root yield, pounds of recoverable sucrose and gross revenue A^{-1} compared to the control. There were no differences among any treatments for percent sucrose and pounds of sugar per ton.

Summary for Breckenridge, 2005-2008: When data were combined for 4 years of sugar beet production, all rates of lime (applied in April, 2004) significantly ($P = 0.01$) decreased Aphanomyces root rot compared to the control. Lime significantly ($P = 0.01$) increased seedling stand, number of harvested roots, and root and sucrose yields compared to the control. There were quadratic relationships between rate of lime and plant response for these factors. For instance, with 5 tons of lime there was a steep increase in recoverable sucrose compared to the control and maximum yields occurred at 15 tons of wet lime A^{-1} ($R^2 = 0.9504$). Lime had no effect on LTM. Despite dramatic increases in sucrose yields with lime applications at Breckenridge, yields were lower than at Hillsboro, likely because of severe Aphanomyces root rot. From 2004 to 2008, SIVs fluctuated but tended to be very high across all plots, indicating a high potential for disease. At 4 months after lime was applied, SIVs averaged 82 in limed plots and 100 in the control. By 2008, SIVs averaged 94 in limed plots and 100 in the control.

In conclusion, soil application of all rates of factory lime increased soil pH within a few months and these values remained stable through 2008. All rates of lime were beneficial to sugar beet from the second through fifth growing season by reducing Aphanomyces root rot and increasing root and sucrose yields, especially at 15 to 20 tons wet weight per acre (= 8 to 10 tons dry weight). Aphanomyces soil index values fluctuated and were not related to decreases in root rot occurring in the field.