# INFLUENCE OF SOIL pH ON *APHANOMYCES COCHLIOIDES* IN SUGARBEET

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## Introduction

Aphanomyces root rot and black root in sugarbeet seedlings caused by the fungus *Aphanomyces cochlioides* is becoming more prevalent in the Red River Valley of North Dakota and Minnesota, southern Minnesota and other sugarbeet growing regions of the world. Warmer temperatures, higher than normal precipitation and crop rotation practices are causing an increase in *A. cochlioides* populations and sugarbeet infection (Adams, 1991). Sugarbeet stand and yield are reduced due to the above factors resulting in lost revenue for the grower. *A. cochlioides* is an oomycete whose infective unit is a zoospore. Water saturated soil is necessary for production, movement and germination of the zoospore within the soil profile (Rush and Vaughn, 1993). Moisture allows zoospores to migrate to the sugarbeet root system resulting in infection. Dryer soil will leave the zoospore virtually immobile and less likely to cause disease. During infection the hydrolytic enzymes produced by the fungus cause cell collapse allowing the fungus to spread more rapidly in the sugarbeet tissue (Papavizas and Ayers, 1974). Management strategies previously used for this disease have included seed treatment, development of resistant cultivars, enhanced drainage, controlling weed hosts and crop rotation.

## Objectives

Evaluate the effect of added lime on sugarbeet Aphanomyces root rot and *A. cochlioides* populations in low and high pH soils.

## Materials and Methods

<u>Field</u>: The field used for the low soil pH study was located near Wolverton, Minnesota. Soil pH ranged from 5.3 to 6.2. *A. cochlioides* was present and uniform throughout the plots. Two blocks of plots were used in this experiment, North and South. The blocks were 200 ft apart, plots were 60 by 33 ft., soil pH in both blocks was similar. Selected plots were limed at 3 and 10 ton/A with spent calcium carbonate (14% less neutralization power than virgin lime) from the nearby Minn-Dak Farmers Cooperative processing plant at Wahpeton, ND. The plots were seeded in 22-inch rows with '8277RR' sugarbeet from Hilleshog on April 28, 1999 and May 3, 2001. Roundup Ultra was applied May 25, 1999 at 2 pt/A, June 10, 1999 at 2.5 pt/A, May 31, 2001 at 3 pt/A and June 27,2001 at 4 pt/A respectively. A randomized complete block design with four replicates was used. Field plot size was 60 by 33 feet. Soil samples 6 inches deep were collected from the plots

before liming, after liming, and at the end of the growing season and were analyzed for soil pH levels.

The field used for the high pH study was located near Moorhead, Minnesota. Soil pH ranged from 7.5 to 7.8. *A. cochlioides* was present and uniform throughout the plots. Plots were limed at 3 and 10 ton/A with spent calcium carbonate from the nearby American Crystal Sugar Company processing plant located in Moorhead, MN. The field was seeded in 22-inch rows with '8277RR' sugarbeet on May 4, 2001. Roundup Ultra was applied May 30, 2001 at 3 pt/A. A randomized complete block design with four replicates was used. Field plot size was 60 by 33 ft. Soil samples 6 inches deep were collected from the plots before liming and the following spring and were analyzed for soil pH levels.

Three 15 ft. long rows of sugarbeet were harvested from the middle of each plot at both locations. Root rot ratings were taken on harvested sugarbeet. Sugarbeet root yield was determined using the following equation; ton/A net =clean wgt. lbs/% of A/2000. Sugarbeet was analyzed for % sugar, sodium content, potassium content and amino nitrogen content by the research tare laboratory of American Crystal Sugar Company. Extractable sucrose content was calculated for this analysis using the equations below:
Purity index = (3.5 * Na ppm) + (2.5 *K ppm) + (9.5 *AmN ppm)/% sucrose
Sugar loss lb/A = Purity index * (% sugar/100 * ton/A net * 1.5)/10,000
Extractable sucrose lb/A = ((ton/A net) * (% sugar/100) - sugar loss) * 2000

<u>Controlled Environment Chamber</u>: 'Maribo 9363' sugarbeet was planted in soil taken from the low pH study near Wolverton in spring of 1999 and 'ACH 261' sugarbeet was planted in spring of 2001. 'ACH 261' sugarbeet was planted in soil taken from the high pH study and planted in spring of 2000 and the spring of 2001. Soil was added to plastic pots (4x4x4 inches); 25 sugarbeet seeds were sown and covered with soil. Pots were arranged in a randomized block design of five replicates per treatment in a growth chamber set at 68ºF for 1 week to favor emergence and then increased to 80ºF to favor *A. cochlioides*. Soil was watered, as needed, to keep moist. Notes were collected on initial emergence and stand counts were taken twice weekly. Seedlings were removed and a select number were prepared and microscopically examined to verify presence of *A. cochlioides*.

Results and Discussion

The controlled environment chamber study indicated that soil samples taken before the field treatments were applied in 1999 and 2000, exhibited high uniform root rot indices across all field plots in the experiment. When the chamber study was repeated with soil samples taken after sugarbeet harvest, high uniform *A. cochlioides* was again present across the unlimed and limed plots. This suggests that the lime had no direct effect on the pathogenicity of *A. cochlioides.*

In the low pH study, soil pH increased with time in plots that were limed at 3 and 10 t/A. Figure 1 illustrates the change in pH from initial addition of lime in1999 to 2001.

Unlimed field plot soil pH did not significantly change from 1999 to 2001. In 2000, the soil pH increased approximately one pH unit to 6.7 in the field plots limed at 3 ton/A. At the 10 ton/A rate, field plot soil pH rose approximately two pH units to 7.7. This is consistent with previous research (Bresnahan et. al, 1998). In 2001, plots limed at 3 ton/A did not change significantly from the previous year, however plots limed at 10 ton/A dropped to one pH unit from the initial soil pH before liming.

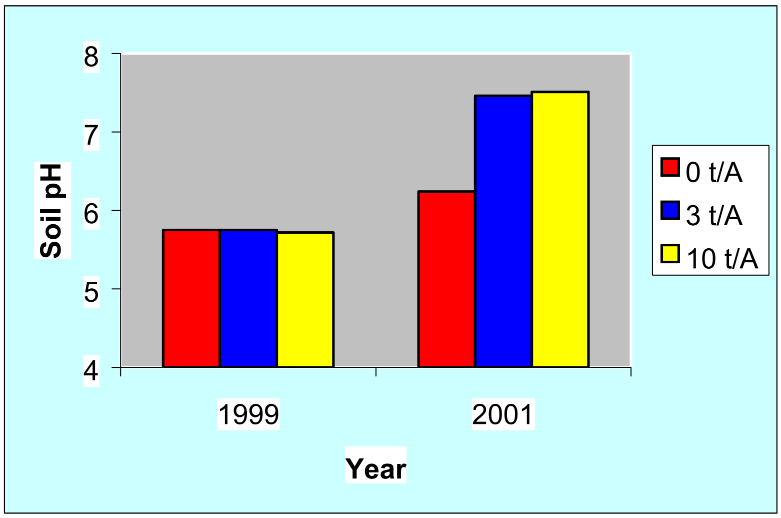


Figure 1

In the high pH field study the soil pH increased approximately 0.2 tenths of a pH unit at the 3 ton/A rate and approximately 0.5 tenths of a pH unit at the 10 ton/A rate.

Although the presence of *A. cochlioides* was uniform across all plots, both treated and untreated, sugarbeet root yield and extractable sucrose were significantly lower in the unlimed plots than in the limed field plots at Wolverton (Table 1, 2 and 3). Extractable sucrose increased 86% in plots limed at 3 ton/A compared with the untreated plots (Table 1). Plots limed at 10 ton/A had an increase of 132% extractable sucrose compared to the untreated plots. Extractable sucrose was 25% higher in plots limed at 10 ton/A as compared to 3 ton/A.

Table 1. Effect of Lime on Soil pH, Root Yield and Extractable Sucrose in 1999. (Wolverton South)

| Lime Treatment | Soil pH | Root Rot Rating* | Root Yield | Extractable Sucrose |
|---|---|---|---|---|
| 1999-S | | | t/A | lb/A |
| 0 ton/A | 5.9 | 2.7 | 6.7 | 1310 |
| 3 ton/A | 6.7 | 2.2 | 12.6 | 2434 |
| 10 ton/A | 7.7 | 1.8 | 16.0 | 3036 |
| LSD (0.05) | | 0.4 | 5.4 | 1055 |

*Root rot rating scale – 0 = healthy plant 7 = dead plant

Sugarbeet was again planted in the Wolverton south location in 2001. Although the yields were low, the differences between the limed and unlimed plots were even more apparent. Extractable sucrose increased 156% in plots limed at 3 ton/A compared with the untreated plots (Table 2). Plots limed at 10 ton/A had an increase of 387% extractable sucrose from the untreated plots. Extractable sucrose was 91% higher in plots limed at 10 ton/A as compared to 3 ton/A.

Table 2. Effect of Lime on Soil pH, Root Yield and Extractable Sucrose in 2001. (Wolverton South)

| Lime Treatment | Soil pH | Root Rot Rating | Root Yield | Extractable Sucrose |
|---|---|---|---|---|
| 2001-S | | | t/A | lb/A |
| 0 ton/A | 6.4 | 4.4 | 3.3 | 598 |
| 3 ton/A | 7.6 | 3.7 | 8.4 | 1528 |
| 10 ton/A | 7.8 | 3.1 | 14.0 | 2911 |
| LSD (0.05) | | 0.4 | 3.1 | 445 |

The Wolverton North location also exhibited the same trend as observed in Wolverton south in 1999 and 2001. Extractable sucrose increased 39% in plots limed at 3 ton/A compared with the untreated plots (Table 3). Plots limed at 10 ton/A had an increase of 84% extractable sucrose from the untreated plots. Extractable sucrose was 33% higher in plots limed at 10 ton/A as compared to 3 ton/A.

Table 3. Effect of Lime on Soil pH, Root Yield and Extractable Sucrose in 2001. (Wolverton North)

| Lime Treatment | Soil pH | Root Rot Rating | Root Yield | Extractable Sucrose |
|---|---|---|---|---|
| 2001-N | | | t/A | lb/A |
| 0 ton/A | 6.1 | 4.2 | 11.2 | 2480 |
| 3 ton/A | 7.3 | 4.3 | 14.3 | 3437 |
| 10 ton/A | 7.8 | 3.3 | 17.0 | 4556 |
| LSD (0.05) | | 0.9 | 4.1 | 1053 |

The Moorhead location provided higher yields than the Wolverton location. Sugarbeet from the unlimed plots yielded less than sugarbeet from plots limed at 10 ton/A. Extractable sucrose increased 33% in plots limed at 10 ton/A compared with the untreated plots (Table 4). No significant increase in extractable sucrose was observed where 3 ton/A of spent lime was applied. However, the same trend seen in the Wolverton location was also evidenced in the Moorhead location, even though the starting pH was 7.9 at Moorhead and 6.1 or 6.4 at Wolverton.

Table 4. Effect of Lime on Soil pH, Root Yield and Extractable Sucrose in 2001. (Moorhead)

| Lime Treatment | Soil pH | Root Rot Rating | Root Yield | Extractable Sucrose |
|---|---|---|---|---|
| | | | t/A | lb/A |
| 0 ton/A | 7.8 | 3.1 | 29.4 | 7899 |
| 3 ton/A | 8.1 | 3.1 | 30.0 | 8509 |
| 10 ton/A | 8.2 | 2.4 | 36.6 | 10479 |
| LSD (0.05) | | 0.9 | 4.1 | 1053 |

Sucrose percentage was similar in sugarbeet from limed and unlimed plots in both the Wolverton locations and the Moorhead location (data not presented).

## Conclusion

The addition of spent lime apparently enhanced the ability of the sugarbeet to resist the effect of *A. cochlioides* on root yield and extractable sucrose production. Plants apparently were generally healthier and produced better yields in soils with a pH over 6.5 (Bresnahan et. al, 1998). Soil pH does not appear to affect the overall population of *A. cochlioides.* Adjusting soil pH with spent lime increased growth of sugarbeet, which subsequently increased sugarbeet tolerance to disease. However, the observed response on high pH soil indicates that soil pH may not be the only factor for increased disease tolerance. Spent lime may have some unknown effect on the interaction between lime, sugarbeet and the disease organism. (High soil pH data is one year, one location and will be repeated.)

## References

Adams, M.J. 1991. Transmission of plant viruses by fungi. Appl. Biol. 118:479-492.

Bresnahan, G.A, Dexter, A.G., and Koskinen, W.C. 1998. The effect of soil pH on sugarbeet yield and herbicide degradation. Sugarbeet Research and Extension Reports. 29:82-88.

Papavivas, G.C., and Ayers, W.A. 1974. Aphanomyces species and their root diseases in pea and sugar beet. U.S. Dep. Agric. Tech. Bull. 1485. 158pp.

Rush, C.M. and Vaughn, K.M. 1993. Effect of irrigation, soil matric potential, and seed priming on sugar beet seed germination and damping-off caused by *Aphamnomyces cochlioides*. Phytopathology 62:1314-1317.