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THE EFFECT OF SPENT LIME ON SUGARBEET YIELD AND *APHANOMYCES COCHLIOIDES* SUPPRESSION

Gail A. Bresnahan[1], Alan G. Dexter[1], Carol E. Windels[2],
Jason R. Brantner[2] and John L Luecke[1]

[1] Plant Sciences Department, North Dakota State University
and the University of Minnesota, Fargo.

[2] Northwest Research and Outreach Center, University of Minnesota, Crookston

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 spent lime to soil on Aphanomyces root rot infection in sugarbeet an on *A. cochlioides* populations in low pH and high pH soils. To determine the effect of added spent lime to soil on sugarbeet yield in low pH and high pH soils.

Materials and Methods

Field: The field used for the low pH soil study was located near Wolverton, Minnesota. Soil pH ranged from 5.3 to 6.2. Soil type was sandy loam. *A. cochlioides* was present and uniform throughout the plots. 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 composition of the spent calcium carbonate was determined and is reported in Table 1. The field was seeded in 22-inch rows with '8277RR' sugarbeet from Hilleshog on April 28, 1999, May 3, 2001 and May 1, 2002. 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. Two applications of Roundup Ultra were used in the 2002 field trials. 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.

Table 1. Composition of Spent Lime

Element	PPM	Element	PPM
Phosphorus	5269	Zinc	40
Potassium	956	Copper	21
Calcium	297047	Boron	9
Magnesium	11115	Lead	0
Aluminum	3433	Nickel	1.5
Iron	3042	Chromium	8.6
Sodium	273	Cadmium	0.2
Manganese	223	Organics	5.6%

The field used for the high pH study was located near Moorhead, Minnesota. Soil pH ranged from 7.5 to 8.1. Soil type was a silty clay. *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 processing plant located in Moorhead, MN in the spring, 2000. The field was seeded in 22-inch rows with '8277RR' sugarbeet from Hilleshog on May 4, 2001 and May 1, 2002. Roundup Ultra was applied May 30, 2001 at 3 pt/A. Two applications of Roundup Ultra were also used in 2002 field trials. 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 to analyze soil pH levels.

Three 15 ft. row of sugarbeet was harvested from the middle of each plot in both of the above fields. 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. 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

Controlled Environment Chamber: 'Maribo 9363' sugarbeet was planted in soil taken from the Wolverton location in spring of 1999. 'Caribou' sugarbeet was planted in spring of 2000, 2001 and 2002. 'Caribou' sugarbeet was planted in soil taken from the Moorhead location in spring of 2000, 2001 and 2002. 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 Aphanomyces. 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 sampled before the field treatments were applied in 1999 at the Wolverton location and 2000 at the Moorhead location, exhibited high uniform root rot indices across all field plots. When the chamber study was repeated in 2000 and 2001 with Wolverton soil and in 2001and 2002 with Moorhead soil, high uniform *Aphanomyces* was again present across the unlimed and limed plots at both locations. This would suggest that lime had no direct effect on the pathogenicity of *A. cochlioides.* However, in 2002, at Wolverton, root rot indices were affected by spent lime (Table 2). Root rot indices fell from 93 to 100% in the unlimed plots to 62% in the plots limed at 3 and 10 t/A at the Wolverton location.

Table 2. Root Rot Index 2002 - Wolverton

Spent Lime Treatment	Root Rot Index
	%
Unlimed	93-100
3 t/A Lime	62
10 t/A Lime	62

Soil pH increased with time in plots that were limed at 3 and 10 t/A at the Wolverton location. Figure 1 illustrates the change in pH from initial addition of spent lime in 1999 to 2002. Unlimed field plot soil pH did not significantly change from 1999 to 2002. 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 2002, plots continued to maintain a consistent increase of approximately one pH unit when limed at the 3 ton/A and two pH units when limed at 10 ton/A.

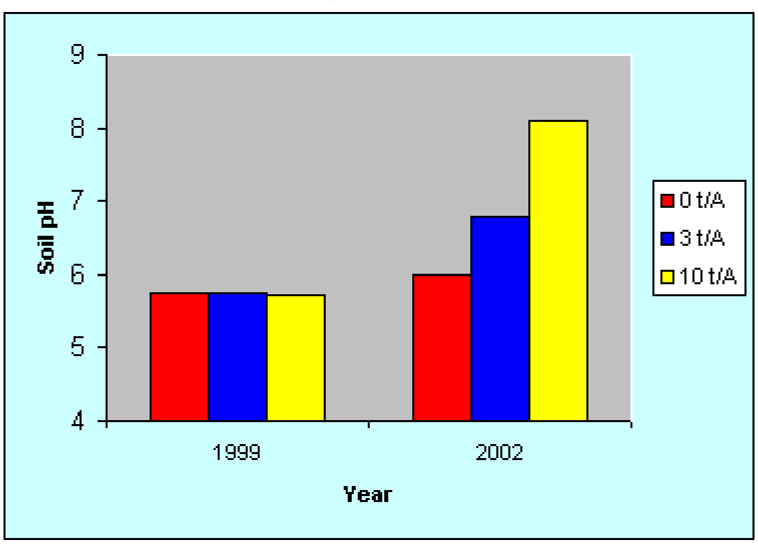

Figure 1

Soil pH did not increase significantly from the 3 ton/A or 10 ton/A rate at the Moorhead location (data not shown).

Results were averaged across years for Wolverton. The sugarbeet root yield and extractable sucrose were significantly lower in the unlimed plots than in the limed field plots, this trend was consistent from 1999 to 2002 (Table 3). Extractable sucrose on average increased 40% in plots limed at 3 ton/A compared with the untreated plots. Plots limed at 10 ton/A had an increase of 54% extractable sucrose from the untreated plots. Extractable sucrose was 23% 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 (Wolverton)

Spent Lime Treatment	Soil pH	Root Yield	Extractable Sucrose
1999-2002		ton/A	lb/A
0 ton/A	6.0	7.7	1581
3 ton/A	6.8	12.3	2630
10 ton/A	8.1	15.4	3422
LSD (0.05)		3.2	830

Results were averaged across years at Moorhead. Consistently higher sugarbeet yields were produced at the Moorhead location as compared to yields from the Wolverton location (Table 4). Although not significant, sugarbeet yield in the Moorhead location followed a similar trend as the Wolverton location. Sugarbeet from the unlimed plots yielded less than sugarbeet from plots treated with lime.

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

Spent Lime Treatment	Soil pH	Root Yield	Extractable Sucrose
2000-2002		ton/A	lb/A
0 ton/A	7.9	14.5	3771
3 ton/A	8.1	14.8	3877
10 ton/A	8.2	15.4	4135
LSD (0.05)		2.1	637

Sucrose percentage was similar in sugarbeet from limed and unlimed plots at both locations.

Conclusion

Soil that was treated with spent lime produced generally healthier sugarbeet and higher yields than the unlimed plots at both locations. (Bresnahan et al, 1998). The overall population of *A. cochlioides* in 1999 and 2001 was unaffected by the spent lime treatment at both locations. However, in 2002, the Wolverton location showed a decrease in the population of *A. cochlioides* when plots were treated with spent lime at both the 3 T/A and 10 T/A rate. This decrease may be attributed to a component or combination of components in the spent lime which may adversely affect the *A. cochlioides* population. Or, *A. cochlioides* populations in soil could be reduced by increased growth and health of the sugarbeet itself. A healthier sugarbeet may have more tolerance to *A. cochlioides* infection which subsequently could also have an impact on the population. An unknown interaction between the spent lime, sugarbeet and the disease organism is also possible. Further research is needed in an effort to determine what factors are responsible for the observed decrease in *A. cochlioides* population and increased sugarbeet yield.

References

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