A *Cercospora* leaf spot management program for American Crystal Sugar Company growers in 1999-2000

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Introduction

*Cercospora* leaf spot caused an estimated $40,000,000 loss in revenue to American Crystal Sugar Company shareholders during the 1998 crop year. Both yield and quality declined and storage losses of sucrose increased. A majority of all fields had disease severity well above economic loss levels. That significant amount of loss was suffered after those shareholders spent $20,000,000 for *Cercospora* control in 1998.

The money spent for control was in the face of moderate to high levels of disease resistance and tolerance to the available fungicides. Triphenyltin hydroxide (TPTH) and benzimidazole fungicides have been used in North Dakota and Minnesota for *Cercospora* control for nearly twenty years. However, the *Cercospora* fungus developed resistance to Topsin and Benlate (benzimidazole fungicides) in North Dakota and Minnesota in the early 1980’s, and the USDA lab in Fargo found tolerance to TPTH in the Southern Minnesota beet growing area in 1994. The evidence of tolerance to TPTH prompted the Sugarbeet Research and Education Board of Minnesota and North Dakota to fund projects to determine the extent and severity of resistance and tolerance to fungicides starting in 1995 and continuing each year since 1995.

The objective of the *Cercospora* management program implemented in 1999 was to cost effectively reduce *Cercospora* severity below economic loss levels in all fields in spite of the moderate to high levels of disease resistance and tolerance to the available fungicides.

Procedures

In the late summer of 1998 American Crystal Sugar Company agronomists collected infected leaf samples from over 700 fields throughout the Red River Valley. The samples were taken to the USDA-ARS Fargo Laboratory and tested for levels of resistance to thiophanate methyl (TM; a benzimidazole), and tolerance to TPTH and Mancozeb. Spores obtained from the samples were transferred to each of seven petri plates containing unamended potato dextrose agar (PDA), PDA + 0.2 ppm TPTH, PDA = 1.0 ppm TPTH, PDA + 5 ppm Mancozeb, PDA + 10 ppm Mancozeb, and PDA + 5 ppm benomyl. The cultures were incubated at 22°C and evaluated for growth at 5 to 7 days after plating.

The results from the tests were presented as the percent of leaf spots that exhibited tolerance to TPTH and Mancozeb and resistance to TM at the various levels. Site specific management maps were created from the test results, pin pointing the severity of resistance and tolerance to fungicides by section (1 square mile) or township (36 square miles). The maps were created in the geographic information system (GIS), ArcView™.
For this paper, we will report the results summarized on a township basis for tolerance to TPTH at 0.2 ppm, to Mancozeb at 5 ppm and resistance to benzimidazole at 5 ppm. The tolerance and resistance was grouped into five categories of percent of leaf spots that exhibited the tolerance or resistance. Zero percent represented no tolerance or resistance; 1% to 25% was low tolerance or resistance; 26% to 50% was moderate tolerance or resistance; 51% to 75% was high tolerance or resistance; and, 76% to 100% was very high tolerance or resistance.

American Crystal Sugar Company agronomists met with North Dakota State University, University of Minnesota and USDA research scientists and extension specialists to plan resistance management utilizing the maps and other grower education efforts. In addition to the usual one on one agronomy services, information was provided to the growers by newsletter, radio, news releases, tape recorded messages, DTN (the Data Transmission Network) and the internet. Through the American Crystal Sugar Company grower practices system the Company agronomists documented efficacy of the grower implemented disease control programs on 50% of all fields in 1999.

A similar program was carried out in the fall of 1999 with the similar procedures. In addition to the site specific maps created with the 1999 data, site specific maps were made comparing the tolerance and resistance found in 1999 fields to that found in 1998 fields. The comparisons were grouped into three categories. Less tolerance or resistance indicated that the area was less tolerant or resistant in 1999 than it was in 1998. The same tolerance or resistance indicated the same level both years and more tolerant or resistant indicated that the area was more tolerant or resistant in 1999 than it was in 1998.

Results and Discussion

Figures 1, 2 and 3 below are maps of the Red River Valley region of North Dakota and Minnesota. The beet growing area stretches from the Canadian border on the north end some 200 miles to the South Dakota border and is some 40 to 80 miles wide. The five factory locations for American Crystal Sugar Company are shown. All of the maps for the 1998 study and the comparison of 1999 and 1998 will have the same geographic extent. The 1999 maps include the Minn-Dak Farmers Cooperative and The Southern Minnesota Beet Sugar Cooperative growing areas.

The first map, Figure 1, displays the tolerance to TPTH at 0.2 ppm. Notice that moderate to very high tolerances are spread throughout the Red River Valley but the occurrence of high to very high tolerance is concentrated in the south part of the American Crystal Sugar Company growing area in the Moorhead factory district. In the south end of the valley there are even fewer townships with no tolerance than the few found in the north end.

Figure 2 displays the resistance to benzimidazole at 5 ppm. This map shows some very high tolerance spread throughout the valley but this time the concentration of high and very high tolerances occur in the north end of the valley, north of Crookston and East Grand Forks.
Figure 1. Cercospora Tolerance Study - 1998
TPTH at .2 ppm

Tolerances and resistance are summarized by township
Figure 3 displays the tolerance to Mancozeb at 5 ppm. Here the tolerance is concentrated in the far north end of the valley, in the Drayton factory district but stretching down into the East Grand Forks district. The high tolerances found in this region is due to the use of Mancozeb in almost the entire crop rotation including potatoes, beans, wheat and sugarbeets. *Cercospora* surviving on alternate hosts would receive Mancozeb application nearly every year.

**Figure 2. Cercospora Resistance Study - 1998**

*Benzimidazole at 5 ppm*
With the geographic distribution of the tolerance and resistance to fungicides shown in the figures above, American Crystal agronomists made some relatively specific recommendations for the 1999 crop: They recommended that Mancozeb use should be limited in the Drayton factory district. Topsin and Benlate should only be used once per season the then only in a tank mix. But in high or very high resistance areas the use of Topsin and Benlate was completely discouraged. The new fungicide, Eminent must be alternated with other fungicides.
Apply the correct number of applications, don’t quit early.

The effort of disseminating this information included not only one to one exchanges but also by newsletters; radio; new releases; tape recorded messages; posters at area applicator offices, elevators and dealers; DTN and the internet. With the growers responding to the advice, the effect was reducing fungicide applications by 10% from the 1998 crop while reducing the revenue loss to 10% of the 1998 levels. Table 1 below shows some 1999 crop results based on the number of fungicide applications applied. The data are drawn from a survey of 2301 fields. Notice that in all but one case did the number of applications increase crop revenue per acre. In all cases four applications of fungicide show the highest revenue.

<table>
<thead>
<tr>
<th>Number Of Sprays</th>
<th>Moorhead</th>
<th>Hillsboro</th>
<th>Crookson</th>
<th>East Grand Forks</th>
<th>Drayton</th>
<th>Red River Valley</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>$580</td>
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<td>$633</td>
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In the fall of 1999, American Crystal Sugar Company agronomists again sampled the same general areas that they did in 1998. In addition to the above samples, agronomists from Minn-Dak Sugarbeet Cooperative and Southern Minnesota Beet Sugar Cooperative also sampled their areas and those samples were included in the maps. Their factory locations, Wahpeton and Renville are also shown on the maps. Figures 4, 5 and 6 below are maps of tolerance to TPTH at 0.2 ppm, Topsin M at 5 ppm and Mancozeb at 5 ppm. The results of the testing done at the USDA lab in Fargo are summarized by township into the same five catagories as were the 1998 results.

Figure 4 again show tolerances to TPTH spread throughout the Red River Valley but in the American Crystal Sugar growing area the concentration is in the soouthern part. Note the heavy concentration of very high tolerance in both the Minn-Dak and the Southern Minnesota growing areas.

Figure 5 shows high and very high resistance to Topsin M throughout the Red River Valley, from the Canadian border down through the Minn-Dak growing area. The Southern Minnesota growing area has a much more moderate resistance than the northern areas. However, they have not used TM for fifteen years.

Figure 6 shows little tolerance to Mancozeb in any of the areas sampled. Only a few townships show moderate tolerance.
Figure 4. Cercospora Tolerance Study - 1999
TPTH at .2 ppm

Tolerances and resistance are summarized by township.
Figure 5. Cercospora Resistance Study - 1999
Topsin M at 5 ppm

Tolerances and resistance are summarized by township.
For the 1999 crop study, we also included comparison maps, comparing the 1999 levels of tolerances and resistance to the 1998 levels. Three categories were defined; less tolerance or resistance, the same tolerance or resistance and more tolerance or resistance. Figures 7, 8 and 9
below are maps with those comparisons for tolerance to TPTH at 0.2 ppm, resistance to benzimidazole at 5 ppm and tolerance to Mancozeb at 5 ppm.

Figure 7 - Cercospora Tolerance Study
1999 - 1998 Comparison - TPTH at .2 ppm

Tolerances and resistance are summarized by township.
It is quite clear from the above map that tolerance to TPTH grew much worse in 1999 than it was in 1998. Resistance to benzimidazole also increased in the 1999 crop from 1998 in most areas.
Figure 9 shows some localized areas of increased tolerances and a large area of decreased tolerances, especially in the Drayton district.
American Crystal Sugar Company agronomists again gave some specific recommendations for fungicide use for the 2000 crop; Topsin and Benlate should only be used in tank mixes and never more than once per season. South of Highway 2 (a line drawn between Crookston and East Grand Forks and then straight west of East Grand Forks) use Eminent first followed by TPTH and continue to alternate. North of Highway 2 use TPTH first followed by Eminent and continue to alternate in that fashion. North of Highway 2 Topsin and Mancozeb tank mixes should be used only in sections or townships with moderate to low resistance levels. Never use Topsin or Benlate alone. Always tank mix with a Mancozeb product. Never use Topsin or Benlate more than once per year.

Table 2 below shows some 2000 crop results per acre based on the number of applications of fungicides. These data are summarized from 2317 fields that were surveyed by American Crystal Sugar company agronomists. Included in this table are some results for zero applications of fungicide. The missing data in some of the cells reflect fewer than 10 observations.

<table>
<thead>
<tr>
<th>Number Of Sprays</th>
<th>Moorhead</th>
<th>Hillsboro</th>
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<th>Drayton</th>
<th>Red River Valley</th>
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Given the good results realized by the management program in 1999 that nearly eliminated grower yield loss to *Cercospora* in 1999 and greatly reduced those losses for the 2000 crop, where do we go from here? With the usefulness of the site specific maps used in this program, American Crystal Sugar Company agronomists are making some recommendations for the 2001 crop: There is a need to know the levels of resistance and tolerance in a growers local area. The growers need to consider resistant seed varieties. There is a need to consider seed variety/planting date/application date interactions along with planting date/application date interaction. Back to back applications of Eminent must be eliminated.

Along with these recommendations comes a word of warning. American Crystal Sugar Company had 15% of all the fields surveyed sprayed with Eminent alone or back to back Eminent. If that practice continues the *Cercospora* fungus will develop resistance to Eminent within 5 years.