



# A Management Model for Cercospora Leaf Spot of Sugarbeets

Roger K. Jones  
Extension Plant Pathologist  
Dept. of Plant Pathology, St. Paul, MN

Carol E. Windels  
Associate Professor of Plant Pathology  
NW Experiment Station, Crookston, MN

Cercospora leaf spot is the most economically important disease of sugarbeets in Minnesota and North Dakota. The disease is caused by the fungus *Cercospora beticola*. Cercospora leaf spot can be controlled with the integrated use of resistant varieties, cultural practices, and foliar fungicides. To assist growers in making profitable decisions regarding the application of foliar fungicides, components of a predictive model were developed by the University of Minnesota. This bulletin will describe all components of the predictive model and relate these to the Cercospora Spray Advisory program available to sugarbeet growers through local cooperatives.

## The Cercospora Management System

The Cercospora Management System is a comprehensive approach to reducing losses from Cercospora leaf spot. It is composed of several key components that are used together

to obtain the most profitable management of the disease. The system consists of planting **approved varieties** (screened for susceptibility to Cercospora leaf spot) in fields with a **minimum rotation interval of one year in three**. Leaf spot control in these fields can then be profitably achieved using the **Cercospora Spray Advisory** in conjunction with **field monitoring** to determine the need and timing for fungicide applications. Failure to utilize all components of the Cercospora Management System can result in less than desired control of this important disease.

## Varietal Resistance

Varieties differ in their susceptibility to Cercospora leaf spot. Since 1982, the Variety Approval System has supported rigorous screening of commercial varieties for their reaction to Cercospora leaf spot. This screening, conducted annually at Betaseed's Cercospora Screening Nursery in Shakopee, MN, requires all

approved sugarbeet varieties to exhibit a 5.5 rating or less on the expanded 0-9 Kleinwanzlebener Saatzucht scale (KWS Scale). Varieties are rated twice weekly from late July until early September. Final ratings are then compiled from the average of these weekly ratings. An approved variety must demonstrate a final Cercospora rating of less than 5.5 (as set by individual cooperatives) when averaged over 3 years. Screening varieties for their reaction to Cercospora leaf spot eliminates highly susceptible varieties from commercial production. Most currently approved varieties range in Cercospora leaf spot rating from 4.5 to 5.5 on the 0 - 9 KWS scale. Varieties with ratings in this range are considered moderately resistant to moderately susceptible to Cercospora leaf spot. This limited susceptibility makes control of Cercospora leaf spot possible when it is combined with crop rotation and the judicious use of effective foliar fungicides.

ST. PAUL CAMPUS  
LIBRARIES

## Pathogen Survival and Disease Onset

The *Cercospora* leaf spot fungus may be seedborne, but more often, disease is initiated from old infected leaf residue of previous sugarbeet crops. *C. beticola* can survive for at least 2 years as mycelia and spores in leaf debris. Survival of the fungus during the off-season is an important link in the recurrence of the disease. Tilling beet residue into soil helps reduce survival and spread of the fungus. Weed hosts likely are insignificant in survival of the fungus.

Crop rotations that involve a minimum of 2 years out of beet production on a particular field are critical to the successful use of the *Cercospora* Management System. Shorter rotations allow for significant survival of the fungus in crop debris and can result in higher levels of initial infection. This makes subsequent control with fungicides much more costly and difficult.

Disease onset is governed by the presence of overwintering spores of the fungus (primary inoculum) and is regulated by environmental factors such as temperature and relative humidity. Although spores may be present in debris, initial infections are seldom found before mid June to early July.

### Conditions for Infection

Spores of *C. beticola* require moisture to germinate and infect leaves in much the same way that seeds require moisture to germinate and grow. And like seed, these fungus spores germinate within a particular temperature range. If conditions are too cold, too hot, or too dry, spores fail to germinate and infections do not occur. The optimum temperature for spore germination is

Hrs/Day >90° RH	Daily Infection Condition Value																																		
24	1	2	4	5	5					7	7	7	7	7	7	7	7	7	7	7	3														
23	1	2	3	4	5																7	3													
22	1	1	3	4	5																	7	3												
21	0	1	2	4	4	5	5	5	5	5													7	3											
20	0	1	2	3	4	5	5	5	5	5														7	3										
19	0	0	1	3	4	5	5	5	5	5															7	3									
18	0	0	1	2	3	4	4	4	4	4	5	5	5	5	5											7	3								
17	0	0	1	2	3	4	4	4	4	4	4	5	5	5	5												7	3							
16	0	0	0	2	3	4	4	4	4	4	4	4	4	4	5													7	3						
15	0	0	0	1	3	4	4	4	4	4	4	4	4	4	4	5													7	3					
14	0	0	0	1	3	3	3	3	3	3	3	4	4	4	4	4	5													7	3				
13	0	0	0	0	3	3	3	3	3	3	3	3	4	4	4	4	4	5													7	3			
12	0	0	0	0	2	3	3	3	3	3	3	3	3	4	4	4	4	5													7	3			
11	0	0	0	0	2	3	3	3	3	3	3	3	3	3	3	3	4	5														7	3		
10	0	0	0	0	2	2	2	2	2	2	2	3	3	3	3	3	3	4	4														7	3	
9	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	4	5												3		
8	0	0	0	0	1	2	2	2	2	2	2	2	2	2	2	2	2	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	
7	0	0	0	0	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	
6	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	4	4	4	4	4	4	4	4	4	4	4	4	3	
5	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	
4	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Temp °F 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94

**Figure 1: Daily Infection Condition Values for *Cercospora* leaf spot as calculated from the number of hours per day with relative humidity greater than 90% and the average temperature during those hours.**

76°F when relative humidity is 100%. Under these conditions, spores will germinate and penetrate the leaf surface in about 8 hours.

Infection will occur over a range of temperatures and relative humidities wider than just the optimum. Penetration of a germinating spore into a stomate on the leaf surface will require longer periods of favorable humidity at temperatures below 76°F. Infections will rarely develop at any temperature if relative humidities fall below 70%.

Temperature and relative humidity conditions favorable for infection of sugarbeet leaves by *C. beticola* are measurable. This information can then be used to generate a Daily Infection Condition Value (DICV). The DICV indicates if environmental conditions have been favorable or unfavorable for infection by spores of the fungus. The DICV can be obtained by input of the total

number of hours with relative humidities greater than 90% for the previous 24 hour period (beginning at midnight) and the average temperature during those hours (**Figure 1**).

### Disease Spread

Successful infection by the *Cercospora* fungus usually requires 7 days or more to result in spots on the leaves that are visible to the naked eye. During this time, the fungus is growing from its initial penetration site (stomates on the leaf) to invade and kill cells in the surrounding leaf tissue. Individual leaf spots are restricted in size and seldom attain a diameter of more than 1/4 inch. Resistant reactions by cells of the sugarbeet leaf will “wall off” the fungus and prevent further spread within the leaf. This resistant reaction is characterized by a dark reddish brown circle that surrounds and defines the small leaf spot.

In susceptible varieties, the

fungus is not completely walled off and chlorotic (yellow) halos of leaf tissue surround the brown circle. The chlorophyll in this yellow tissue has been damaged by toxins produced by the fungus. The ability of this chlorotic leaf area to capture sunlight and produce sug-

ars for later movement into the taproot has been significantly reduced.

The center of each individual leaf spot is typically tan to grey in color. Spores are produced on the upper surface of the leaf spot (**Figure 2**). The

production of new spores occurs over a temperature range of 50 to 95°F, which is broader than the range of temperatures over which infection occurs. The optimum temperature for sporulation is 86°F. Sporulation requires at least 12 hours of high (greater than 90%) rela-

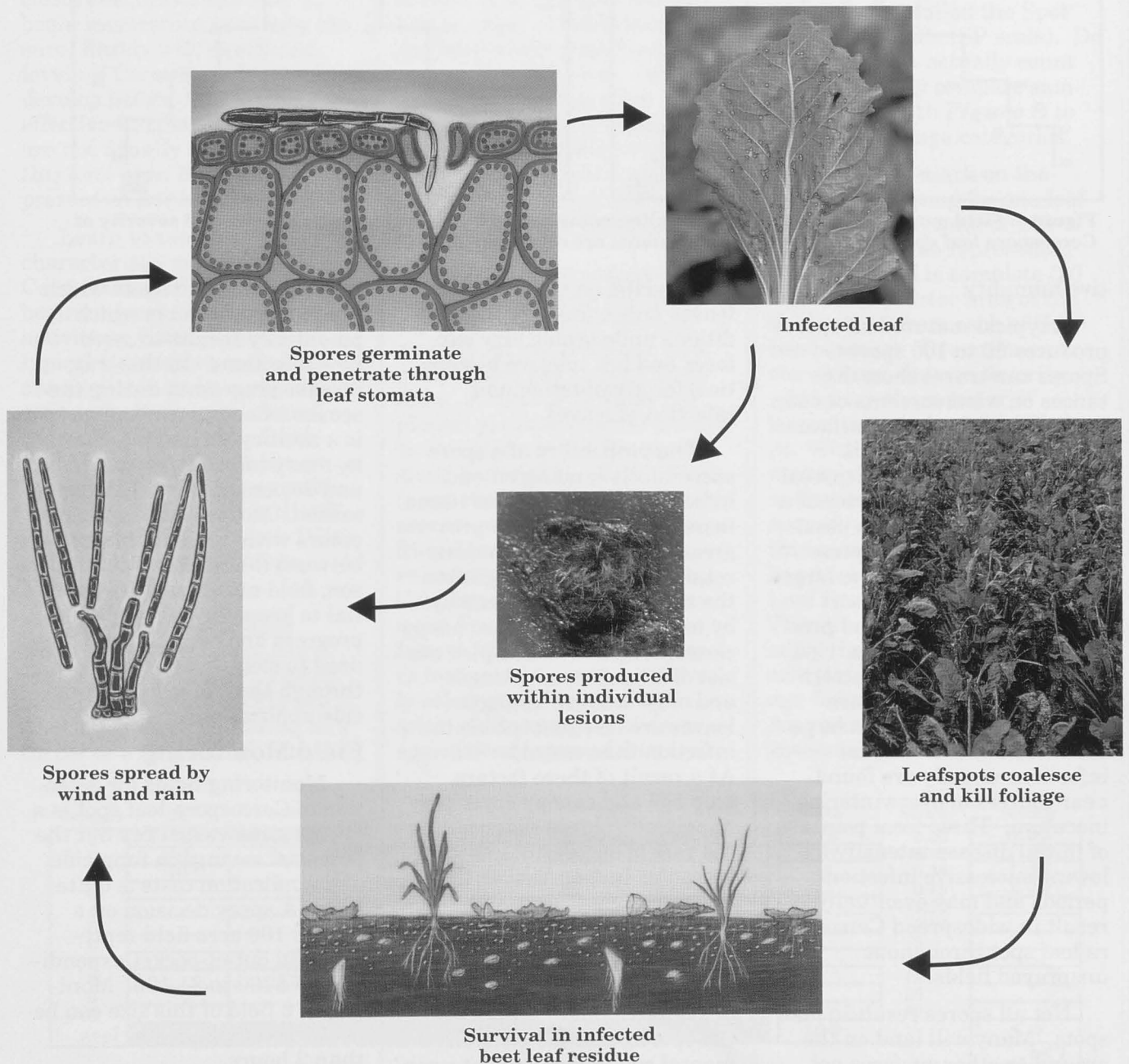
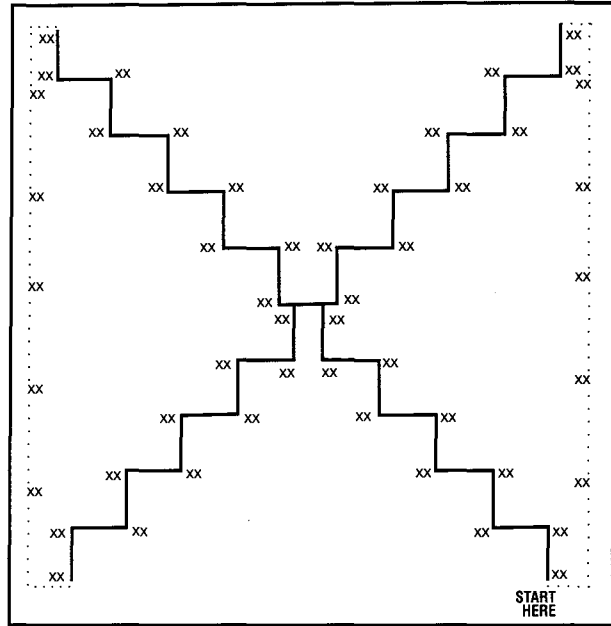
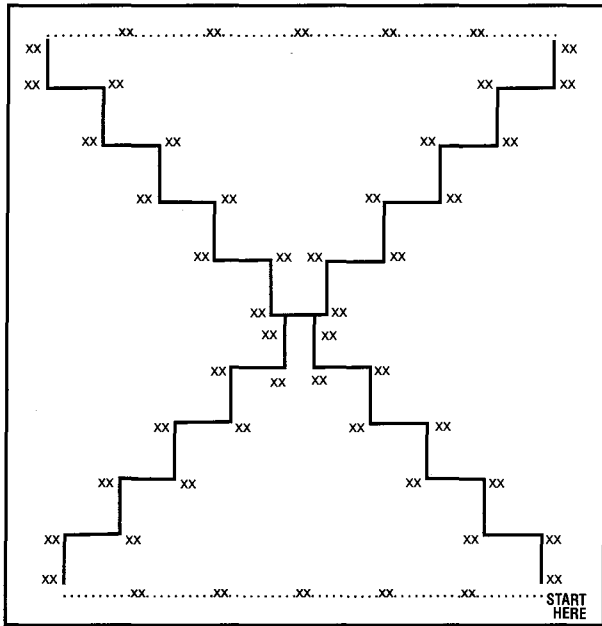


Fig. 2: Disease cycle of *Cercospora* leaf spot of sugarbeet caused by *Cercospora beticola*.



**Figure 3: Field monitoring schemes used on alternating weeks to determine the incidence and severity of *Cercospora* leaf spot of sugarbeet. Sampled plants are represented by an X.**

tive humidity.

A typical mature leaf spot produces 50 to 100 spores. Spores can travel short distances on wind currents or can be dislodged from the surface of the leaf spot when it is struck by raindrops. Dispersal of spores of up to a quarter of a mile in wind currents is possible. Usually spores disperse along a gradient with the large majority moving very short distances (a few feet) and progressively fewer being carried farther away. Such a pattern of dispersal causes intense patches of the disease in large commercial fields. Initial infections usually are found near sources of overwintering inoculum. These focal points of initial disease intensify following successive infection periods and may eventually result in widespread *Cercospora* leaf spot throughout unsprayed fields.

Not all spores result in leaf spots. Many will land on the ground or other surfaces not suitable for infection. Spores

that do land on sugarbeet leaves may encounter leaf conditions unfavorable (dry surfaces and low relative humidities) for germination and infection of leaves.

The probability of a spore successfully landing on and infecting susceptible leaf tissue increases as the season progresses. Sugarbeet canopies retain leaf wetness long into the morning hours especially by mid-season when the canopy closes. Sugarbeet canopies consist of a mixture of younger and older leaves. Younger leaves are less susceptible to infection than are older leaves. As a result of these factors, crop age and canopy cover play important roles in determining the rate of successful infection by spores in a particular field.

The number of new leaf spots is a product of the number of existing spots that are producing spores, the number of available landing sites for the spores, and the environmental conditions present upon landing. Successful infections

produce more leaf spots which produce more spores which potentially results in more new infections. In this way, disease progresses during the season. *Cercospora* leaf spot is a multicyclic disease. That is, many infection cycles can and do occur during a given season. Most disease spread occurs within a field and not between fields. For this reason, field monitoring is essential to keep abreast of disease progress and to determine the need to slow disease progress through the use of foliar fungicide applications.

### Field Monitoring

Monitoring fields for detection of *Cercospora* leaf spot is a labor-intensive activity but the potential savings in fungicide and application costs is quite high. A spray decision on a typical 100 acre field represents an out-of-pocket expenditure of \$700 to \$1,100. Monitoring a field of this size can be easily accomplished in less than 2 hours.

The objectives of field moni-

toring are divided into two phases. These phases are referred to as *Initial Detection* and *Spray Delay*. Field monitoring for the Initial Detection of *Cercospora* leaf spot in a field should begin on or about July 1 (slightly earlier in Southern Minnesota). This date should correspond to the approximate date of canopy closure in most fields. If canopy closure occurs before July 1, begin monitoring at canopy closure. Rarely will significant levels of *Cercospora* leaf spot develop before July 1. Cost effective fungicide applications are not usually made before this date even if the disease is present at low levels.

Learn to recognize the characteristic symptoms of *Cercospora* leaf spot before beginning any field monitoring activities. Color pictures of typical *Cercospora* leaf spots are available in several publications including the annual Sugarbeet Production Guide and "Cercospora Leafspot of Sugarbeet" (available as publication PP-764 from the NDSU Extension Service, North Dakota State University, Fargo, ND 58105).

If possible, walk fields when leaves are free of morning dew. An X-shaped, zigzag pattern is suggested (*Figure 3*). Commence monitoring at a corner of a field. Walk into the

field a set number of rows then walk up between the rows a set number of feet. Walk over a set number of rows and then walk up the set number of feet. Pay close attention where fields border hedgerows, windbreaks and ditches. *Cercospora* leaf spot may develop earlier in areas protected from wind or near water since leaves will remain wet for longer periods of time. Also pay close attention to edges of fields that border land where sugarbeets were grown last year. *Cercospora* leaf spot is often detected first along edges of fields bordering last year's sugarbeets. This is particularly true if severe leaf spot developed in that field last year.

Scan the beet canopy as you go, especially along the field borders. Record the disease severity on two plants at each point where you change directions. A total of 10 stops (20 plants) per field quarter should be sampled. Make five stops along both field borders. Closely examine all leaves on these sample plants. If all leaves are free of *Cercospora* leaf spot, record them as zeros on the *Cercospora* Leaf Spot Assessment Form (*Figure 4 and Insert Figure A*). If *Cercospora* leaf spot is present, randomly select one lower leaf and estimate its category of damage. The category of damage

for each plant sampled should be recorded as the scout progresses through the field.

To make the assessment easy and fast, use the damage categories (*Insert Figure B*). Damage categories are determined from the average number of spots per leaf at low disease severities and a percent severity value at higher levels of disease intensity. This rating system is called the Spot Percentage scale (SP scale). Do not attempt to actually count spots. Visually compare sampled leaves with *Figure B* to establish damage categories.

Each tally mark on the sheet is the rating for one leaf on one plant. A total of 100 plants should be represented when the field is complete (20 from each quarter area of the field and 10 from each of the two borders). To summarize the average disease severity, add across the number of leaves in each damage category. With a hand calculator, multiply the number of leaves in that category by the percent severity of that category. Put this number in the far right hand column of the *Cercospora* Leaf Spot Assessment Form. The sum of this column, divided by the number of plants sampled (100) gives the average % Severity for this field. An example of a completed assessment for a sugarbeet

Damage Category	SE	NW	Border	NE	SW	Border	Total	% Severity	Average Severity
0							75	0.00	0.00
1							17	0.10	1.70
2							5	0.35	1.75
3							3	0.75	2.25
4								1.50	
5								2.50	
6								3	
7								6	
8								12	
9								25	
10								50	
							100		5.7
									.057

Figure 4: A *Cercospora* Leaf Spot Assessment Form completed for a sugarbeet field near Milan, MN on August 15.

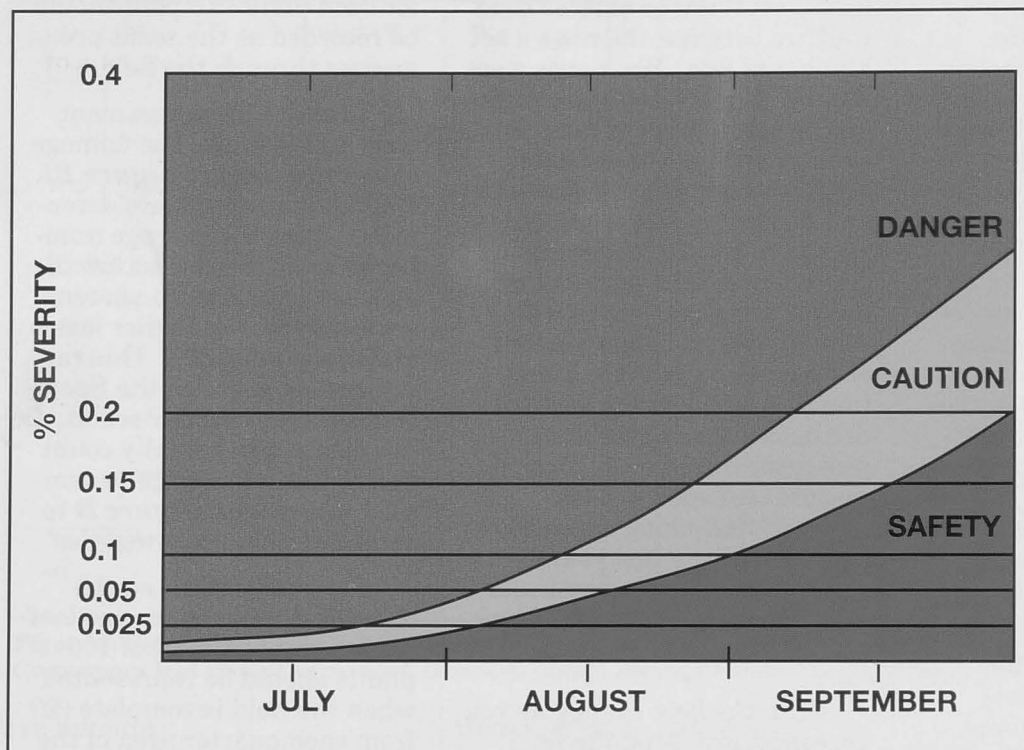


Figure 5: Action zones for Cercospora leaf spot of sugarbeet.

field near Milan, Minnesota, conducted on August 15 is shown in **Figure 4**. The average severity is .057 percent (5.7 divided by 100). This % Severity exceeds the amount of disease considered safe for an unsprayed field (**Figure 5**).

When confirmed Cercospora leaf spot exceeds the Safety Zone threshold for a given calendar date (**Figure 5**), a fungicide spray should be applied to the field. As long as the average % Severity remains within the Safety Zone, fungicide applications are not economical. As soon as the average % Severity enters the Caution Zone, an initial fungicide application should be made. Use recommended rates of protectant materials. Always be conscious of pre-harvest intervals.

Cercospora Leaf Spot Assessment Forms are available from your County Extension Agent and from your local cooperative. Leaves with

unusual or atypical spots which you suspect are not caused by *Cercospora beticola* should be collected and taken to your local County Extension Agent or Sugarbeet Agriculturist for positive identification.

All fields should be examined at least once before July 15. Fields should be monitored once per week for 8 to 10 weeks thereafter, or until the average disease severity exceeds the Safety Zone as determined in **Figure 5**. Monitoring conducted in this manner will represent a maximum time investment of less than 15 minutes per acre per season on a typical 100 acre field. Remember to select a slightly different walking pattern each time fields are monitored. This will ensure that different plants are sampled each week. A total of 100 plants should be sampled in each field each week. Sample plants along alternate sides of the field boundary during successive weeks (**Figure 3**).

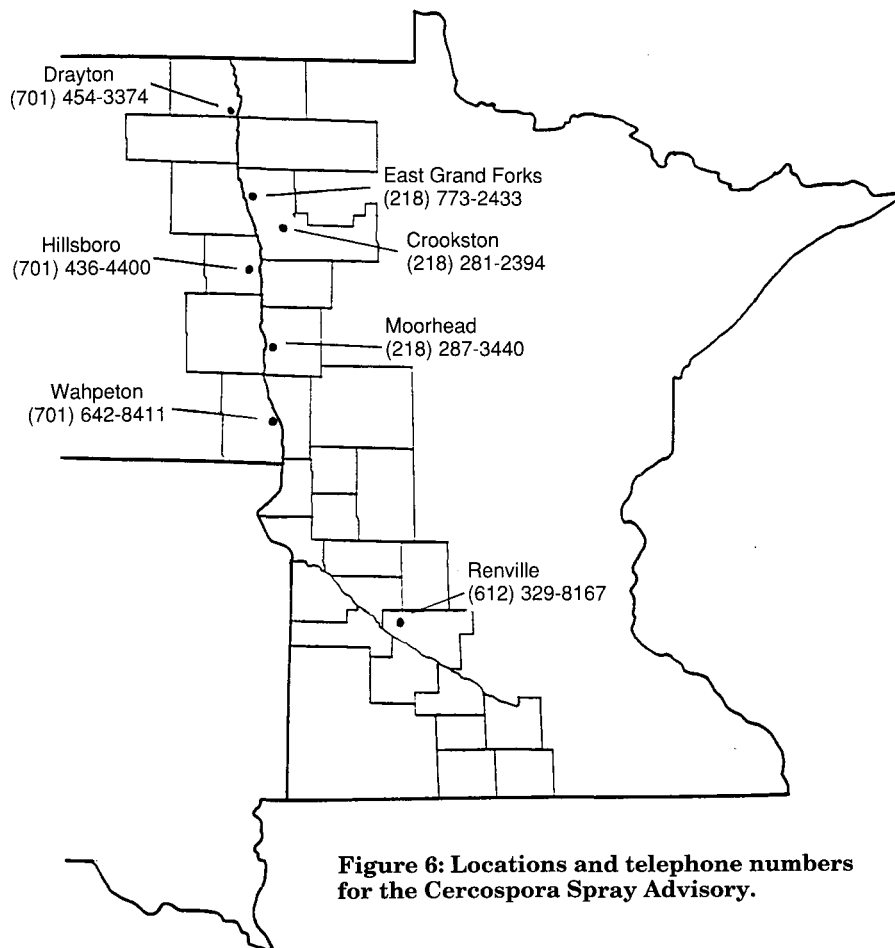
## The Cercospora Spray Advisory and Subsequent Fungicide Sprays

Significant yield loss occurs when the average incidence of Cercospora leaf spot reaches 3% at harvest. To reduce the potential for the development of Cercospora leaf spot, Minnesota and North Dakota Sugarbeet Factory Districts have made a daily Cercospora Spray Advisory available to growers in the immediate vicinity. This advisory is available via telephone recordings at

the local factory offices and certain beet receiving stations.

The advisories are the result of a sophisticated computer link between the offices and CR-21 or CR-10 weather stations located in each factory district (**Figure 6**). The weather stations are equipped with a humidity probe set 2 inches below the top of the leaf canopy. Measurements begin when the leaves start covering the rows. An air temperature probe is active in each instrument.

A computer at each factory district automatically calls each weather station at 1:00 a.m. and transfers information on temperature and relative humidity for the previous 24 hours. A simple program then computes the Daily Infection Condition Value (DICV) from this information. The computer program then calculates the 2 day Cercospora Spray Advisory. Each morning by 9:00 a.m.,



**Figure 6: Locations and telephone numbers for the Cercospora Spray Advisory.**

the local factory Agricultural Staff get the Cercospora Advisory via Fax and update the situation on the telephone answering machines. Growers calling the numbers listed in **Figure 6** will receive information that is updated daily.

The Cercospora Spray Advisory describes the potential for infection by *C. beticola* that existed during the previous 48 hours in a single whole number. The Cercospora Spray Advisory is determined by adding together the DICV's for the two preceding 24 hour periods. Conditions for infection during this period have been unfavorable if the sum of the DICV's for the previous 2 days is less than 6. Conditions favorable for infection are the result of two successive DICV's that add up to more than 6. A

value of 6 represents marginal conditions for infection during the preceding 48 hours.

Valley growers north of the Polk - Norman county line should apply a fungicide as soon as disease severity enters into the Caution Zone (**Figure 5**). Resume field monitoring immediately after this first spray interval lapses (14 days later for triphenyl tin hydroxide or TPTH fungicides and 10 days later for mancozeb) to determine if and when subsequent sprays are needed.

Southern Minnesota growers and Valley growers south of the Polk - Norman county line, should apply a fungicide as soon as disease severities enter the Caution Zone (**Figure 5**). A second fungicide application should then be made as soon as

the spray interval lapses (14 days later for TPTH fungicides and 10 days later for mancozeb). At the end of the second spray interval, resume field monitoring to determine if and when subsequent sprays are needed.

The second phase of field monitoring is called Spray Delay monitoring. The sampling protocol is identical to that used in determining when to make the first spray application. Its results are used in conjunction with the Cercospora Spray Advisory. It is designed to allow growers to delay spraying during periods that are unfavorable for the development of Cercospora leaf spot.

Weekly average disease severities are determined for a particular field. The average % severity and the calendar date are used to determine the appropriate Cercospora Leaf Spot Action Zone from **Figure 5**. As long as the average % Severity for the field remains in the Safety Zone, fungicide applications are not economical. As soon as the average number of leaf spots per acre enters the Caution Zone, call and obtain the Cercospora Spray Advisory on a daily basis.

If the average % Severity is in the Caution Zone and weather conditions are unfavorable for Cercospora leaf spot infection (Cercospora Spray Advisory is less than 6), do not spray. Continue to delay spraying until the daily Cercospora Spray Advisory suggests that conditions favorable for infection have occurred.

When the Cercospora Spray Advisory reports that conditions favorable (more than 6) for infection have been experienced over the previous 48 hours, apply a fungicide spray.

Wait 14 days (TPTH) or 10 days (mancozeb) and then resume scouting to determine if and when subsequent sprays are needed.

If the Cercospora Spray Advisory reports that conditions have remained unfavorable for leaf spot for 7 consecutive days, re-scout the field and recalculate the appropriate Cercospora Leaf Spot Action Zone. Continue monitoring the Cercospora Spray Advisory. Withhold sprays as long as the % Severity remains in the Safety Zone or if the % Severity

enters the Caution Zone and the Cercospora Spray Advisory reports conditions unfavorable for infection.

If Cercospora leaf spot ever reaches the Danger Zone, shift to a standard 14 day (TPTH) or 10 day (mancozeb) spray schedule and discontinue scouting.

All field monitoring activities can be terminated September 15. Do not apply mancozeb fungicides within 14 days of harvest. Do not apply TPTH fungicides within 21 days of harvest.

## ACKNOWLEDGEMENTS

The Cercospora Management System is intended as a tool to assist growers with their disease management decisions. It is based on extensive research supported, in part, by the Sugarbeet Research and Education Board of Minnesota and North Dakota. The authors wish to acknowledge the contributions of Dr. Paul S. Teng, Dr. William W. Shane, and numerous other individuals who assisted in the development of this information. We also thank Elizabeth Dempsey, University of Minnesota, for illustrations.

The information in this publication is for educational purposes only. Reference to commercial products or trade names is made with the understanding that no discrimination is intended and no endorsement by the Minnesota Extension Service is implied.

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Patrick J. Borich, Dean and Director of Minnesota Extension Service, University of Minnesota, St. Paul, Minnesota 55108. The University of Minnesota, including the Minnesota Extension Service, is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, religion, color, sex, national origin, handicap, age, veteran status, or sexual orientation.