CERCOSPORA BETICOLA INSENSITIVITY IN MICHIGAN AND MICHIGAN SUGAR COMPANY'S RESISTANCE MANAGEMENT STRATEGIES

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Introduction

Cercospora leafspot, caused by the fungus *Cercospora beticola*, is the most serious foliar disease of sugarbeets in Michigan. Research trials conducted in Michigan show that poorly controlled Cercospora leafspot (25 to 50% canopy desiccation) resulted in losses of 2 to 4 tons per acre and from 0.25 to 1.0 point of sucrose. The disease is managed with an integrated program which includes proper rotations, varietal tolerance and fungicide sprays. Most of the varieties in Michigan have relatively good tolerance to Cercospora; however, our highest producing varieties are quite susceptible to the disease.

Michigan growers benefit from the predictive model BEETcast, which monitors leaf wetness and temperatures at over 50 locations and predicts optimum fungicide application timings. Cercospora infection levels were high in 2005 and 2006 then trended lower until 2010, 2011 and late season of 2012, when disease levels increased significantly. For the most part, Cercospora leafspot is adequately controlled in Michigan. However, with the introduction of high producing varieties that have less disease tolerance some control problems have occurred. More aggressive Cercospora control programs have been implemented by the Cooperative which has been successful in protecting varieties with low levels of Cercospora resistance from yield and quality losses.

The use of strobilurin and triazole fungicides along with the BEETcast spray model improved the level of Cercospora leafspot control in Michigan significantly. By 2008, Michigan Sugar Company growers were planting Roundup Ready and nematode tolerant varieties without adequate tolerance to Cercospora. In 2010, control of Cercospora became more difficult despite more aggressive BEETcast spray recommendations. The following year, QoI resistant isolates were identified to harbor the G143A mutation. This mutation was discovered in Michigan Sugar Company's efficacy trial near Elkton, MI, and was confirmed by Michigan State University and USDA-ARS **(Figure 1)**.

To effectively manage Cercospora in Michigan, tank-mixed fungicides were recommended prior to the first sign of the leafspot. Application timing was also modified by Cercospora tolerance level of the variety being grown. Fungicide insensitivity in sugarbeets can be managed; however, growers needed to follow a resistance management program set by Michigan Sugar Company.

Research Objectives

Trials have been conducted in recent years to evaluate three objectives with respect to Cercospora leafspot: 1) Efficacy of fungicides for Cercospora leafspot control; 2) Timing of

fungicide applications; 3) Efficacy and antagonism of tank mixed fungicides for Cercospora control.

Materials and Methods

Fungicide efficacy trials were conducted in Michigan to evaluate registered and experimental fungicides for control of Cercospora leafspot. An intensive Cercospora fungicide trial was conducted in 2012 (Elkton, MI) that evaluated all of the approved fungicides and also evaluated an experimental product, Bravo. Leafspot pressure was very high at this trial location.

The Elkton trial was planted on April 12, 2012 and harvested on October 8, 2012. The plot size was 6 rows X 50 feet with 4 replications with row spacing of 22". The variety was ACH RR824 (Susceptible Variety). Fungicide applications were applied with a JD 990 plot sprayer at 90 psi, 25 GPA, and at 3 mph. The treatments are based on disease severity values (DSV's) which are taken from BEETcast stations (wwww.michiganbeets.com) in the Michigan Sugar Company's growing regions. The Michigan Sugar Company's sugarbeet growing regions are divided into high, moderate and low Cercospora risk zones and the spray treatments are different for each zone. Application timings at the Elkton trial were made at 57 DSV's (7/7/2012), 107 DSV's (8/3/2012), 133 DSV's (8/14/2012), and 151 DSV's (8/30/2012), with a total of 171 DSV's for the season.

All of the fungicides were tested alone and tank mixed with Dithane. The addition of Dithane improved Cercospora control in every case. The treatments were applied as part of a four spray sequence. The tested fungicide was the first and last in the sequence, with Dithane and copper being the number two and three sprays program.

Cercospora leafspot severity was rated on the KWS scale of 0 to 9 then converted to percent desiccation. A rating of zero indicated no disease, a rating of three indicated that all outer leaves displayed typical symptoms and was the early stages of economic loss level, and a rating of nine indicated that the plants had only new leaf growth, all earlier leaves being dead. Cercospora leafspot severity was assessed throughout the season. Three percent in desiccation indicates that yield loss and percent sugar could be measured.

The trial was defoliated mechanically and harvested using a mechanical harvester. The middle four rows of each plot were harvested and weighed for root yield. Twelve to fifteen random roots from each plot, not including roots on the ends of the plot, were analyzed for quality at Michigan Agricultural Research Laboratory (MARL), Carrollton, MI. The least significant difference (LSD) test was used to compare treatments when the F-test for treatments was significant (p=0.05). The data analysis was performed with the ANOVA procedure of the Agriculture Research Manager Software package (Gylling Data Management Inc., Brookings, South Dakota).

Results and Discussion

Fungicide efficacy trials are conducted each year to monitor the effectiveness of available fungicides for controlling Cercospora leafspot in Michigan. Triazole and strobilurin fungicides have always been our two strongest fungicides for Cercospora control throughout our growing region until 2010 when the control of Cercospora with strobilurins became more difficult despite more aggressive BEETcast spray recommendations.

Michigan Sugar Company has been evaluating a Cercospora leafspot spray timing model and adapting it to our growing region since 2002. The model is called BEETcast and measures leaf wetness and temperatures at over 50 sites in our growing region. **Figure 2** shows percent

desiccation caused by Cercospora leafspot with various treatments from 2008-2012. There is an increase in the rate of insensitivity from 2010-2012 with strobilurins. The 2009 data was purged due to low infection for that year.

When considering percent desiccation, there is no significant difference between Inspire and Super Tin in 2012. Widespread insensitivity to Headline and GEM along with Topsin has been ascertained; however, Topsin not being as severe as the strobilurins. The timing of applications is more important than which fungicide to choose from the top group. Several growers consider which product will provide suppression of Rhizoctonia when choosing a fungicide for their first leafspot spray.

The alternation of different classes of fungicides provided effective disease control and will also serve to prevent or delay the development of other fungicide resistant isolates. Treatments where Inspire, Eminent, and Super Tin were tank mixed with another mode-of-action had good disease control. The use of Inspire, Eminent, and Super Tin provided excellent disease control **(Figure 3)**. Also, with utilization of a tank mixed partner as a Best Management Practice the trial indicated that there were higher tons per acres compared to tank mixing strobilurins with another mode-of-action (**Figure 4).** Tank mixing does have an improvement in tons per acre and lower percent of desiccation, thus indicating that there is no antagonism when mixing triazoles or Super Tin with another mode-of-action.

Recoverable White Sugar per Acre (RWSA) was consistent in terms of an increase in RWSA when a different mode-of-action was tank mixed with the triazoles, strobilurins, TPTH, Bravo, and Topsin All treatments were higher than the untreated check in RWSA **(Figure 5).**

The data indicated that fungicides with different modes-of-action are effective at controlling Cercospora leafspot when used as a tank mix, thus should be used in alternation to provide effective disease control and maintain high yield of recoverable sucrose while reducing selection pressure for the development of fungicide insensitivity to *C. beticola* isolates.

Summary and Conclusions

With strobilurins failing, the triazole fungicides (Inspire, Eminent, Proline, Enable and Topguard) will be our front line of defense against Cercospora leafspot. These products must be used responsibly or resistance will develop to this group also. Triazole fungicides should be used no more than twice during a season and should always be tank mixed with an EBDC or Copper. When Super Tin is included as a rotation partner it will be possible to follow a resistance management plan utilizing triazoles, Super Tin, EBDC's and Coppers.

There is some evidence that triazoles may not be a truly single site mode of action, according to Brent and Holomon (2007). If this is correct, we would expect something with more than one site of action to take longer to develop resistance, but this is still not really clear. What is clear is that all the resistance that has been found to DMIs is quantitative resistance, unlike the strobilurins being qualitative.

Growers have been reluctant to use Super Tin because it is a restricted product and is more dangerous than our other fungicides. Inhaling the fumes (dust or fine droplets) is the main risk of poisoning. However, the product is used in other sugarbeet areas (without incident). It is important to wear the proper protective clothing and have a cab with the proper filter when using Super Tin.

Super Tin is not as effective as the triazoles or strobilurins (when resistance is not an issue), however, could be very useful as an alternative to triazoles in a resistance management program. Super Tin is more effective than the other protectants that are available for use in sugarbeets.

Other protectants including EBDC's (Dithane, Manzate, etc.) and Copper fungicides need to be a part of our overall resistance management program. EBDC fungicides are somewhat more effective than Copper. These products have multiple modes of action and the risk of developing resistance is relatively low. The main value of these protectants is in tank mixing with a triazole fungicide.

Looking toward the future we have reason for optimism. We conditionally approved several varieties with poor Cercospora tolerance when we switched over to the Roundup Ready system a few years ago. Now those varieties are being phased out and replaced with better overall varieties. We will still have some nematode tolerant varieties with poor Cercospora tolerance for a few years, but we are definitely making progress with new varieties that have better disease tolerance. Within a few years we should have nematode tolerance with acceptable Cercospora tolerance; and a long term goal is a GMO sugarbeet with resistance to Cercospora. Seed companies are working on additional GMO traits but Cercospora resistance is probably ten years from becoming a reality.

We are not aware of any new fungicides being developed for Cercospora control in sugarbeets. We are working with Michigan State University, Syngenta and Sipcam to secure a Section 18 registration for chlorothalonil (Bravo, Echo) in sugarbeets; however, the USDA and EPA have denied an emergency label for sugarbeets for 2012.

It is important that we all understand the situation we are in and make smart choices that will help us control leafspot and preserve our remaining fungicides. Growers who plant Cercospora susceptible varieties will need to employ an aggressive Cercospora control program. Growers need to follow leafspot control measures that include tank mixing all fungicides with different modes-of-actions to minimize the risk of resistance developing to other fungicides.

Michigan Sugar Company's Cercospora leafspot management strategy that is currently in place includes:

- Alternate fungicide modes of action when tank mixing.
- Apply the suggested rates of all fungicides, and do not apply triazoles or Super Tin more than twice in a season.
- Do not apply triazoles back-to-back even if you tank mix with another mode of action.
- Do not apply Super Tin back-to-back even if you tank mix with another mode of action.
- Do not tank mix triazoles and Super Tin together.
- Do not mix Coppers with glyphosate and AMS or crop injury may occur or phytotoxicity may occur.
- Be cautious on using Strobilurins and do not tank mix with triazoles or Super Tin.
- EBDCs and Coppers can be sprayed multiple times with or without a tank mix partner, and can be applied back-to-back.
- Apply fungicides in an approach to insure maximum coverage, thus improving Cercospora leafspot control.
- Use 20-25 gallons of water with a minimum of 90 PSI; 100 PSI will give better performance. Use surfactants and additives as required by product labels.
- Do not wait until the first spot is noticed.
- Use BEETcast (http://www.michiganbeets.com) to help you plan on timely applications, especially your first spray.
- Crop rotation plays a key component in reducing Cercospora leafspot inoculums from over-wintering in plant debris and soils. A four year rotation is recommended.

- Continue your fungicide spray program through mid-September if beets are going to be harvested for permanent piling.

References

Brent, J. K. & Hollomon D. W. (2007). *Fungicide resistance: the assessment of risk.* FRAC *Monograph No. 2*, pp. 1–28. Fungicide Resistance Action Committee. www.frac.info

Figure 1: Michigan Sugar Company, Cercospora Leafspot Insensitivity and Sensitivity - 2011-2012, Michigan State University

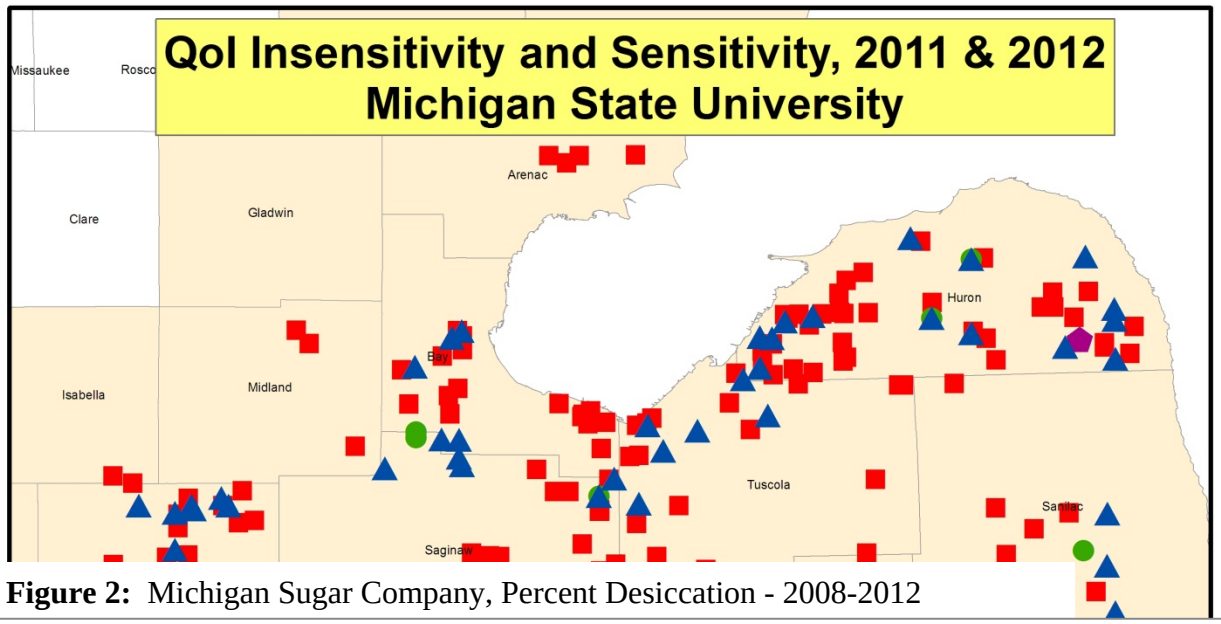

Figure 2: Michigan Sugar Company, Percent Desiccation - 2008-2012

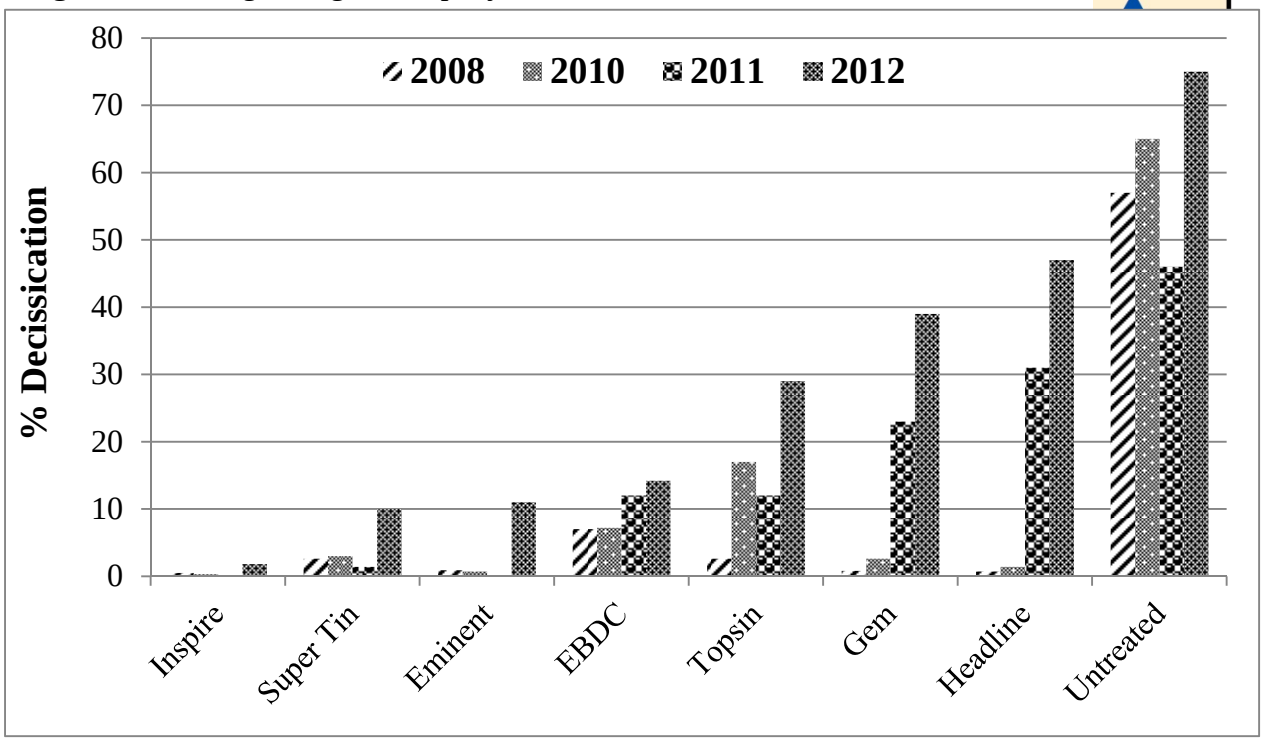

Figure 3: Michigan Sugar Company, Percent Desiccation with Tank Mix vs. Without, Elkton, MI - 2012.

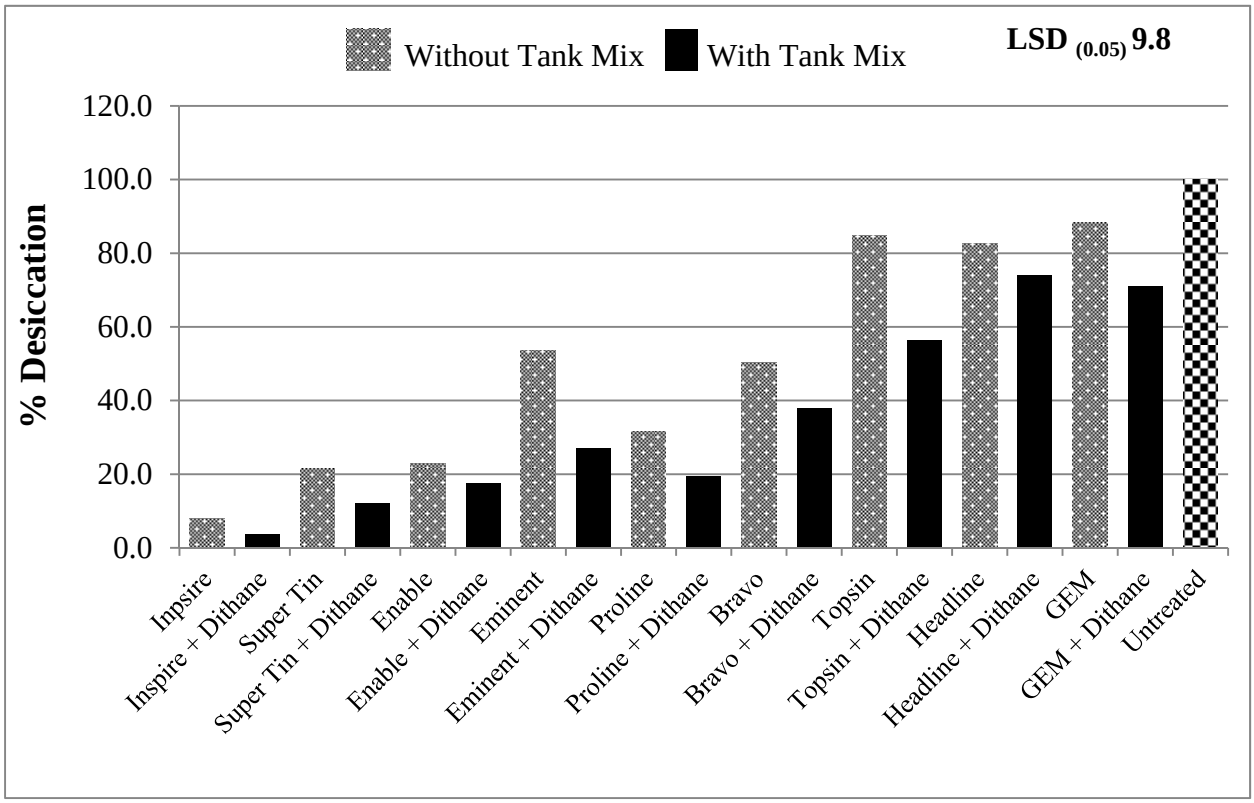

Figure 4: Michigan Sugar Company, Tons/Acre with Tank Mix vs. Without, Elkton, MI-2012

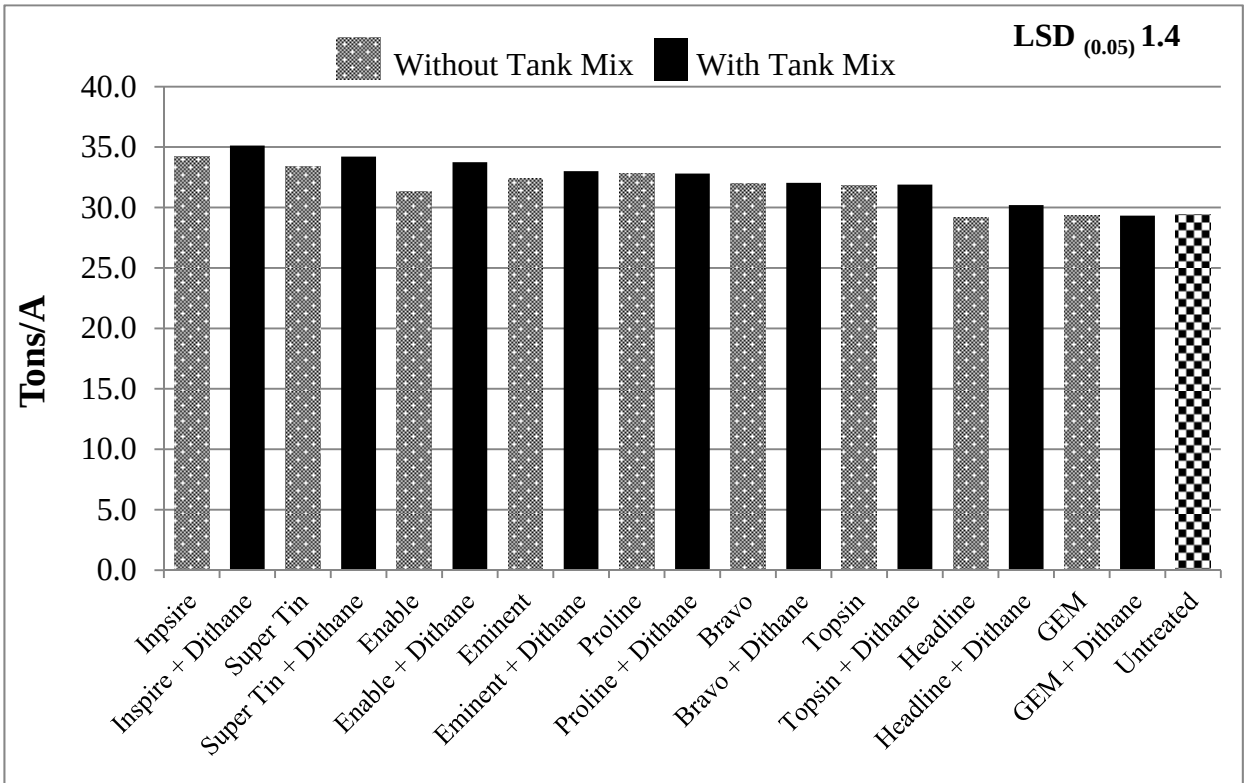

Figure 5: Michigan Sugar Company, Recoverable White Sugar per Acre with Tank Mix vs. Without, Elkton, MI - 2012