Genetic Resistance, Fungicide Protection and Variety Approval Policies for Controlling Yield Losses from Cercospora Leaf Spot Infections

Jay Miller, Margaret Rekoske and Arthur Quinn

Betaseed, Inc. 1788 Marschall Road, Shakopee, Minnesota 55379

ABSTRACT

Cercospora *(Cercospora beticola* Sacc.) leaf spot infections can result in significant losses in many sugarbeet producing areas of the United States. The principal means of controlling losses is the use of resistant varieties and/or fungicide protectants. Currently available resistant varieties significantly outperform non-resistant genotypes under severe *Cercospora* infections, but may be 10% or more lower yielding in the absence of disease. Thus, in some areas of potential heavy infestation, *Cercospora* leaf spot is managed primarily through the use of triphenyltin fungicides. However, *Cercospora* isolates resistant to the triphenyltin compounds were reported in Greece in 1978. U.S. sugarbeet researchers are concerned that strains of *Cercospora* resistant to the triphenlytin compounds may develop, resulting in an epidemic similar to that which occurred in Southern Minnesota in 1981 when benomyl resistant strains of *Cercospora* emerged. Furthermore, the use of triphenlytin products has become restricted by the EPA and may even be discontinued due to human safety considerations. No replacement fungicides with a similar efficacy appear forthcoming. Resistant levels currently required for variety approval vary from region to region depending on potential disease severity and grower experience with fungicides. It is recommended that variety approval policies anticipate this potential loss of chemical protection and implement a gradual increase in the genetic resistance.

Additional Key Words: *Beta vulgaris, Cercospora beticola,* plant disease, fungicide resistance, sugarbeet yield

Cercospora *(Cercospora beticola* Sacc.) leaf spot infections occur in many sugarbeet producing areas of the United States. Disease infection often results in significant reductions in yield and sucrose and increased concentrations of impurities (Shane and Teng, 1992; Smith and Martin, 1978). Relative dollar losses have been reported as high as 43% (Shane and Teng, 1992). The principal means of controlling losses due to infection is through resistant varieties and/or fungicide protectants. In some areas of potentially heavy infection, *Cercospora* leaf spot is managed primarily through the use of fungicides. Past history has documented the capability of the pathogen to overcome commercial protectants. Strains of *Cercospora* resistant to benomyl were reported in Greece in 1973 (Georgopoulos and Dovas, 1973). In 1978 *Cercospora* isolates resistant to triphenyltins were reported in Greece (Giannopolitis, 1978). In 1981 an epidemic occurred in Minnesota and North Dakota when benomyl resistant strains of *Cercospora* emerged. Another epidemic could occur in this area if triphenyltin resistant strains appear. Furthermore, the EPA has restricted the use of triphenyltins and could ban them due to human safety considerations. No replacement fungicides with similar efficacy are available. The goal of this research was to compare, at various levels of *Cercospora* infection, the performance of moderately resistant varieties (widely grown in Minnesota and North Dakota, the Red River Valley or RRV), with that of highly resistant varieties (widely grown in Michigan and Ohio).

Table 1. Varietal information and *Cercospora* resistance levels.

Varieties	Average *Cercospora* Resistance Rating
Highly resistant:	
ACH 185, ACH 197, Beta 5315 (Approved for Michigan and Ohio)	3.8†
Moderately resistant	
KW 1745, HMH 5135 (Approved for American Crystal and Minn-Dak)	5.1†
Beta 1996 (Approved for Manitoba)	

† All *Cercospora* ratings were obtained from 7 readings in 1990 and 6 readings in 1992 at Shakopee, Minnesota.

MATERIALS AND METHODS

Three highly resistant and three moderately resistant varieties (Table 1) were selected and data extracted from four replicate, 49-entry performance trials conducted in 1990 and 1992. Plots were two rows 56 centimeters apart extending from 8 to 10 meters. The trial locations and the various levels of disease infection are shown in Table 2. The infection levels are described in Table 3. No fungicides were applied. Analyses of variance were performed for yield, percent sucrose, and pounds of recoverable sugar per acre for the individual trial locations.

Cercospora leaf spot evaluations were conducted at Shakopee, Minnesota, with similar field layouts, except that plot length was 2.9 meters. Disease ratings were taken every 4 to 6 days for six weeks starting the last week of July. Ratings were based on the KWS 1 to 9 scale. Analyses of variance also were performed on disease ratings.

Table 2. Infection level, location, and year of yield trials.

Infection level	Location(s)	Year
None	Sabin, Minnesota	1992
Very light	Breckenridge, Minnesota	1992
	Saginaw, Michigan	1992
Light	Auburn, Michigan	1990
	Harbor Beach, Michigan	1990
Moderate	Akron, Michigan	1990
	Munger, Michigan	1990

RESULTS AND DISCUSSION

Significant differences were observed for yield, percent sucrose and pounds of recoverable sugar per acre from each trial location.

In the absence of infection, the sucrose levels of all varieties were similar, but the highly resistant varieties produced 18% lower tonnage (Figure 1). Thus, sugar per acre and grower payment per acre were 16-17% lower for the highly resistant varieties (Figure 1).

Under very light infection, this advantage for the moderately resistant varieties was reduced by 50% for both tonnage and sugar per acre (Figure 1). Sugar contents of the highly resistant varieties also were higher (Figure 1). Actual grower returns based on a quality payment system (such as that of American Crystal or the Southern Minnesota

Beet Sugar Cooperative) were only 5% less for the highly resistant varieties (Figure 1). Under light infection, the highly resistant varieties outperformed the moderately resistant varieties in percent sucrose, sugar per acre, and payment per acre.

Table 3. Description of infection levels.

Infection level	Description
None	No *Cercospora* lesions were noted on any of the moderately resistant varieties throughout the growing season. This is probably due to suitable control with fungicides and/or climatic conditions not being conducive to disease development.
Very light	Some *Cercospora* lesions were noted on moderately resistant varieties, but disease ratings on the KWS scale were no more than "3" at peak infection.
Light	Definite coalescing of lesions occurred on the moderately resistant varieties, but peak infection generally occurred September 1st or later. Disease ratings did not exceed "5" on the KWS scale. (This level of infection is common after September 1 if fungicides are discontinued and climatic conditions are favorable for disease buildup.)
Moderate	*Cercospora* lesions noted on moderately resistant varieties by mid-August, with their disease ratings reaching a "6" to "7" by peak infection, generally at the end of August or early September. (The 1981 Southern Minnesota *Cercospora* epidemic would probably have been characterized as "moderate". In this case systemic fungicides applied in early August were not effective but later applications of tin fungicides prevented the infection from developing further.)
Severe	Disease rating on moderately resistant varieties generally reached "6" to "7" by mid-August; plants became nearly defoliated by late August, with only new leaves present in early September. (This is the usual case for the Betaseed *Cercospora* disease nursery at Shakopee, Minnesota.)

Under moderate infection, the highly resistant varieties outproduced the moderately resistant varieties by 23% for recoverable sugar per acre, and resulted in 49% more in quality payment.

In areas where climatic conditions are often conducive for *Cercospora* infections, sugarbeet growers presently use either highly resistant varieties or only moderately resistant varieties and then rely heavily on fungicide sprays. While the performance advantages of less resistant varieties usually compensates for the cost of fungicide applications, total dependence on chemical control of *Cercospora* raises concerns. The pathogen has mutated to biotypes resistant to the fungicides benomyl and triphenyltin. Additionally, the EPA has restricted the use of triphenyltins to only 24 ounces of active ingredient during the growing season (three to four applications at recommended

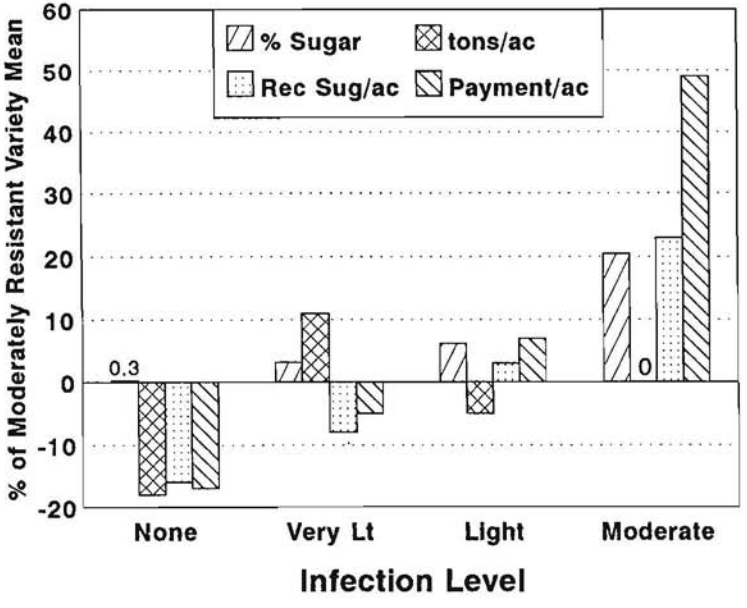

Figure 1. Comparison, under four *Cercospora beticola* infection levels, of highly *Cercospora* resistant sugarbeet varieties with moderately resistant varieties, for percent sugar, root yield (tons/acre), recoverable sugar (pounds/acre), and grower return (payment/acre). Means of data from three highly resistant varieties are shown as percent of the means for three moderately resistant varieties. (See Tables 1-3 for varieties in each group, growing locations and years, and infection levels.)

rates), and forbids application within three weeks of harvest. More severe restrictions on the triphenyltins are possible as the EPA reviews the labeling of this chemical class. Alternative fungicides based on copper and maneb are not as efficacious. Furthermore, heavy reliance on fungicides is not consistent with the goal of more sustainable agriculture.

In areas where fungicide use is high, many present approval systems require only a moderate level of genetic resistance. Most newly approved varieties are bred for grower payment per acre with resistance levels just adequate for approval. Areas such as these are especially vulnerable if fungicide resistant strains of *Cercospora* become prevalent and/or if triphenyltin compounds are further restricted. Alternatively, this research suggests that presently available highly resistant varieties would be competitive even under light infection levels.

Variety approval committees may wish to consider implementing an approval system to gradually increase the genetic resistance required. An approval procedure similar to that used by some of the sugar industry to obtain gradual increases in sucrose content could be used. This process requires that new varieties must equal or exceed the mean of the already approved varieties. Older approved varieties are often disallowed if their mean drops a certain percentage below the continually increasing approved mean. With such a method, the required level of *Cercospora* resistance should increase over time.

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