VALIDATING THE CERCOSPORA PREDICTION MODEL AND THE POTENTIAL USE OF SPORE COUNT TO MANAGE CERCOSPORA LEAF SPOT IN SUGARBEET

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ABSTRACT

Cercospora leaf spot is the most damaging foliar disease of sugarbeet in North Dakota and Minnesota. Research was conducted to determine the most effective and economical method for controlling Cercospora using fungicides, and trapping and counting Cercospora spores. Research was conducted in 2001 and 2002 using susceptible HH Agate and tolerant Crystal 222 sugarbeet varieties at Breckenridge, MN, and St. Thomas, ND. Fungicide applications were made using the Cercospora prediction model, where daily infection values (DIVs) were calculated at RH > 86% and > 90%, and compared with a modified prediction model, calendar spraying, and common growers practice. At Breckenridge, in 2001 and 2002, DIVs and disease severity were low and there was no significant difference in recoverable sucrose ha^{-1} between the untreated and treated susceptible HH Agate or between untreated and treated tolerant Crystal 222. At St. Thomas, in 2001 and 2002, disease severity was higher compared to Breckenridge. In 2001, at St. Thomas, significantly lower recoverable sucrose ha^{-1} occurred in untreated compared to treated HH Agate. No significant difference in RSA occurred between untreated and treated Crystal 222. It was economical to apply fungicides to HH Agate but not always economical for Crystal 222. In 2002, two fungicide applications were necessary for higher recoverable sucrose ha^{-1} and effective Cercospora leaf spot control on the susceptible and tolerant varieties. The DIVs calculated at RH > 86% and at RH > 90% at both locations were not significantly different and thus did not impact on spray decisions. Spore count was highest in late August to mid-September that corresponded to the time that Cercospora leaf spot symptoms were most prevalent, and the locations that had more spores had more severe leaf spot symptoms. The Burkard trap was more effective at collecting spores than the hand-made trap.

INTRODUCTION

The United States is one of the top sugarbeet producers in the world (Harveson et al., 2002). Sugarbeet was planted on 625,000 ha in 2000, making sugarbeet a major contributor to the U.S. sugar industry. Minnesota and North Dakota contributes 48% of the total production of sugarbeet in the U.S. (U.S. Department of Agriculture, Economic Research Service, 2001).

Cercospora leaf spot caused by *Cercospora beticola* Sacc. is one of the most serious foliar diseases of sugarbeet in the United States and in the world (Karaoglanidis et al, 2001, Weiland and Halloin, 2001). In Minnesota and North Dakota, losses in 1998 were estimated at $113 millions from reduced tonnage and increased production cost as a result of fungicides ineffectiveness against *C. beticola* (Cattanach, 2000). Khan et al. (2001) have reported losses of 4.5-6.7 Mg ha^{-1} and 30% in recoverable sucrose under heavy disease conditions. The disease produces circular spots having ash gray centers with dark brown to reddish purple margins on sugar beet leaves. Favorable environmental conditions for the disease development are day temperatures (25-35°C), night temperature (16°C), and prolonged periods of relative humidity (90-95%) or free moisture on leaves (Shane and Teng, 1984, Windels et al., 1998). Recommended measures for the control of Cercospora leaf spot include fungicide applications, crop rotation, deep tillage to bury infected debris, and planting disease tolerant varieties (Miller et al., 1994).

There are four to five genes responsible for *Cercospora* resistance in sugarbeet (Smith and Gaskill, 1970). It is difficult to incorporate *Cercospora* resistance genes into sugarbeet varieties with superior agronomic characteristics (Smith and Campbell, 1996). As a result, commercial sugarbeet varieties have only moderate levels of resistance to Cercospora and require fungicide applications to obtain adequate levels of protection against the disease (Miller et al., 1994).

Using fungicides to control Cercospora during 1999 and 2000 was effective but costly. During 2000, Southern Minnesota Beet Sugar Cooperative growers reported an average of four fungicide applications at an estimated cost of $163.95 ha^{-1}. Since control of Cercospora leaf spot in sugarbeet is largely dependent upon multiple applications of fungicides, it is imperative to determine the most effective and economical management strategy for controlling the disease without adversely affecting sugar yield and quality.

According to the Cercospora leaf spot prediction model (Shane and Teng, 1984), growers south of the Polk-Norman county line should apply the first fungicide application at first symptoms, a second application 14 d after, and subsequent applications are based on the presence of disease and daily infection values. Growers north of the Polk-Norman county line should apply the first fungicide application at first symptoms, and subsequent applications are based on the presence of disease and daily infection values. The majority of sugarbeet fields are south of the Polk-Norman county line. It is possible that the model used for growers north of the Polk-Norman county line can be applicable for growers south of the county line. It may be possible to reduce the number of fungicide applications without affecting disease control for growers south of the county line. The model can be enhanced if the presence and number of Cercospora spores can be accurately determined during the growing season.

The prediction model consists of two integrally related components: percent disease severity based on field monitoring and a Cercospora Advisory (CA) based on weather information. The CA describes the potential for infection by *Cercospora beticola* that exists the previous 48 h as a whole number between 0 and 14 based on the DIV. The DIV ranges from 0 to 7 and is calculated from the number of hours per day with RH > 90% [but the Sugar Cooperatives use RH > 86%] and the average temperature during those hours. If the sum of two adjacent days were less than six, the potential for infection was low; a sum of six was marginal; and a sum of 7 to 14 indicated conditions favorable for infection.

This research was conducted to determine whether the cost of controlling Cercospora leaf spot could be reduced without adversely affecting sucrose yield and quality.

Our objectives were to determine the best time for applying fungicides on Cercospora tolerant and susceptible varieties that would result in effective and economical disease control, and to determine when Cercospora spores are present in the fields by using spore traps.

MATERIALS AND METHODS

EXPERIMENT 1 - EVALUATING CERCOSPORA CONTROL USING FUNGICIDES APPLIED AT DIFFERENT TIMES.

Research was conducted at Breckenridge, MN, and St. Thomas, ND in 2001 and 2002. 'HH Agate' sugarbeet susceptible to Cercospora leaf spot and 'Crystal 222' sugarbeet tolerant to Cercospora leaf spot were planted into plots 3.35 m in width (6 56-cm wide rows) and 9 m in length. Seeds were placed 3 cm deep and 7.6 cm apart in rows that were 56 cm wide. Terbufos was applied at 13.32 kg ha^{-1} at planting to control sugarbeet root maggot. The experiment design was a randomized complete block design with four replications. Plots were thinned manually to 150 beets per 30.5 m of row. The cultural practices and fungicide application dates for each location are in **Table 1**. Treatments were applied directly to the 4-inner rows of the 6-row plots with a boom sprayer operating at 689 kilopascals and delivering 187 l ha^{-1} of spray solution. The fungicides used were Eminent (tetraconazole) at 0.93 L ha^{-1} and Headline (pyraclostrobin) at 0.65 L ha^{-1}. There were also untreated check plots. Fertilization was done according to standard recommendation for sugarbeet. Plots were kept weed free using micro-rates of herbicides recommended for sugarbeet, hand-pulling, and cultivation.

The middle two rows of each 6-rows plot were harvested. Yield was determined, and quality analysis performed by American Crystal Sugar Company Quality Tare Laboratory, East Grand Forks, Minnesota. Data was analyzed for differences by analysis of variance and LSD using Agriculture Research Manager, version 6.0.

The treatments for Breckenridge were as follows:

(1) Untreated check.

(2) 14 d interval calendar spray with the first application at first symptoms and continuing until conditions are unfavorable for the disease in late August.

(3) First application at first symptoms followed by a second application 21 d after. One more application possible in August will be based on the

factory district Cercospora advisory indicating the possibility of infection being 'high'.

(4) First application at first symptoms (0.01% infection) followed by a second application 14 d after. Subsequent applications of at least 14d intervals will be based on the factory district Cercospora advisory indicating the possibility of infection being 'high'.

(5) First application at first symptoms (0.01% infection). Subsequent applications of at least 14 d intervals will be based on DIVs for two consecutive days totaling seven or more when the RH is above 90% (using Hobo's) in the presence of disease.

(6) First application at first symptoms (0.01% infection). Subsequent applications of at least 14 d intervals will be based on DIVs for two consecutive days totaling seven or more when the RH is above 87% (using Hobo's) in the presence of disease.

(7) After row closure, first, and subsequent applications of at least 14 d intervals when DIVs for two consecutive days totaling seven or more when the RH is above 87% (using Hobo's).

(8) After row closure, first, and subsequent applications of at least 14 d intervals when DIVs for two consecutive days totaling seven or more when the RH is above 90% (using Hobo's).

(9) First application when symptoms are present in plots followed by a second application 14 d after. Subsequent applications based on DIVs for two consecutive days totaling seven or more when the RH is above 87% (using Hobo's) in the presence of disease.

(10) First application when symptoms are present in plots followed by a second application 14 d after. Subsequent applications based on DIVs for two consecutive days totaling seven or more when the RH is above 90% (using Hobo's) in the presence of disease.

The treatments for St. Thomas were as follows:

(1) Untreated check.

(2) First application when symptoms are present in plots followed by a second application 14 d after. There may be a third application based on the factory district Cercospora advisory being 'high' in the presence of disease.

(3) First application when symptoms are present in plots. Subsequent applications of at least 14 d intervals when DIVs for two consecutive days totaling seven or more when the RH is above 90% (using Hobo's) in the presence of disease.

(4) First application when symptoms are present in plots. Subsequent applications of at least 14 d intervals when DIVs for two consecutive days totaling seven or more when the RH is above 87% (using Hobo's) in the presence of disease.

(5) First and subsequent applications of at least 14 d intervals based on DIVs for two consecutive days totaling seven or more when the RH is above

87% (using Hobo's). In 2002, the first treatment was applied when there was 2% disease severity.

EXPERIMENT 2 - TRAPPING AND COUNTING *CERCOSPORA BETICOLA* SPORES.

This experiment was conducted in sugarbeet fields at Breckenridge, MN, Crookston, MN, Fargo, ND, and St. Thomas, ND, to determine when *Cercospora beticola* spores were disseminated in the field. Spore traps made of 1 kg coffee cans opened at both ends were placed in the field, 0.3 and 0.6 m above the ground. Microscope slides covered with petroleum jelly on 645 mm^2 area were attached in the coffee cans using clamps. Each coffee can contained two slides facing opposite directions. Each field had 8 slides, except St. Thomas with 4 slides, facing four directions. The slides were replaced weekly and examined microscopically to determine the number of spores trapped per week. This work was conducted during June through mid-September in 2002. At Breckenridge and Crookston, Burkard spore traps were also used from mid-August to mid-September in 2002.

RESULTS

The effect of fungicides applied at different times for Cercospora leaf spot control at Breckenridge and St. Thomas in 2001, and 2002 are shown in **Tables 2, 3, 4, and 5,** respectively.

2001

BRECKENRIDGE (SOUTH OF NORMAN-POLK COUNTY LINE):

Cercospora leaf spot severity was low during the season with the untreated check plots having a KWS Cercospora leaf spot rating of 4.6 at harvest. There was no significant difference in recoverable sucrose ha^{-1} between the untreated and treated susceptible HH Agate or between untreated and treated tolerant Crystal 222. It was not economical to apply fungicides in most of the treatments in the low disease conditions that prevailed.

ST. THOMAS (NORTH OF NORMAN-POLK COUNTY LINE):

Cercospora leaf spot rating was highest (5.5) for the untreated susceptible HH Agate. Recoverable sucrose ha^{-1} was significantly lower in the untreated susceptible HH Agate compared to the treated susceptible HH Agate. There was no significant difference in recoverable sucrose ha^{-1} between the untreated and treated tolerant Crystal 222. It was economical to apply fungicides to the susceptible HH Agate. One fungicide application, based on spraying only when symptoms were present and the possibility of infection was high, was as effective but more economical than two fungicide applications (where the second application was applied 14 days after the first, irrespective of disease severity or environmental conditions). It was not always economical to apply fungicides to the tolerant Crystal 222.

2002

BRECKENRIDGE (SOUTH OF NORMAN-POLK COUNTY LINE)

Cercospora leaf spot severity was low during the season with the untreated susceptible check plots having a KWS Cercospora leaf spot rating of 2.5 at harvest. For both susceptible and tolerant varieties, recoverable sucrose ha^{-1} in the untreated check was not significantly different from the fungicide treatments. There was a general trend where the tolerant 'Crystal 222' variety produced significantly higher recoverable sucrose ha^{-1} than the susceptible 'HH Agate' variety receiving the same fungicide treatment.

ST. THOMAS (NORTH OF NORMAN-POLK COUNTY LINE)

Cercospora leaf spot severity was high late in the season with the untreated susceptible check plots having a KWS Cercospora leaf spot rating of 7.3 at harvest. Two fungicide applications were necessary for higher recoverable sucrose ha^{-1} and effective Cercospora leaf spot control on the susceptible and tolerant varieties. The first fungicide application was required at the onset of the disease. One fungicide application later in the season when disease severity was 2% was ineffective at managing the disease.

SPORE TRAPS AND SPORE COUNT

The number of *Cercospora beticola* spores trapped using the self-made coffee can traps at Fargo, Breckenridge, and St. Thomas was highest in late August and early to mid-September (**Table 6**). The presence of spores corresponded to the time that Cercospora leaf spot symptoms were most prevalent, and the locations that had more spores had more severe leaf spot symptoms. The Burkard trap was more effective at collecting spores than the hand-made trap. More spores were trapped at the Cercospora disease nursery at Crookston where disease severity was significantly higher than at Breckenridge (**Table 7**). Spore count can be a useful tool in the decision making process for managing Cercospora leaf spot with fungicides.

CONCLUSIONS

Over the years, Cercospora leaf spot has consistently been more severe in the areas south of the Norman-Polk county line than the areas north of the Norman-Polk county line. In 2001 and 2002, Cercospora leaf spot severity was less at Breckenridge, south of the Norman-Polk county line, than at St. Thomas, north of the Norman-Polk county line. It is possible that more fungicide applications on sugarbeet in the southern areas resulted in a lower inoculum pressure than the northern areas.

At Breckenridge, in low disease conditions, fungicide treatments applied at first symptoms and later only when conditions were favorable for disease development were as effective as treatments based on the prediction model for areas south of the Norman-Polk county line. It was possible to have effective disease control using less fungicide applications under low disease conditions by applying fungicides at first symptoms, and subsequent applications based on disease severity and environmental conditions than applying fungicides based on the prediction model for areas south of the Polk-Norman county line.

At St. Thomas, under high disease pressure, fungicide applications based on growers practice and the prediction model for areas north of the Polk-Norman county line resulted in good disease control and higher recoverable sucrose than the untreated check for both susceptible and resistant varieties. In 2002, fungicides applied late in the season to plants with 2% disease severity were ineffective at controlling the disease in both susceptible and tolerant varieties.

By adopting the practice of applying fungicides at first symptoms, and subsequent applications based on disease severity and environmental conditions, sugarbeet growers can reduce fungicide applications and effectively control Cercospora leaf spot.

Information on the timing of spore dispersal and spore numbers can be used to complement the information on disease severity and environmental conditions. Information on when spores are first dispersed may be useful especially when applying a protectant fungicide in the first application. The most effective fungicides may be used when spore numbers are high since this seems to result in severe infections.

Table 1. Cultural practices and application date information for Cercospora control at Breckenridge and St. Thomas in 2001 and 2002.

	Breckenridge 2001	**Breckenridge 2002**	**St. Thomas 2001**	**St. Thomas 2002**
Planting Date	May 11	June 5	May 10	May 9
Previous Crop	Wheat	Wheat	Wheat	Wheat
Variety	HM Agate Crystal 222	HM Agate Crystal 222	HM Agate Crystal 222	HM Agate Crystal 222
Weed Control	Betamix – micro-rate	Betamix – micro-rate	Betamix – micro-rate	Betamix – micro-rate
	Betanex – m/rate	Betanex – m/rate	Betanex – m/rate	Betanex – m/rate
	Upbeet – m/rate	Upbeet – m/rate	Upbeet – m/rate	Upbeet – m/rate
	Stinger – m/rate	Stinger – m/rate	Stinger – m/rate	Stinger – m/rate
	Poast – m/rate	Poast – m/rate	Poast – m/rate	Poast – m/rate
	MSO – micro-rate	MSO – micro-rate	MSO – micro-rate	MSO – micro-rate
	Hand labor	Hand labor	Hand labor	Hand labor
	Cultivation	Cultivation	Cultivation	Cultivation
Insecticide	Terbufos	Terbufos	Terbufos	Terbufos
Plant Population	88,000 ha^{-1}	88,000 ha^{-1}	88,000 ha^{-1}	88,000 ha^{-1}
Fungicide App. 1st	July 24	August 15	August 3	August 16
2nd	August 7	August 29	August 17	August 31
3rd	August 14	September 9		
4th	August 20			
5th	September 5			
Spray Vol (L ha^{-1})	187	187	187	187
Spray Pressure (kPa)	689	689	689	689
Harvest Date	September 19	September 24	September 24	October 1

Table 2. Cercospora leaf spot control using fungicides at Breckenridge, 2001.

**Cercospora leaf spot measured on KWS scale 1-9 (no leaf spot – dead outer leaves, inner leaves severely damaged, regrowth of new leaves)*

Treatment	App. Date	Recoverable Sucrose kg ha^{-1}	Recoverable Sucrose kg t^{-1}	Root Yield t ha^{-1}	Sucrose Content %	CLS* KWS
HH Agate – Susceptible						
Untreated Check		6744	158	43.0	17.2	4.6
App 1 - 4, 14 d interval	7/24 8/7, 8/20, 9/05	7412	155	48.1	16.9	1.2
App 1 - row closure: App 2 - 21 d after: FDIV high	7/24, 8/14	7129	158	45.7	17.2	1.3
App 1 - 0.01% disease: App 2 - 14 d after: FDIV high	7/24, 8/7	7346	152	48.8	16.5	1.4
App 1 - 0.01% disease: DIV >6, RH >87%	7/24	7654	161	48.2	17.4	1.2
App 1 - 0.01% disease: DIV >6, RH >90%	7/24	6904	150	46.8	16.4	1.4
App 1 – after row closure & DIV >7, RH >87%	7/24	6979	144	48.4	15.8	1.3
App 1 – after row closure & DIV >7, RH >90%	7/24	7073	150	47.0	16.4	1.1
App 1 - 0.01% disease: App 2 - 14 d after: App 3 – DIV >6, RH >87%	7/24, 8/14	6711	159	42.6	17.3	1.3
App 1 - 0.01% disease: App 2 - 14 d after: App 3 – DIV >6, RH >90%	7/24, 8/14	7351	168	46.6	17.2	1.1
Crystal 222- Tolerant						
Untreated Check		6901	160	43.7	17.3	2.1
App 1 - 4, 14 d interval	7/24 8/7, 8/20, 9/05	7316	159	46.6	17.1	1.3
App 1 - row closure: App 2 - 21 d after: FDIV high	7/24, 8/14	7027	161	44.1	17.4	1.2
App 1 - 0.01% disease: App 2 - 14 d after: FDIV high	7/24, 8/7	6234	148	42.8	16.0	1.2
App 1 - 0.01% disease: DIV >6, RH >87%	7/24	7236	152	48.4	16.5	1.2
App 1 - 0.01% disease: DIV >6, RH >90%	7/24	7517	156	48.4	16.9	1.1
App 1 – after row closure & DIV >7, RH >87%	7/24	6643	157	42.3	17.0	1.2
App 1 – after row closure & DIV >7, RH >90%	7/24	7003	153	46.4	16.6	1.2
App 1 - 0.01% disease: App 2 - 14 d after: App 3 – DIV >6, RH >87%	7/24, 8/14	6661	156	43.0	16.9	1.2
App 1 - 0.01% disease: App 2 - 14 d after: App 3 - DIV >6, RH >90%	7/24, 8/14	7068	165	43.5	17.8	1.3
LSD (P=0.05)		1115.9	11.8	9.6	1.2	0.27
CV%		11.2	5.4	14.8	4.9	13.3

Table 3. Cercospora leaf spot control using fungicides at St. Thomas, 2001.

**Cercospora leaf spot measured on KWS scale 1-9 (no leaf spot – dead outer leaves, inner leaves severely damaged, regrowth of new leaves)*

Treatment	App. Date	Recoverable Sucrose kg ha^{-1}	Recoverable Sucrose kg t^{-1}	Root Yield t ha^{-1}	Sucrose Content %	CLS* KWS
HH Agate – Susceptible						
Untreated Check		7240	147	49.7	16.6	5.1
App 1 - 0.01% disease: App 2 - 14 d after: FDIV high	8/3 8/17	7834	148	53.1	16.6	1.4
App 1 - 0.01% disease: DIV>6. RH >90%	8/3	8172	159	51.9	17.6	1.2
App 1 - 0.01% disease: DIV>6. RH >87%	8/3	8279	160	52.2	17.6	1.2
App DIV>7. RH> 87%	8/3	7992	156	52.2	17.4	1.3
Crystal 222 – Tolerant						
Untreated Check		7494	152	50.2	17.0	2.6
App 1 - 0.01% disease: App 2 - 14 d after: FDIV high	8/3. 8/17	7829	155	51.3	17.0	1.0
App 1 - 0.01% disease: DIV>6. RH >90%	8/3	7805	161	49.5	17.6	1.2
App 1 - 0.01% disease: DIV>6. RH >87%	8/3	7597	144	53.8	16.2	1.4
App DIV >7. RH > 87%	8/3	7767	151	51.9	16.8	1.0
LSD (P=0.05)		573.7	12.3	4.0	1.0	0.8
CV%		5.0	5.5	5.4	4.1	32

Table 4. Cercospora leaf spot control using fungicides at Breckenridge, 2002.

**Cercospora leaf spot measured on KWS scale 1-9 (no leaf spot – dead outer leaves, inner leaves severely damaged, regrowth of new leaves)*

Treatment	App. Date	Recoverable Sucrose kg ha^{-1}	Recoverable Sucrose kg t^{-1}	Root Yield t ha^{-1}	Sucrose Content %	CLS* KWS
HH Agate – Susceptible						
Untreated Check		4825	120	41.2	14.2	2.5
Row Closure/ 14 d interval	8/15 8/29	5184	125	42.3	14.7	2.3
App 1 – row closure; App 2 - 21 d after; FDIV high	8/15 9/6	4874	120	41.4	14.3	2.0
App 1 - 0.01% disease; App 2 - 14 d after; FDIV high	8/15 8/29	5286	125	43.0	14.7	2.0
App 1 - 0.01% disease; DIV>6, RH >87%	8/15 8/29	5103	121	43.0	14.3	2.0
App 1 - 0.01% disease; DIV>6, RH >90%	8/15 8/29	5220	122	43.7	14.3	2.0
App 1 – after row closure & DIV>7, RH >87%	8/15 8/29	5056	124	43.2	14.2	2.8
App 1 – after row closure & DIV>7, RH >90%	8/15 8/29	5128	118	44.4	14.2	2.7
App 1 - 0.01% disease; App 2 - 14 d after; App 3 – DIV>6, RH>87%	8/15 8/29	5284	124	43.5	14.6	2.7
App 1 - 0.01% disease; App 2 - 14 d after; App 3 – DIV>6, RH >90%	8/15 8/29	5098	123	42.3	14.4	2.8
Crystal 222- Tolerant						
Untreated Check		5675	141	40.8	15.9	2.5
Row Closure/ 14 d interval	8/15 8/29	6279	137	46.6	15.5	1.8
App 1 – row closure; App 2 - 21 d after; FDIV high	8/15 9/6	5877	137	43.5	15.6	2.0
App 1 - 0.01% disease; App 2 - 14 d after; FDIV high	8/15 8/29	5778	137	42.6	15.5	2.3
App 1 - 0.01% disease; DIV>6, RH >87%	8/15 8/29	6173	138	45.5	15.6	2.3
App 1 - 0.01% disease; DIV>6, RH >90%	8/15 8/29	6178	138	45.2	15.6	2.3
App 1 – after row closure & DIV>7, RH >87%	8/15 8/29	5946	136	44.4	15.2	2.5
App 1 – after row closure & DIV>7, RH >90%	8/15 8/29	5538	131	43.0	15.0	2.0
App 1 - 0.01% disease; App 2 - 14 d after; App 3 – DIV>6, RH>87%	8/15 8/29	5669	131	44.1	14.9	2.5
App 1 - 0.01% disease; App 2 - 14 d after; App 3 – DIV>6, RH >90%	8/15 8/29	6168	137	45.9	15.4	2.3
LSD (P=0.05)		768	12.0	4.0	1.0	0.6
CV%		9.9	6.6	6.7	4.9	18.1

Table 5. Cercospora leaf spot control using fungicides at St. Thomas, 2002.

**Cercospora leaf spot measured on KWS scale 1-9 (no leaf spot – dead outer leaves, inner leaves severely damaged, regrowth of new leaves)*

Treatment	App. Date	Recoverable Sucrose Kg ha^{-1}	Recoverable Sucrose kg t^{-1}	Root Yield t ha^{-1}	Sucrose Content %	CLS* KWS
HH Agate – Susceptible						
Untreated Check		5285	133	40.5	15.1	7.3
App 1 - 0.01% disease; App 2 - 14 d after; FDIV high	8/17 8/31	6017	129	47.7	14.6	2.5
App 1 - 0.01% disease; DIV >6, RH >90%	8/17 8/31	5993	128	49.9	14.6	3.0
App 1 - 0.01% disease; DIV >6, RH >87%	8/17 8/31	5762	129	45.5	14.8	2.8
App DIV >7, RH >87%	8/31	5196	131	40.5	14.8	5.5
Crystal 222 – Tolerant						
Untreated Check		5081	131	39.4	14.7	5.0
App 1 - 0.01% disease; App 2 - 14 d after; FDIV high	8/17 8/31	5638	127	45.2	14.5	2.0
App 1 - 0.01% disease; DIV >6, RH >90%	8/17 8/31	6180	136	45.7	15.2	2.0
App 1 - 0.01% disease; DIV >6, RH >87%	8/17 8/31	5775	132	44.4	14.9	2.0
App DIV >7, RH >87%	8/31	5347	132	41.2	14.9	5.3
LSD (P < 0.05)		600	15.5	4.0	1.3	0.96
CV%		7.31	8.2	6.2	6.0	17.9

Table 6. Cercospora spores trapped using self- made spore traps in sugarbeet fields at Fargo, Breckenridge, and St. Thomas

Week	Weekly total number of spores trapped		
	Fargo	Breckenridge	St. Thomas
6/20 - 6/27/02	0	0	0
6/27 - 7/4/2	0	0	0
7/4 - 7/13/2	0	3	0
7/13 - 7/21/2	0	0	0
7/21 - 7/27/2	0	4	0
7/27 - 8/2/2	0	0	0
8/2 - 8/9/2	0	9	1
8/9 - 8/16/2	5	0	0
8/16 - 8/22/2	3	2	0
8/22 - 8/29/2	0	17	4
8/29 - 9/4/2	8	1	50
9/4 - 9/12/2	0	20	35
9/12 - 9/17/2	1	13	47

Table 7. Cercospora spores trapped in the sugarbeet field at Breckenridge and Crookston Cercospora nursery using Burkard Traps

Date	Weekly total number of spores trapped	
	Breckenridge	Crookston
8/15 8/22	50	1895
8/22 8/29	194	880
8/29 9/5	134	6039
9/5 9/12	106	5663
9/12 9/19	24	2422

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