

Management of New Highly Tolerant CLS Varieties

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Introduction: Cercospora Leaf Spot (CLS) is the most destructive foliar disease to impact sugar beet production in the SMBSC growing area. Without effective new fungicides, controlling the disease has become more difficult.

Objective: Genetic tolerance to CLS may be a key tool to controlling this disease. However, these new highly tolerant varieties must be evaluated to determine the best fungicide program to pair with this new tool.

Materials and Methods: Two trials were conducted as randomized complete block with four replications at separate locations. One trial site was located near Clara City, MN and the other trial site was located south of Hector, MN. These trials evaluated three varieties with differing levels of tolerance to CLS (2.0, 3.0, and 4.0 on the KWS rating scale) across six fungicide programs. The varieties used at each location were the same, but the fungicide programs were slightly different (Table 5 and 6). The Clara City Trial was planted on April 27th using 3gpa of 6-24-6 starter fertilizer applied in-furrow. The Hector Trial was planted on May 5th using 3gpa of 6-24-6 starter fertilizer applied in-furrow. Dual Magnum was applied preemergence and as a layby application with Roundup Powermax to keep the sites weed free. The sites were inoculated with pulverized leaves from the previous year that were infected with CLS. The inoculum was spread evenly across the site with a Gandy Orbit-Air applicator on July 6th at Clara City and July 10th at Hector. Fungicide applications began July 9th at Clara City and July 16th at Hector and continued on a ten to twelve-day spray interval. Applications were made using a custom-made tractor sprayer traveling 3.6mph with a spray volume of 20gpa and 60psi, utilizing XR11002 spray nozzles. Each plot consisted of six rows that were 40ft in length. The sprayer used CO₂ as a propellant and was designed to apply the treatment to the center four rows, leaving rows one and six untreated. Plots were rated for foliar damage using the KWS (Kleinwanzlebener Saatzucht) scale with one being disease free and nine being completely necrotic. The center two rows of each six row plot were harvested on September 25th at Clara City and October 9th at Hector using a six row defoliator and a two row research lifter. The beets harvested from the center two rows were weighed on the lifter and a sample of those beets were used for a quality analysis at the tare lab. The data was analyzed for significance using SAS version 9.4.

Clara City Trial Results: There were significant differences in the yield parameters between the varieties and between the fungicide programs within a single variety (Table 1). The 4.0 variety in combination with a tank-mixed 6 spray program had the highest percent sugar and extractable sugar per ton. However, the 2.0 variety tended to have higher tons per acre and extractable sugar per acre when compared to the 4.0 variety across the same fungicide programs. There were also many significant differences in the foliar ratings (Table 2). The 2.0 variety had the lowest foliar ratings when compared across fungicide programs to the other varieties. None of the fungicide programs provided acceptable control for the 4.0 variety. The 6 spray tank-mixed program did provide adequate control for the 3.0 variety. Excluding the check, all of the fungicide programs provided acceptable control for the 2.0 variety. The disease ratings show that the new CLS tolerance of the 2.0 variety is not immunity to the disease. A fungicide program will be required to maintain CLS control on these new varieties.

Trt #	Variety	Fungicide Program	Percent Sugar	Tons PerAcre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	2.0	Check	15.7 gh	30.9 efgh	13.2 gh	263.8 gh	8140.5 efg	90.8 a
2	2.0	3 Spray Program (ACE)	17.1 bc	35.9 b	14.5 abc	289.3 abc	10373.5 ab	90.9 a
3	2.0	6 Spray Program	16.8 bcde	39.0 a	14.1 bcde	282.8 bcde	11007.5 a	90.6 ab
4	2.0	3 Spray No Tank-Mix (ACE)	16.5 cdef	35.4 bc	13.9 cdef	278.0 cdef	9842.8 bcd	90.8 a
5	2.0	6 Spray No Tank-Mix	16.8 bcde	33.1 bcde	14.2 bcde	283.0 bcde	9378.0 cd	90.6 ab
6	2.0	3 Spray No Tank-Mix (CDE)	16.4 def	35.9 b	13.8 defg	275.3 defg	9872.0 bc	90.5 abcd
7	3.0	Check	14.8 i	25.3 k	12.2 j	244.8 j	6180.8 j	89.8 d
8	3.0	3 Spray Program (ACE)	16.6 cde	29.9 ghi	14.0 cde	279.5 cde	8312.0 ef	90.6 abc
9	3.0	6 Spray Program	17.0 bcd	31.1 efgh	14.3 bcd	286.5 bcd	8913.3 def	90.6 ab
10	3.0	3 Spray No Tank-Mix (ACE)	16.7 cde	28.7 hij	14.0 cde	279.5 cde	8029.0 fgh	90.2 abcd
11	3.0	6 Spray No Tank-Mix	16.7 cde	32.0 defg	14.1 bcde	281.8 bcde	9001.0 cde	90.8 a
12	3.0	3 Spray No Tank-Mix (CDE)	15.7 g	27.8 ijk	13.1 hi	261.0 hi	7258.8 ghi	90.0 bcd
13	4.0	Check	15.1 hi	26.0 jk	12.5 ij	249.8 ij	6493.8 ij	89.9 cd
14	4.0	3 Spray Program (ACE)	17.1 abc	34.4 bcd	14.4 abc	288.0 abcd	9879.5 bc	90.4 abcd
15	4.0	6 Spray Program	17.7 a	32.9 cdef	15.0 a	300.8 a	9881.5 bc	90.8 a
16	4.0	3 Spray No Tank-Mix (ACE)	16.3 efg	30.2 fghi	13.6 efgh	272.5 efgh	8221.5 ef	90.3 abcd
17	4.0	6 Spray No Tank-Mix	17.3 ab	33.3 bcde	14.7 ab	292.5 ab	9712.0 bcd	90.7 a
18	4.0	3 Spray No Tank-Mix (CDE)	15.9 fg	26.9 jk	13.3 fgh	266.0 fgh	7171.3 hi	90.3 abcd
		Mean	16.4	31.6	13.8	276.4	8759.4	90.5
		CV%	2.7	6.5	3.3	3.3	7.7	0.5
		Pr>F	<.0001	<.0001	<.0001	<.0001	<.0001	0.0469
		lsd (0.05)	0.64	2.92	0.64	12.8	951.0	0.68

Table 1: Yield parameter results for the Clara City Trial. Values with different letters are significantly different. Table 5 contains a full description of each treatment.

Trt #	Variety	Fungicide Program	29-Jul	7-Aug	17-Aug	26-Aug	4-Sep	14-Sep
1	2.0	Check	1.1 e	1.9 ef	2.7 ghi	5.1 ef	6.0 ef	6.7 d
2	2.0	3 Spray Program (ACE)	1.1 e	1.2 i	1.3 k	1.6 i	2.1 k	2.0 j
3	2.0	6 Spray Program	1.0 e	1.3 ghi	1.3 k	1.7 i	2.0 k	1.7 j
4	2.0	3 Spray No Tank-Mix (ACE)	1.1 e	1.1 i	1.3 k	2.0 i	2.8 j	2.9 i
5	2.0	6 Spray No Tank-Mix	1.1 e	1.3 hi	1.3 k	1.8 i	2.4 jk	2.0 j
6	2.0	3 Spray No Tank-Mix (CDE)	1.3 e	1.7 fgh	1.9 j	3.3 h	4.0 hi	4.0 h
7	3.0	Check	3.3 b	4.9 b	5.9 c	8.1 b	8.8 a	8.5 ab
8	3.0	3 Spray Program (ACE)	1.2 e	2.1 ef	2.6 ghi	4.0 g	4.7 g	5.4 f
9	3.0	6 Spray Program	1.3 e	2.0 ef	2.2 ij	3.3 h	3.7 i	4.2 h
10	3.0	3 Spray No Tank-Mix (ACE)	1.8 cd	3.3 c	3.8 de	5.8 d	6.7 cd	7.1 cd
11	3.0	6 Spray No Tank-Mix	1.1 e	1.8 fg	2.6 hi	4.0 g	4.4 gh	4.8 g
12	3.0	3 Spray No Tank-Mix (CDE)	3.6 b	4.7 b	5.5 c	6.5 c	7.2 c	7.4 c
13	4.0	Check	4.9 a	5.7 a	7.3 a	9.0 a	9.0 a	9.0 a
14	4.0	3 Spray Program (ACE)	1.8 d	2.8 d	3.5 ef	5.3 de	6.4 de	7.1 cd
15	4.0	6 Spray Program	1.2 e	2.3 e	2.8 gh	4.7 f	5.0 g	6.1 e
16	4.0	3 Spray No Tank-Mix (ACE)	2.2 c	3.6 c	4.3 d	6.5 c	7.9 b	8.3 b
17	4.0	6 Spray No Tank-Mix	1.2 e	2.1 ef	3.1 fg	5.1 ef	5.8 f	6.6 de
18	4.0	3 Spray No Tank-Mix (CDE)	4.7 a	5.8 a	6.5 b	8.0 b	9.0 a	9.0 a
		Mean	1.9	2.7	3.3	4.8	5.4	5.7
		CV%	17.2	11.6	11.1	9.6	8.0	6.6
		Pr>F	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
		lsd (0.05)	0.47	0.45	0.52	0.64	0.61	0.53

Table 2: Foliar ratings for the Clara City Trial using the KWS rating system with 1 being disease free and 9 being completely necrotic. Ratings with different letters are significantly different. Table 5 contains a full description of each treatment.

Hector Trial Results: This trial site received several large rain events during the growing season that led to saturated soil conditions and a reduced crop yield for the entire site. The differences in the yield parameters at this site were not as large as the differences at the Clara City site, however the trends remained similar (Table 3). This trial also had a reduced canopy which led to CLS developing later in the season with a lower disease severity overall across the site (Table 4). Although the disease severity was lower the trend remained the same as at the Clara City site. The 2.0 variety had the lowest foliar ratings when compared across fungicide programs to the other varieties. None of the fungicide programs provided acceptable control for the 4.0 variety. The 6 spray tank-mixed program did provide adequate control for the 3.0 variety. Excluding the check, all of the fungicide programs provided acceptable control for the 2.0 variety. Similar to the Clara City site, the disease ratings show that the new CLS tolerance of the 2.0 variety is not immunity to the disease

Trt #	Variety	Fungicide Program	Percent Sugar	Tons PerAcre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	2.0	Control	15.7 efg	25.5 bcd	12.9 cdef	257.8 bcde	6557.0 bc	89.1
2	2.0	6 Spray Program	16.0 abcde	25.9 abc	13.2 abcd	262.5 abc	6831.3 ab	89.0
3	2.0	2 Spray Program (AC)	16.2 abcd	25.7 bc	13.4 ab	267.8 a	6877.8 ab	89.5
4	2.0	3 Spray Program (ABC)	15.8 bcdef	28.2 a	13.1 abcde	260.5 abcd	7343.5 a	89.3
5	2.0	3 Spray Program (CDE)	15.8 cdef	27.4 ab	13.0 abcdef	259.5 abcde	7113.3 ab	89.1
6	2.0	2 Spray Program (CE)	16.1 abcde	25.9 bc	13.3 abc	265.8 ab	6881.8 ab	89.3
7	3.0	Control	14.6 h	20.3 hi	11.9 g	237.8 f	4812.3 fg	88.8
8	3.0	6 Spray Program	16.2 abc	21.2 ghi	13.4 ab	268.3 a	5674.8 de	89.4
9	3.0	2 Spray Program (AC)	15.2 g	23.8 cdef	12.5 f	249.8 e	5939.0 cd	89.1
10	3.0	3 Spray Program (ABC)	15.5 fg	23.4 defg	12.7 def	254.5 cde	5978.0 cd	89.1
11	3.0	3 Spray Program (CDE)	15.7 def	20.3 hi	12.9 cdef	257.5 bcde	5215.0 ef	88.8
12	3.0	2 Spray Program (CE)	15.7 efg	21.9 fgh	13.0 bcdef	259.3 abcde	5678.0 de	89.7
13	4.0	Control	14.1 i	19.0 i	11.3 h	226.3 g	4302.5 g	88.1
14	4.0	6 Spray Program	16.3 ab	24.3 cde	13.5 a	268.5 a	6529.8 bc	89.4
15	4.0	2 Spray Program (AC)	15.5 fg	23.4 defg	12.6 ef	252.3 de	5891.3 cde	88.4
16	4.0	3 Spray Program (ABC)	16.3 a	22.1 efgh	13.4 ab	267.8 a	5931.8 cd	88.9
17	4.0	3 Spray Program (CDE)	16.2 acbd	22.6 efg	13.2 abc	264.8 ab	5980.3 cd	88.7
18	4.0	2 Spray Program (CE)	15.4 fg	22.5 efgh	12.7 ef	252.8 cde	5684.5 de	89.0
		Mean	15.7	23.5	12.9	257.4	6067.9	89.0
		CV%	2.13	6.80	2.69	2.73	7.91	0.67
		Pr>F	<.0001	<.0001	<.0001	<.0001	<.0001	0.0722
		lsd (0.05)	0.47	2.27	0.49	10.0	681.6	NS

Table 3: Yield parameter results for the Hector Trial. Values with different letters are significantly different. Table 6 contains a full description of each treatment.

Trt #	Variety	Fungicide Program	11-Aug	20-Aug	31-Aug	10-Sep	21-Sep	1-Oct
1	2.0	Control	1.2 efg	1.8 defg	3.1 ef	3.6 fg	3.9 g	4.6 h
2	2.0	6 Spray Program	1.0 g	1.4 fg	1.5 i	1.5 i	1.9 jk	2.1 k
3	2.0	2 Spray Program (AC)	1.1 fg	1.4 fg	1.8 hi	1.9 hi	2.8 hi	2.7 j
4	2.0	3 Spray Program (ABC)	1.0 g	1.2 g	1.7 i	1.6 i	2.1 jk	2.4 jk
5	2.0	3 Spray Program (CDE)	1.2 efg	1.5 efg	1.7 i	1.6 i	1.8 k	1.5 l
6	2.0	2 Spray Program (CE)	1.3 defg	1.8 def	2.4 g	2.2 h	2.4 ij	2.7 j
7	3.0	Control	1.4 def	2.8 b	5.9 b	7.1 b	7.6 c	8.0 bc
8	3.0	6 Spray Program	1.1 fg	1.4 efg	1.6 i	2.3 h	3.3 h	4.0 i
9	3.0	2 Spray Program (AC)	1.3 defg	1.3 fg	3.3 e	4.8 e	5.5 e	7.0 e
10	3.0	3 Spray Program (ABC)	1.0 g	1.3 fg	2.3 gh	3.9 f	5.1 ef	6.3 f
11	3.0	3 Spray Program (CDE)	1.7 cd	2.5 bc	2.5 fg	3.4 fg	3.9 g	5.5 g
12	3.0	2 Spray Program (CE)	1.8 bc	2.7 b	4.0 d	4.9 e	5.6 e	7.4 de
13	4.0	Control	2.1 ab	4.1 a	7.7 a	9.0 a	9.0 a	9.0 a
14	4.0	6 Spray Program	1.3 defg	1.8 def	2.8 efg	3.1 g	5.0 f	6.2 f
15	4.0	2 Spray Program (AC)	1.5 cde	2.3 bcd	4.4 cd	6.4 c	7.8 bc	8.5 ab
16	4.0	3 Spray Program (ABC)	1.2 efg	1.9 cde	3.0 ef	5.2 e	6.9 d	7.7 cd
17	4.0	3 Spray Program (CDE)	2.4 a	3.7 a	4.6 c	5.8 d	6.4 d	7.3 de
18	4.0	2 Spray Program (CE)	2.4 a	3.9 a	5.4 b	6.7 bc	8.2 b	8.7 a
		Mean	1.4	2.2	3.3	4.2	4.9	5.6
		CV%	19.5	18.1	12.3	9.3	7.5	6.6
		Pr>F	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
		lsd (0.05)	0.40	0.55	0.58	0.55	0.53	0.53

Table 4: Foliar ratings for the Hector Trial using the KWS rating system with 1 being disease free and 9 being completely necrotic. Ratings with different letters are significantly different. Table 6 contains a full description of each treatment.

Conclusion: There are genetic differences in the yield potential of the varieties evaluated in these trials. The 2.0 variety has a higher tons per acre potential while its sugar content is lacking compared to the 4.0 variety. The 2.0 variety clearly does not need the same rigorous fungicide program that the 4.0 variety needs in order maintain extractable sugar per acre in a high disease pressure situation. These new highly tolerant varieties can be used as another tool to help reduce the impact of CLS and also reduce the cost of fungicide programs. However, CLS tolerance is only one attribute of a variety and there are many other factors that can impact the yield of a sugar beet field.

Trt #	Variety	Fungicide Program		Rate/Acre	Application Code
1	2.0	Control	n/a	n/a	ABCDEF
2	2.0	3 Spray Program	SuperTin	8 oz	AE
			Masterlock	6.4 oz	ACE
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	ACE
3	2.0	6 Spray Program	SuperTin	8 oz	ACE
			Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Badge SC	32 oz	CF
			Manzate Prostick	2 lbs	ABDE
			Proline	5.7 oz	F
4	2.0	3 Spray No Tank-Mix	SuperTin	8 oz	A
			Masterlock	6.4 oz	ACE
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	E
5	2.0	6 Spray No Tank-Mix	SuperTin	8 oz	CE
			Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	AD
			Proline	5.7 oz	F
6	2.0	3 Spray No Tank-Mix	SuperTin	8 oz	D
			Masterlock	6.4 oz	CDE
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	E
7	3.0	Control	n/a	n/a	ABCDEF
8	3.0	3 Spray Program	SuperTin	8 oz	AE
			Masterlock	6.4 oz	ACE
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	ACE
9	3.0	6 Spray Program	SuperTin	8 oz	ACE
			Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Badge SC	32 oz	CF
			Manzate Prostick	2 lbs	ABDE
			Proline	5.7 oz	F
10	3.0	3 Spray No Tank-Mix	SuperTin	8 oz	A
			Masterlock	6.4 oz	ACE
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	E
11	3.0	6 Spray No Tank-Mix	SuperTin	8 oz	CE
			Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	AD
			Proline	5.7 oz	F
12	3.0	3 Spray No Tank-Mix	SuperTin	8 oz	D
			Masterlock	6.4 oz	CDE
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	E
13	4.0	Control	n/a	n/a	ABCDEF
14	4.0	3 Spray Program	SuperTin	8 oz	AE
			Masterlock	6.4 oz	ACE
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	ACE
15	4.0	6 Spray Program	SuperTin	8 oz	ACE
			Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Badge SC	32 oz	CF
			Manzate Prostick	2 lbs	ABDE
			Proline	5.7 oz	F
16	4.0	3 Spray No Tank-Mix	SuperTin	8 oz	A
			Masterlock	6.4 oz	ACE
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	E
17	4.0	6 Spray No Tank-Mix	SuperTin	8 oz	CE
			Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	AD
			Proline	5.7 oz	F
18	4.0	3 Spray No Tank-Mix	SuperTin	8 oz	D
			Masterlock	6.4 oz	CDE
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	E

Table 5: Clara City Trial treatment list. The application code indicates when the product was applied in the spray program.

Trt #	Variety	Fungicide Program		Rate/Acre	Application Code
1	2.0	Control	n/a	n/a	ABCDEF
2	2.0	6 Spray Program	SuperTin	8 oz	ACE
			Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Badge SC	32 oz	CF
			Manzate Prostick	2 lbs	ABDE
			Proline	5.7 oz	F
3	2.0	2 Spray Program	Eminent VP	13 oz	D
			SuperTin	8 oz	A
4	2.0	3 Spray Program	Masterlock	6.4 oz	AC
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	AC
			SuperTin	8 oz	AC
5	2.0	3 Spray Program	Masterlock	6.4 oz	ABC
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	ABC
			SuperTin	8 oz	CE
6	2.0	2 Spray Program	Masterlock	6.4 oz	CDE
			Inspire XT	7 oz	D
			Manzate Prostick	2 lbs	CDE
			SuperTin	8 oz	C
7	3.0	Control	Masterlock	6.4 oz	CE
			Inspire XT	7 oz	E
			Manzate Prostick	2 lbs	CE
			SuperTin	8 oz	C
8	3.0	6 Spray Program	Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Badge SC	32 oz	CF
			Manzate Prostick	2 lbs	ABDE
			Proline	5.7 oz	F
			Eminent VP	13 oz	D
9	3.0	2 Spray Program	Masterlock	6.4 oz	AC
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	AC
			SuperTin	8 oz	A
10	3.0	3 Spray Program	Masterlock	6.4 oz	ABC
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	ABC
			SuperTin	8 oz	AC
11	3.0	3 Spray Program	Masterlock	6.4 oz	CDE
			Inspire XT	7 oz	D
			Manzate Prostick	2 lbs	CDE
			SuperTin	8 oz	CE
12	3.0	2 Spray Program	Masterlock	6.4 oz	CE
			Inspire XT	7 oz	E
			Manzate Prostick	2 lbs	CE
			SuperTin	8 oz	C
13	4.0	Control	n/a	n/a	ABCDEF
14	4.0	6 Spray Program	Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Badge SC	32 oz	CF
			Manzate Prostick	2 lbs	ABDE
			Proline	5.7 oz	F
			Eminent VP	13 oz	D
15	4.0	2 Spray Program	Masterlock	6.4 oz	AC
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	AC
			SuperTin	8 oz	A
16	4.0	3 Spray Program	Masterlock	6.4 oz	ABC
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	ABC
			SuperTin	8 oz	AC
17	4.0	3 Spray Program	Masterlock	6.4 oz	CDE
			Inspire XT	7 oz	D
			Manzate Prostick	2 lbs	CDE
			SuperTin	8 oz	CE
18	4.0	2 Spray Program	Masterlock	6.4 oz	CE
			Inspire XT	7 oz	E
			Manzate Prostick	2 lbs	CE
			SuperTin	8 oz	C

Table 6: Hector Trial treatment list. The application code indicates when the product was applied in the spray program.