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. The possibility of improving the longevity of current fungicide products with this new tool also must be evaluated.

Materials and Methods: Two trials were conducted as randomized complete blocks 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 24th and the Hector Trial was planted on April 29th. 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 June 28th at Clara City and July 8th at Hector. Fungicide applications began June 30th at Clara City and July 12th at Hector and continued on a ten to twelve-day spray interval. Applications were made using a custom-made tractor mounted sprayer traveling 3.3mph 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 CO^2 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 (1-9) 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 23rd at Clara City and September 10th 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 SMBSC 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). All the 2.0 variety fungicide programs, except the control, had significantly higher extractable sugar per acre (ESA) than all other treatments apart from treatments 8, 14, and 16. Treatments 8 and 14 were the 6 spray fungicide programs for the 3.0 and 4.0 varieties. The 6 spray program for the 3.0 and 4.0 varieties had significantly higher ESA than all other fungicide spray programs for the 3.0 and 4.0 varieties with the exception of treatment 16.

There were significant differences in the foliar disease ratings between the varieties and the fungicide spray programs within varieties (Table 2). The 2.0 variety with a 6 spray program had the lowest foliar disease rating followed by the 3 spray programs in that variety. The 2 spray programs in the 2.0 variety had significantly higher ratings and were similar to the 6 spray programs of the 3.0 and 4.0 varieties. All other treatments had significantly higher ratings and did not provide adequate disease control.

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	Control	14.4 cde	38.2 de	11.8 cde	236.9 cde	9026.1 c	89.6
2	2	6 Spray Program	15.2 ab	42.8 abc	12.7 abc	254.3 abc	10891.4 ab	90.4
3	2	2 Spray Program(AC)	15.2 ab	44.4 a	12.9 ab	258.2 ab	11230.6 a	91.6
4	2	3 Spray Program (ABC)	15.4 a	44.2 ab	12.9 ab	257.1 ab	11345.9 a	90.0
5	2	3 Spray Program (CDE)	15.2 ab	41.3 abcd	13.0 ab	260.6 ab	10758.8 ab	92.0
6	2	2 Spray Program (CE)	15.2 ab	42.9 abc	12.4 abcd	248.4 abcd	10646.8 ab	88.8
7	3	Control	12.6 h	25.6 i	10.2 f	204.4 f	5226.2 g	89.4
8	3	6 Spray Program	15.5 a	40.5 cd	13.2 a	264.0 a	10671.7 ab	91.5
9	3	2 Spray Program(AC)	13.7 ef	34.8 fg	11.5 de	230.3 de	7948.1 def	91.4
10	3	3 Spray Program (ABC)	14.5 bcd	35.7 ef	12.3 abcd	245.7 abcd	8759.7 cd	91.4
11	3	3 Spray Program (CDE)	13.4 f	32.4 gh	11.2 e	224.4 e	7265.2 f	91.1
12	3	2 Spray Program (CE)	13.9 def	30.3 h	11.6 de	232.7 de	7077.0 f	91.0
13	4	Control	12.6 gh	29.5 h	10.1 f	202.5 f	5967.0 g	88.4
14	4	6 Spray Program	15.3 a	42.4 abc	12.7 abc	254.9 abc	10822.6 ab	90.0
15	4	2 Spray Program(AC)	13.7 ef	38.8 de	11.6 de	232.2 de	9003.1 c	91.7
16	4	3 Spray Program (ABC)	14.9 abc	41.0 bcd	12.4 abcd	248.3 abcd	10174.4 b	90.1
17	4	3 Spray Program (CDE)	14.4 cde	34.5 fg	12.2 bcd	243.3 bcd	8413.0 cde	91.5
18	4	2 Spray Program (CE)	13.3 fg	34.7 fg	11.0 ef	220.8 ef	7643.3 ef	90.3
		Mean	14.4	37.4	12.0	239.8	9032.9	90.5
		CV%	3.6	6.1	5.6	5.6	7.9	1.8
		Pr>F	<.0001	<.0001	<.0001	<.0001	<.0001	0.0756
		lsd (0.05)	0.73	3.3	0.94	18.8	1011.7	ns

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	30-Jul	6-Aug	16-Aug	25-Aug	8-Sep	15-Sep
1	2	Control	1.4 ef	2.0 f	3.0 e	4.4 d	5.7 f	6.8 e
2	2	6 Spray Program	1.1 f	1.1 i	1.1 h	1.1 g	1.1 k	1.2 j
3	2	2 Spray Program(AC)	1.0 f	1.2 hi	1.2 h	1.3 g	2.1 j	3.1 gh
4	2	3 Spray Program (ABC)	1.0 f	1.2 i	1.1 h	1.2 g	1.8 j	2.4 i
5	2	3 Spray Program (CDE)	1.5 ef	1.7 fgh	2.0 fg	2.5 f	2.8 i	2.9 hi
6	2	2 Spray Program (CE)	1.6 e	1.7 fg	2.4 f	2.7 f	3.5 g	3.9 f
7	3	Control	4.6 a	5.5 a	7.9 a	8.8 a	8.8 a	9.0 a
8	3	6 Spray Program	1.3 ef	1.4 ghi	1.7 g	2.6 f	3.0 hi	3.1 gh
9	3	2 Spray Program(AC)	2.6 d	2.7 e	4.2 d	5.6 c	8.0 bc	8.9 ab
10	3	3 Spray Program (ABC)	1.2 ef	1.6 ghi	2.2 fg	3.6 e	6.3 e	8.0 cd
11	3	3 Spray Program (CDE)	4.5 ab	4.8 bc	6.0 bc	7.0 b	6.9 d	6.6 e
12	3	2 Spray Program (CE)	4.3 abc	4.4 dc	5.9 c	7.1 b	7.8 bc	7.9 d
13	4	Control	4.0 bc	5.2 ab	8.2 a	9.0 a	9.0 a	9.0 a
14	4	6 Spray Program	1.3 ef	1.5 ghi	1.9 g	2.6 f	3.4 gh	3.6 fg
15	4	2 Spray Program(AC)	2.1 d	2.6 e	4.3 d	5.4 c	8.2 b	9.0 a
16	4	3 Spray Program (ABC)	1.1 ef	1.4 ghi	2.1 fg	3.3 e	6.1 e	7.8 d
17	4	3 Spray Program (CDE)	4.2 abc	4.7 bc	6.4 b	7.4 b	7.7 c	7.7 d
18	4	2 Spray Program (CE)	3.9 c	4.2 d	5.7 c	7.1 b	8.2 b	8.5 bc
		Mean	2.4	2.7	3.7	4.6	5.6	6.1
		CV%	15.2	12.1	8.3	6.3	5.7	5.5
		Pr>F	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
		lsd (0.05)	0.51	0.46	0.44	0.41	0.45	0.47

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: There were significant differences in the yield parameters between the varieties and between the fungicide programs within a single variety (Table 3). The control and the 2 spray triazole program with the 3.0 and 4.0 varieties had significantly lower ESA than most other treatments. The majority of the treatments did not significantly differ in yield parameters.

There were significant differences in the foliar disease ratings between the varieties and the fungicide spray programs within varieties (Table 4). The 5 spray program and the EBDC alone program had the lowest foliar disease rating when used in combination with the 2.0 variety. The 3 spray programs with the 2.0 variety had slightly higher ratings followed by the 2 spray program with the 2.0 variety and the 5 spray programs for the 3.0 and 4.0 varieties. The EBDC alone program for the 3.0 and 4.0 varieties had significantly lower foliar disease ratings than the 3 spray programs for those varieties. The 3.0 and 4.0 varieties had very similar foliar disease ratings when compared across the same fungicide spray program.

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	Control	13.9 ab	34.5 abc	11.2 ab	224.3 ab	7734.8 abc	88.3 abcde
2	2	5 Spray Program (0ABCDE)	14.1 a	34.4 abc	11.3 ab	225.6 ab	7724.6 abcd	88.0 abcdef
3	2	3 Spray Tin Program (0ACE)	13.7 ab	34.5 abc	10.8 ab	216.4 ab	7455.5 bcde	87.1 defg
4	2	3 Spray Triazole Program(0ACE)	13.7 ab	33.2 bcd	10.9 ab	217.6 ab	7125.2 de	87.4 cdefg
5	2	2 Spray Triazole Program (BD)	13.9 ab	34.4 abc	11.3 ab	225.9 ab	7778.5 ab	89.0 ab
6	2	EBDC Alone Program (0ABCDE)	13.9 ab	34.6 abc	11.1 ab	221.4 ab	7646.7 bcd	87.5 bcdef
7	3	Control	13.4 bc	24.6 h	10.7 bc	214.4 bc	5275.0 i	88.4 abcd
8	3	5 Spray Program (0ABCDE)	14.0 a	30.4 ef	11.4 ab	227.7 ab	6916.6 ef	88.8 abc
9	3	3 Spray Tin Program (0ACE)	14.1 a	31.6 de	11.6 a	231.0 a	7284.3 bcde	89.4 a
10	3	3 Spray Triazole Program(0ACE)	14.0 a	30.4 ef	11.4 ab	228.7 ab	6940.1 ef	89.0 ab
11	3	2 Spray Triazole Program (BD)	13.9 ab	27.6 g	11.2 ab	222.6 ab	6122.9 gh	87.8 bcdef
12	3	EBDC Alone Program (0ABCDE)	14.0 ab	31.7 de	11.3 ab	225.7 ab	7137.2 cde	88.5 abcd
13	4	Control	12.8 c	28.7 fg	10.0 c	200.3 c	5736.7 hi	87.0 defg
14	4	5 Spray Program (0ABCDE)	14.0 ab	35.1 ab	11.1 ab	222.6 ab	7780.6 ab	87.6 bcdef
15	4	3 Spray Tin Program (0ACE)	13.9 ab	33.6 bcd	10.9 ab	218.3 ab	7291.4 bcde	86.8 efg
16	4	3 Spray Triazole Program(0ACE)	13.9 ab	34.1 bcd	10.9 ab	218.7 ab	7452.8 bcde	86.7 fg
17	4	2 Spray Triazole Program (BD)	13.0 c	32.2 cde	10.0 c	200.1 c	6439.0 fg	85.9 g
18	4	EBDC Alone Program (0ABCDE)	14.2 a	36.7 a	11.3 ab	226.4 ab	8302.5 a	87.4 cdefg
		Mean	13.8	32.33	11.02	220.5	7119	87.8
		CV%	3.2	5.7	4.7	4.7	6	1.2
		Pr>F	0	<.0001	0.0024	0.003	<.0001	0
		lsd (0.05)	0.62	2.6	0.74	14.7	606.1	1.5

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	6-Aug	16-Aug	30-Aug	8-Sep
1	2	Control	2.2 c	2.9 c	4.6 d	5.5 e
2	2	5 Spray Program (0ABCDE)	1.3 h	1.4 f	1.3 h	1.5 k
3	2	3 Spray Tin Program (0ACE)	1.3 gh	1.7 ef	1.8 h	2.2 ij
4	2	3 Spray Triazole Program(0ACE)	1.3 gh	1.5 f	2.4 g	2.5 i
5	2	2 Spray Triazole Program (BD)	1.6 fg	2.0 de	3.1 f	3.5 gh
6	2	EBDC Alone Program (0ABCDE)	1.2 h	1.5 f	1.5 h	1.9 jk
7	3	Control	4.0 ab	7.0 a	9.0 a	9.0 a
8	3	5 Spray Program (0ABCDE)	1.8 def	2.2 d	2.5 g	3.1 h
9	3	3 Spray Tin Program (0ACE)	2.2 c	3.0 c	5.1 c	6.0 d
10	3	3 Spray Triazole Program(0ACE)	2.2 cd	2.9 c	5.1 c	6.2 cd
11	3	2 Spray Triazole Program (BD)	3.8 b	4.3 b	7.7 b	8.5 b
12	3	EBDC Alone Program (0ABCDE)	2.3 c	2.2 d	3.9 e	4.9 f
13	4	Control	4.2 a	6.8 a	9.0 a	9.0 a
14	4	5 Spray Program (0ABCDE)	1.8 ef	2.1 d	2.7 fg	3.6 g
15	4	3 Spray Tin Program (0ACE)	2.0 cde	2.9 c	5.3 c	6.4 cd
16	4	3 Spray Triazole Program(0ACE)	2.0 cdef	3.0 c	5.4 c	6.5 c
17	4	2 Spray Triazole Program (BD)	3.8 b	4.5 b	7.5 b	8.5 b
18	4	EBDC Alone Program (0ABCDE)	2.0 cde	2.3 d	4.1 e	5.3 ef
		Mean	2.3	3.0	4.6	5.2
		CV%	11.3	9.8	6.6	6.4
		Pr>F	<.0001	<.0001	<.0001	<.0001
		lsd (0.05)	0.37	0.42	0.42	0.47

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: The genetic yield and quality potential of the varieties tested appear to be similar in the absence of disease. The 2.0 variety clearly does not need the same rigorous fungicide program that the 4.0 variety needs in order maintain a similar extractable sugar per acre in a high disease pressure situation. The 3.0 and the 4.0 varieties had a similar performance in both trials. Based upon the results of the Hector Trial it appears that it may be possible to develop a fungicide spray program that removes one of the currently used fungicide mode of action groups to slow resistance development and improve product performance in the future. However, this will only be possible when a high percentage of the acres planted in the growing area contain the new high level of tolerance to CLS.

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. With the results of the trials from 2020 and 2021 it appears that these new highly tolerant varieties should be able to utilize a fungicide spray program with 3 less applications than varieties with a traditional level of CLS tolerance. The number of applications needed to suppress CLS will be dependent on the environmental conditions and inoculum load of a given year. 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	Control	n/a	n/a	n/a
2	2	6 Spray Program	SuperTin	8 oz	ACE
			Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	ABCDEF
			Proline	5.7 oz	F
			Eminent VP	13 oz	D
3	2	2 Spray Program	SuperTin	8 oz	A
			Masterlock	6.4 oz	AC
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	AC
4	2	3 Spray Program	SuperTin	8 oz	AC
			Masterlock	6.4 oz	ABC
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	ABC
5	2	3 Spray Program	SuperTin	8 oz	CE
			Masterlock	6.4 oz	CDE
			Inspire XT	7 oz	D
			Manzate Prostick	2 lbs	CDE
6	2	2 Spray Program	SuperTin	8 oz	C
			Masterlock	6.4 oz	CE
			Inspire XT	7 oz	E
			Manzate Prostick	2 lbs	CE
7	3	Control	n/a	n/a	n/a
8	3	6 Spray Program	SuperTin	8 oz	ACE
			Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	ABCDEF
			Proline	5.7 oz	F
			Eminent VP	13 oz	D
9	3	2 Spray Program	SuperTin	8 oz	A
			Masterlock	6.4 oz	AC
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	AC
10	3	3 Spray Program	SuperTin	8 oz	AC
			Masterlock	6.4 oz	ABC
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	ABC
11	3	3 Spray Program	SuperTin	8 oz	CE
			Masterlock	6.4 oz	CDE
			Inspire XT	7 oz	D
			Manzate Prostick	2 lbs	CDE
12	3	2 Spray Program	SuperTin	8 oz	C
			Masterlock	6.4 oz	CE
			Inspire XT	7 oz	E
			Manzate Prostick	2 lbs	CE
13	4	Control	n/a	n/a	n/a
14	4	6 Spray Program	SuperTin	8 oz	ACE
			Masterlock	6.4 oz	ABCDEF
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	ABCDEF
			Proline	5.7 oz	F
			Eminent VP	13 oz	D
15	4	2 Spray Program	SuperTin	8 oz	A
			Masterlock	6.4 oz	AC
			Inspire XT	7 oz	C
			Manzate Prostick	2 lbs	AC
16	4	3 Spray Program	SuperTin	8 oz	AC
			Masterlock	6.4 oz	ABC
			Inspire XT	7 oz	B
			Manzate Prostick	2 lbs	ABC
17	4	3 Spray Program	SuperTin	8 oz	CE
			Masterlock	6.4 oz	CDE
			Inspire XT	7 oz	D
			Manzate Prostick	2 lbs	CDE
18	4	2 Spray Program	SuperTin	8 oz	C
			Masterlock	6.4 oz	CE
			Inspire XT	7 oz	E
			Manzate Prostick	2 lbs	CE

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	Control	n/a	n/a		n/a
2	2	5 Spray Program	SuperTin	8	oz	ACE
			Masterlock	6.4	oz	0ABCDE
			Inspire XT	7	oz	B
			Manzate Prostick	2	lbs	0ABCDE
			Eminent VP	13	oz	D
3	2	3 Spray Program	SuperTin	8	oz	AE
		(Tin)	Masterlock	6.4	oz	0ACE
			Badge SC	32	oz	C
			Manzate Prostick	2	lbs	0ACE
4	2	3 Spray Program	Proline	5.7	oz	E
		(Early Triazole)	Masterlock	6.4	oz	0ACE
			Badge SC	32	oz	C
			Inspire XT	7	oz	A
			Manzate Prostick	2	lbs	0ACE
5	2	2 Spray Program	Manzate Prostick	2	lbs	BD
		(Late Triazole)	Masterlock	6.4	oz	BD
			Badge SC	32	oz	D
			Inspire XT	7	oz	B
6	2	6 Spray Program	Masterlock	6.4	oz	0ABCDE
		(EBDC only)	Manzate Prostick	2	lbs	0ABCDE
7	3	Control	n/a	n/a		n/a
8	3	6 Spray Program	SuperTin	8	oz	ACE
			Masterlock	6.4	oz	0ABCDE
			Inspire XT	7	oz	B
			Manzate Prostick	2	lbs	0ABCDE
			Eminent VP	13	oz	D
9	3	3 Spray Program	SuperTin	8	oz	AE
		(Tin)	Masterlock	6.4	oz	0ACE
			Badge SC	32	oz	C
			Manzate Prostick	2	lbs	0ACE
10	3	3 Spray Program	Proline	5.7	oz	E
		(Early Triazole)	Masterlock	6.4	oz	0ACE
			Badge SC	32	oz	C
			Inspire XT	7	oz	A
			Manzate Prostick	2	lbs	0ACE
11	3	2 Spray Program	Manzate Prostick	2	lbs	BD
		(Late Triazole)	Masterlock	6.4	oz	BD
			Badge SC	32	oz	D
			Inspire XT	7	oz	B
12	3	6 Spray Program	Masterlock	6.4	oz	0ABCDE
		(EBDC only)	Manzate Prostick	2	lbs	0ABCDE
13	4	Control	n/a	n/a		n/a
14	4	6 Spray Program	SuperTin	8	oz	ACE
			Masterlock	6.4	oz	0ABCDE
			Inspire XT	7	oz	B
			Manzate Prostick	2	lbs	0ABCDE
			Eminent VP	13	oz	D
15	4	3 Spray Program	SuperTin	8	oz	AE
		(Tin)	Masterlock	6.4	oz	0ACE
			Badge SC	32	oz	C
			Manzate Prostick	2	lbs	0ACE
16	4	3 Spray Program	Proline	5.7	oz	E
		(Early Triazole)	Masterlock	6.4	oz	0ACE
			Badge SC	32	oz	C
			Inspire XT	7	oz	A
			Manzate Prostick	2	lbs	0ACE
17	4	2 Spray Program	Manzate Prostick	2	lbs	BD
		(Late Triazole)	Masterlock	6.4	oz	BD
			Badge SC	32	oz	D
			Inspire XT	7	oz	B
18	4	6 Spray Program	Masterlock	6.4	oz	0ABCDE
		(EBDC only)	Manzate Prostick	2	lbs	0ABCDE

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