2008

Southern MN Beet Sugar Cooperative

Research Report

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SMBSC APPROVED VARIETIES – 2009

FULLY APPROVED
UNLIMITED SALES VARIETIES

- Beta 1591R
- Beta 95RR03 (Roundup Ready)
- Crystal RR201 (Roundup Ready)
- Hilleshog 3035Rz
- Hilleshog 3036Rz

SPECIALTY VARIETIES

Beta 4811R	(APH)
Beta 1322R	(APH)
Hilleshog 9093RR	(Rhizoctonia)

UNLIMITED SALES– Last year of sales

- Holly Hybrids 255

TEST MARKET VARIETIES
(Sales shall not exceed 10% of total seed sales for each variety).

- Holly Hybrids HH710
- Beta 97RR17 (Roundup Ready)
- Crystal RR265 (Roundup Ready)

LIMITED TEST MARKET VARIETIES – Roundup Ready
(Sales shall not exceed 5% of total seed sales for each variety).

- Hilleshog 4017RR (Roundup Ready)
- SES/VDH 36835RR (Roundup Ready)

2008 SMBSC Official Variety Trials Specifications

Trial #	Trial Location	Cooperator	Entry Designation	Previous Crop	Total Nitrogen	Planting Date	Stand Counts	Disease	Harvest Date
0856-01	Hector	Keith Johnson	Comm./SemiComm	Field Corn	115	5/18/08	6/13/08	Mod-Severe Rzm	9/29/08
0856-31	Hector	Keith Johnson	Transgenic	Field Corn	115	5/18/08	6/13/08	Light-Mod Rhizoc and Aph	9/27/08
0856-02	Lake Lillian	Schmoll Bros.	Comm./SemiComm	Sw Corn	137+	5/20/08	6/10/08	Mod-Severe Rzm	10/2/08
0856-32	Lake Lillian	Schmoll Bros.	Transgenic	Sw Corn	137+	5/20/08	6/13/08		9/30/08
0856-03	Renville	C&P Haen	Comm./SemiComm	Field Corn	104	5/21/08	6/17/08	Slight Rzm	9/25/08
0856-33	Renville	C&P Haen	Transgenic	Field Corn	104	5/21/08	6/16/08	Light -Mod Rhizoc and Aph	9/24/08
0856-04	DeGraff	Olson/Jansen	Comm./SemiComm	Field Corn	110	5/17/08	6/18/08	Slight Rzm	9/19/08
0856-34	DeGraff	Olson/Jansen	Transgenic	Field Corn	110	5/17/08	6/18/08	Light -Mod Rhizoc and Aph	9/18/08

Table 1. Mean of the Three Year 2009 SMBSC Varieties Approved for Unlimited Sales - Based Upon Approval Criteria

CONVERTED

Entry - Converted	Specialty	RST+ RSA	*Rec/T (lbs)* 3 yr avg	% of mean	*Rec/A (lbs)* 3 yr avg	% of mean	*Yield (T/A)* 3 yr avg	% of mean	*Sugar %* 3 yr avg	% of mean	*Cercospora Leaf Spot* 3 yr avg	% of mean	*Emerg-ence (%)* 3 yr avg	% of mean	*Aphano-myces* 3 yr avg	% of mean	*Purity (%)* 3 yr avg	% of mean	*Revenue/ Ton* % of mean	*Revenue/ Acre* % of mean
2009 APPROVED VARIETIES																				
Beta 1591R		202.67	262.33	98.91	7790.62	103.76	29.87	105.17	15.66	99.52	4.69	97.26			5.35	103.99	90.32	99.54	98.12	103.31
Beta 95RR03		199.98	259.35	97.78	7673.18	102.20	29.84	105.05	15.42	97.99	4.81	99.56	57.98	99.94	4.66	90.62	90.66	99.91	96.19	101.16
Crystal RR201		197.01	269.80	101.72	7154.20	95.29	26.62	93.73	15.87	100.87	5.08	105.33	58.04	100.06	5.21	101.37	91.31	100.62	102.94	96.60
Hilleshog 3035Rz	RZC	199.63	265.48	100.09	7473.46	99.54	28.06	98.80	15.76	100.16	4.53	93.86			5.56	108.10	90.70	99.95	100.18	99.08
Hilleshog 3036Rz		200.71	269.21	101.50	7448.83	99.21	27.62	97.24	15.96	101.45	5.02	103.98			4.93	95.92	90.73	99.98	102.57	99.85
			265.23	100.00	7508.06	100.00	28.40	100.00	15.73	100.00	4.83	100.00	58.01	100.00	5.14	100.00	90.75	100.00	100.00	100.00
2009 SPECIALTY VARIETIES (% of Mean is of Approved Mean)																				
Beta 1322R	APH	204.91	262.90	99.12	7942.57	105.79	30.14	106.14	15.73	99.97	5.35	110.78	70.34	121.26	4.81	93.59	90.17	99.37	98.54	104.70
Beta 4811R	APH & RZM	193.65	257.56	97.11	7248.90	96.55	28.20	99.31	15.42	98.02	4.48	92.72	66.41	114.49	4.55	88.44	90.15	99.34	95.02	94.46
2009 PREVIOUSLY APPROVED VARIETIES NOT MEETING CRITERIA - FINAL YEAR OF SALES (% of Mean is of Approved Mean)																				
Candidate Varieties																				
HOLLY 255	APH & RZM	190.30	260.13	98.07	6924.47	92.23	26.72	94.07	15.50	98.49	4.24	87.87	64.09	110.49	4.90	95.27	90.49	99.72	96.67	91.03
TEST MARKET VARIETIES FOR LIMITED SALES WITH 3 YEARS OF DATA (% of Mean is of Approved Mean)																				
Hilleshog 4017RR		204.25	267.64	100.91	7759.13	103.34	29.13	102.58	15.81	100.47	5.16	106.85	56.34	97.12	6.03	117.20	91.05	100.33	101.59	104.32

Green = RoundUp Ready Varieties

* Revenue per Ton and Revenue per Acre figures were produced using the SMBSC payment forumla for the 2007 crop.

Table 2. Comparison of 2009 Approved Varieties to Candidate Test Market Varieties Based on 2 Year Data, 2007 - 2008

CONVERTED

Entry - Converted	Specialty	RST+ RSA	*Rec/T (lbs)* 2 yr avg	% of mean	*Rec/A (lbs)* 2 yr avg	% of mean	*Yield (T/A)* 2 yr avg	% of mean	*Sugar %* 2 yr avg	% of mean	*Cercospora Leaf Spot* 2 yr avg	% of mean	*Emergence (%)* 2 yr avg	% of mean	*Aphanomyces* 2 yr avg	% of mean	*Purity (%)* 2 yr avg	% of mean	*Revenue/ Ton* % of mean	*Revenue/ Acre* % of mean
2009 APPROVED VARIETIES																				
Beta 1591R		200.48	260.21	98.42	7756.79	102.05	30.04	103.71	15.58	98.80	4.63	97.42	55.18	89.10	5.78	110.64	90.11	99.72	97.21	100.90
Beta 95RR03		200.54	260.31	98.46	7758.93	102.08	30.26	104.47	15.58	98.80	4.70	99.09	60.33	97.43	4.44	84.97	90.18	99.80	97.40	101.84
Crystal RR201		198.10	266.55	100.82	7394.13	97.28	27.99	96.64	15.88	100.71	5.08	107.07	58.33	94.20	5.14	98.43	90.40	100.05	101.39	98.05
Hilleshog 3035Rz	RZC	200.12	267.14	101.04	7530.58	99.08	28.27	97.60	15.86	100.57	4.41	92.95	68.52	110.64	5.75	110.13	90.66	100.33	101.78	99.41
Hilleshog 3036Rz		200.77	267.74	101.27	7562.64	99.50	28.26	97.57	15.95	101.11	4.91	103.47	67.27	108.63	5.01	95.84	90.45	100.10	102.22	99.80
			264.39	100.00	7600.61	100.00	28.96	100.00	15.77	100.00	4.75	100.00	61.93	100.00	5.23	100.00	90.36	100.00	100.00	100.00
2009 SPECIALTY VARIETIES (% of Mean is of Approved Mean)																				
Beta 1322R	APH	203.42	261.23	98.80	7951.74	104.62	30.40	104.97	15.70	99.56	5.44	114.65	71.07	114.77	4.89	93.52	89.85	99.43	97.94	102.88
Beta 4811R	APH & RZM	193.11	255.62	96.68	7329.07	96.43	28.64	98.90	15.38	97.53	4.58	96.55	68.17	110.08	4.56	87.21	89.82	99.40	94.23	93.26
2009 PREVIOUSLY APPROVED VARIETIES NOT MEETING CRITERIA - FINAL YEAR OF SALES (% of Mean is of Approved Mean)																				
Candidate Varieties																				
HOLLY 255	APH & RZM	191.34	258.61	97.82	7108.31	93.52	27.53	95.05	15.44	97.91	4.32	90.99	66.77	107.82	5.14	98.41	90.33	99.96	96.15	91.45
TEST MARKET VARIETIES FOR LIMITED SALES WITH 2 YEARS OF DATA (% of Mean is of Approved Mean)																				
Beta 97RR17		201.33	265.73	100.51	7663.34	100.83	29.02	100.21	15.83	100.36	4.95	104.30	64.91	104.81	4.23	81.04	90.44	100.09	100.84	101.12
Crystal RR265		208.61	265.54	100.43	8221.71	108.17	31.27	107.98	15.85	100.51	4.30	90.67	58.26	94.08	5.08	97.16	90.28	99.91	100.71	108.83
Hilleshog 4017RR		205.41	267.77	101.28	7914.80	104.13	29.87	103.14	15.94	101.08	5.05	106.31	57.89	93.48	5.95	113.77	90.46	100.11	102.20	105.49
Holly HH710		196.98	263.22	99.56	7404.39	97.42	28.15	97.19	15.70	99.53	4.38	92.36			4.73	90.59	90.55	100.21	99.61	96.88

Green = RoundUp Ready Varieties

* Revenue per Ton and Revenue per Acre figures were produced using the SMBSC payment forumla for the 2007 crop.

Table 3. Comparison of 2009 Approved Varieties to Candidate Test Market Varieties Based on 1 Year Data, 2008

CONVERTED

Entry - Converted	Specialty	RST+ RSA	*Rec/T (lbs)* 1 yr avg	% of mean	*Rec/A (lbs)* 1 yr avg	% of mean	*Yield (T/A)* 1 yr avg	% of mean	*Sugar %* 1 yr avg	% of mean	*Cercospora Leaf Spot* 1 yr avg	% of mean	*Emerg-ence (%)* 1 yr avg	% of mean	*Aphano-myces* 1 yr avg	% of mean	*Purity (%)* 1 yr avg	% of mean	*Revenue/ Ton* % of mean	*Revenue/ Acre* % of mean
2009 APPROVED VARIETIES																				
Beta 1591R		196.62	262.12	99.13	7492.37	97.49	28.57	97.92	15.66	99.41	4.59	97.92	44.85	73.53	5.60	113.51	90.31	99.85	98.60	96.57
Beta 95RR03		199.29	260.34	98.46	7748.64	100.82	30.02	102.90	15.55	98.73	4.67	99.65	55.00	90.16	4.36	88.35	90.30	99.84	97.36	100.20
Crystal RR201		199.16	263.65	99.71	7642.94	99.45	29.15	99.92	15.74	99.93	5.09	108.58	69.27	113.56	4.08	82.60	90.30	99.84	99.52	99.46
Hilleshog 3035Rz	RZC	203.15	266.47	100.78	7867.45	102.37	29.63	101.55	15.82	100.42	4.26	90.98	70.33	115.30	5.64	114.33	90.62	100.19	101.20	102.79
Hilleshog 3036Rz		201.78	269.47	101.91	7675.27	99.87	28.51	97.71	15.99	101.50	4.82	102.88	65.54	107.45	5.00	101.20	90.69	100.27	103.32	100.98
			264.41	100.00	7685.33	100.00	29.18	100.00	15.75	100.00	4.68	100.00	61.00	100.00	4.94	100.00	90.44	100.00	100.00	100.00
2009 SPECIALTY VARIETIES (% of Mean is of Approved Mean)																				
Beta 1322R	APH	200.52	262.35	99.22	7785.48	101.30	29.50	101.11	15.70	99.66	5.52	117.75	71.14	116.63	5.14	104.21	90.19	99.72	98.77	99.88
Beta 4811R	APH & RZM	191.25	255.63	96.68	7268.34	94.57	28.28	96.93	15.36	97.50	4.47	95.44	71.44	117.12	4.47	90.54	89.93	99.43	94.26	91.39
Hilleshog 9093RR	RZC	209.14	263.59	99.69	8411.60	109.45	32.05	109.85	15.68	99.55	4.26	90.98	65.10	106.73	4.82	97.65	90.58	100.15	99.52	109.35
2009 PREVIOUSLY APPROVED VARIETIES NOT MEETING CRITERIA - FINAL YEAR OF SALES (% of Mean is of Approved Mean)																				
Candidate Varieties																				
HOLLY 255	APH & RZM	184.59	259.62	98.19	6640.01	86.40	25.65	87.91	15.48	98.27	4.30	91.72	70.04	114.83	5.37	108.86	90.45	100.01	96.89	85.19
TEST MARKET VARIETIES FOR LIMITED SALES WITH 1 YEAR OF DATA (% of Mean is of Approved Mean)																				
Beta 97RR17		195.89	266.34	100.73	7313.62	95.16	27.56	94.46	15.87	100.75	4.61	98.41	63.64	104.33	4.29	86.98	90.37	99.92	101.17	95.59
Crystal RR265		206.86	269.21	101.82	8073.20	105.05	30.21	103.53	15.96	101.32	4.12	88.00	58.50	95.91	4.52	91.63	90.71	100.29	103.04	106.71
Hilleshog 4017RR		204.43	270.39	102.26	7852.33	102.17	29.37	100.66	16.10	102.21	4.85	103.62	62.83	103.00	5.71	115.70	90.41	99.96	103.89	104.60
Holly HH710		194.45	263.04	99.48	7298.97	94.97	27.79	95.25	15.59	98.96	4.39	93.70	64.47	105.69	4.39	88.89	90.90	100.50	99.23	94.54
SV36835RR		206.84	270.20	102.19	8042.43	104.65	30.00	102.83	15.90	100.94	5.28	112.79	66.41	108.88	4.87	98.74	91.25	100.89	103.68	106.63

Green = RoundUp Ready Varieties

* Revenue per Ton and Revenue per Acre figures were produced using the SMBSC payment forumla for the 2007 crop.

2008 Southern Minnesota Beet Sugar Cooperative
Variety Strip Trial Research

There were nine variety strip trials conducted in the SMBSC growing area in 2008. Seven of the strip trials were established in shareholder fields within the area of the Cooperative that is heavily populated with beet production. Two additional variety strip trials were conducted under irrigation in the north and northwest parts of the growing area. The objective of the seven strip trials located in the core of the cooperative area was to provide an opportunity to observe variety performance in actual field conditions. The purpose of the northern strip trials was the same, but an additional purpose was to provide information on variety performance within irrigated conditions that are present in these areas since there are no official variety trials in these areas.

In 2008, there were both conventional variety strip trials, and RoundUp Ready® variety strip trials. There were 5 locations for the RoundUp Ready® strip trials, and 4 locations of conventional varieties. All variety strip trials were planted with the shareholder's planter. The seven trials located in the core growing area were harvested with the shareholder's defoliator and harvester. Harvest of these sites consisted of delivery of harvested loads from a measured strip of land. Each variety had five samples taken for quality analysis. One of the conventional variety strip trials was lost at harvest time, so this report will only show the results of the other three conventional trial locations.

The harvest of the two northern locations consisted of hand harvesting twelve samples per variety at each location. Each sample contained 10 feet of row that was used for quality analysis. Yield was estimated by using the sample weight for the ten feet of harvested row and converting to tons per acre. The northern strip trials are hand harvested due to the distance of the field to the receiving station and the likelihood of needing to haul partial loads a long distance if harvested with shareholder harvesting equipment.

2008 SMBSC Strip Trial Results

Agriculturist: Paul Wallert | Plant date:
Location: Murdock | Harvest date: 10/11/2008

Variety	Tons Per Acre	Sugar %	Purity %	Brei Nitrate	ESA lbs/acre	Revenue $/acre
Beta 1322	31.91	17.13	90.65	17	9239	$1,350.25
Beta 1591	28.44	17.22	91.47	14.6	8379	$1,237.07
Hilleshog 3035	31.21	17.6	91.72	8.6	9439.1	$1,414.70
Hilleshog 3036	29.94	17.22	91.26	15.8	8795.1	$1,296.27
Average	30.375	17.2925	91.275	14	8963.05	$1,324.57

*Revenue per acre determined by using 2007 SMBSC payment formula.

Agriculturist: Lonny Buss | Plant date: 5/8/2008
Location: Hancock | Harvest date: 9/16/2008

Variety	Tons Per Acre	Sugar %	Purity %	Brei Nitrate	ESA lbs/acre	Revenue $/acre
Beta 1322	26.9	15.35	90.8	18	6951.77	$942.13
Beta 1591	23.2	14.92	90.75	18	5813.22	$769.82
Hilleshog 3035	28	15.7	90.73	10	7403.76	$1,019.94
Hilleshog 3036	24.5	15.92	91.4	13	6637	$929.61
Average	25.65	15.47	90.92	14.75	6701.44	$915.38

*Revenue per acre determined by using 2007 SMBSC payment formula.

Agriculturist: Greg Johnson | Plant date:
Location: Renville | Harvest date: 9/26/2008

Variety	Tons Per Acre	Sugar %	Purity %	Brei Nitrate	ESA lbs/acre	Revenue $/acre
Beta 1322	29.3	16.12	90.33	16	7921.59	$1,108.03
Beta 1591	30.48	16.09	90.58	16	8254.12	$1,155.82
Hilleshog 3035	28.4	16.36	90.55	20	7824.08	$1,108.14
Hilleshog 3036	29.8	16.75	90.71	24	8436.08	$1,215.76
Average	29.495	16.33	90.5425	19	8108.968	$1,146.94

*Revenue per acre determined by using 2007 SMBSC payment formula.

2008 SMBSC RoundUp Strip Trial Results

Agriculturist: Lonny Buss — Plant date: 5/9/2008
Location: Montevideo — Harvest date:

Variety	Tons Per Acre	Sugar %	Purity %	Brei Nitrate	ESA lbs/acre	Revenue $/acre
Beta 95RR03	18.7	15.81	88.36	29	4808.24	$649.21
Crystal RR201	18.87	16.12	89.31	20	5025.42	$695.74
Hilleshog 4017RR	19.7	16.99	89.93	12	5597.58	$808.56
SES/VDH 36835	22.1	17.38	90.53	8	6488.03	$955.89
Average	19.84	16.58	89.53	17.25	5479.82	$777.35

*Revenue per acre calculated using 2007 SMBSC payment formula.

Agriculturist: Les Plumley — Plant date: 5/6/2008
Location: Bird Island (early) — Harvest date: 9/17/2008

Variety	Tons Per Acre	Sugar %	Purity %	Brei Nitrate	ESA lbs/acre	Revenue $/acre
Beta 95RR03	23.54	15.67	90.07		6152.92	$840.71
Crystal RR201	22.8	15.9	90.84		6119.87	$851.83
Hilleshog 4017RR	24.59	16.37	90.93		6815.71	$969.15
SES/VDH 36835	27.91	15.66	91.19		7408.26	$1,023.26
Average	24.71	15.90	90.76		6624.19	$921.24

*Revenue per acre calculated using 2007 SMBSC payment formula.

Agriculturist: Reynold Hansen — Plant date: 5/18/2008
Location: Gluek — Harvest date: 10/1/2008

Variety	Tons Per Acre	Sugar %	Purity %	Brei Nitrate	ESA lbs/acre	Revenue $/acre
Beta 95RR03	21.19	16.1	90.57	15	5741.29	$804.23
Crystal 201RR	20.48	16.38	91.38	13	5716.27	$816.47
Hilleshog 4017RR	22.26	17.04	91.3	9	6470.59	$947.73
SES/VDH 36835	26.17	16.54	91.5	5	7392.23	$1,063.87
Average	22.53	16.52	91.19	10.50	6330.10	$908.08

*Revenue per acre calculated using 2007 SMBSC payment formula

2008 SMBSC RoundUp Strip Trial Results

Agriculturist: Les Plumley Plant date: 5/6/2008

Location: Bird Island (late) Harvest date: 10/15/2008

Variety	Tons Per Acre	Sugar %	Purity %	Brei Nitrate	ESA lbs/acre	Revenue $/acre
Beta 95RR03	28.05	17.71	91.74		8543.95	$1,285.64
Crystal RR201	26.7	18.28	92.26		8468.25	$1,302.33
Hilleshog 4017RR	29.16	18.86	91.71		9485.4	$1,477.80
SES/VDH 36835	32.22	18	92.81		10,128.82	$1,550.46
Average	29.03	18.21	92.13		9156.61	$1,404.06

*Revenue per acre calculated using 2007 SMBSC payment formula.

Agriculturist: Jim Rademacher Plant date: 5/9/2008

Location: Belgrade Harvest date: 9/16/2008

Variety	Tons Per Acre	Sugar %	Purity %	Brei Nitrate	ESA lbs/acre	Revenue $/acre
Beta 95RR03	29.7	14.7	90.18	25	7265.21	$944.13
Crystal RR201	26.7	15.65	91.52	19	7115.02	$985.44
Hilleshog 4017RR	28.2	15.6	90.97	25	7431.83	$1,021.37
SES/VDH 36835	31.6	15.13	91.66	15	8139.84	$1,100.51
Average	29.05	15.27	91.0825	21	7487.975	$1,012.86

*Revenue per acre calculated using 2007 SMBSC payment formula.

2008 SMBSC Strip Trial Results

Agriculturist:	Pete Caspers	Plant date:	5/20/2008
Location:	Hector	Harvest date:	9/27/2008

Variety	Tons Per Acre	Sugar %	Purity %	ESA lbs/acre	Revenue $/acre
Beta 95RR03	24.49	16.29	89.6	6623	$926.71
Crystal RR201	21.91	16.68	90.66	6170	$886.43
Hilleshog 4017RR	22.86	17.67	91.64	6937	$1,041.64
SES/VDH 36835	26.54	16.47	91.17	7429	$1,063.01
Average	23.95	16.78	90.77	6789.75	$979.45

RHIZOCTONIA CROWN AND ROOT ROT ON SUGARBEET FOLLOWING CORN

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Rhizoctonia crown and root rot (RCRR) of sugarbeet is caused by the soilborne fungus *Rhizoctonia solani*. The fungus is composed of genetically isolated populations called anastomosis groups or AGs (2). The AG population causing RCRR of sugarbeet is *R. solani* AG 2-2, which is further divided into the intraspecific groups (ISGs) AG 2-2 IIIB and AG 2-2 IV (2,4). While both ISGs cause RCRR on sugarbeet, AG 2-2 IV is reported as the primary cause (4) and AG 2-2 IIIB is reported as the more aggressive population (3).

Reports from Europe (1) indicate *R. solani* AG 2-2 IIIB is an aggressive root rot pathogen in rotations of corn and sugarbeet. In the southeastern U.S.A., *R. solani* AG 2-2 IIIB causes a crown root and brace root rot on corn. In recent field trials in the Red River Valley (RRV), we found that *R. solani* AG 2-2 IIIB caused lesions on roots of a conventional corn variety that displayed no aboveground symptoms of disease or effects on yield, while *R. solani* AG 2-2 IV rarely infected roots (7,8,9). Consequently, these reports have raise concerns about the presence and role of *R. solani* AG 2-2 IIIB and AG 2-2 IV in corn and sugarbeet rotations in the RRV and southern Minnesota.

A wide range of commercial corn varieties are sold in the RRV and southern Minnesota including conventional as well as transgenic (Roundup Ready and insect resistance - with traits for feed or ethanol production). Availability of short-season varieties in the RRV has resulted in increased corn acreage in recent years. In southern Minnesota, however, sugarbeet frequently follows field corn (75% acres), sweet corn (10%), soybean (10%), and other crops (5%). Producers in the RRV and southern Minnesota are reporting increases in RCRR of sugarbeet. The relationship of this disease to corn varieties grown the previous season is unknown.

OBJECTIVES

Field trials were established in the RRV and southern Minnesota to determine 1.) pathogenicity and survival of *R. solani* AG 2-2 IIIB and AG 2-2 IV on varieties of corn with different genetic traits, and 2.) effects on a subsequent sugarbeet crop.

MATERIALS AND METHODS

Field trials were established in 2007 at the University of Minnesota, Northwest Research and Outreach Center, Crookston (RRV) and in 2007 and 2008 by the Southern Minnesota Beet Sugar Cooperative in a field near Gluek, Minnesota. Main plots consisted of a non-inoculated control, inoculation with *R. solani* AG 2-2 IV, and inoculation with *R. solani* AG 2-2 IIIB (inoculum of *R. solani* was grown for 3 weeks on sterilized barley grain). Transgenic corn varieties (Roundup Ready, resistance to corn borer and root worm) with traits for feed or ethanol production were sown as subplots in each main plot (Table 1). Trials were arranged in a split-plot design with four replicates. Trials at both sites were sown to sugarbeet in 2008 and the repeat trial at Gluek will be sown to sugarbeet in 2009.

Field trial establishment: *Red River Valley*. At Crookston, main plots were 77 feet wide by 30 feet long. Plots were fertilized to 130 lb N A^{-1}acre; 30 lb P_2O_5 A^{-1} also was added. On May 17, 2007 main plots were inoculated with 26.4 oz of barley infested with *R. solani* AG 2-2 IV or *R. solani* AG 2-2 IIIB. *Rhizoctonia*-infested grains were sprinkled on the soil surface and incorporated with a Melroe multiweeder; control plots were not inoculated. Then, main plots were divided into seven, 11-ft wide subplots (6 rows, 22 inches apart), which were sown with six transgenic and one conventional corn variety (as sown in previous experiments [7,8,9]) (Table 1). The herbicide Volley (2.25 pints A^{-1}) was applied before emergence on May 25. Plots were cultivated June 21 and hand-weeded on June 28.

Southern Minnesota. At Gluek, main plots (inoculated with *R. solani* AG 2-2 IV or AG 2-2 IIIB and the non-inoculated control) were 66 feet wide by 35 feet long. Plots were fertilized, as recommended for the region. After

Table 1. Corn varieties planted at the University of Minnesota, Northwest Research and Outreach Center (NWROC), Crookston on May 17, 2007 and by the Southern Minnesota Beet Sugar Cooperative in a field near Gluek on May 15, 2007 and May 22, 2008. Plots had been inoculated with *Rhizoctonia solani* AG 2-2 IV or *R. solani* AG 2-2 IIIB a few hours before planting. The control was not inoculated.

NWROC (Red River Valley)		Southern Minnesota [X]			
Variety	Maturity (days)	Variety (2008)	Maturity (days)	Genetics[XY]	End use[Z]
Proseed GVRP80	80	DKC 38-92	88	RR	Feed
DKC 35-51	85	DKC 41-64 (43-31)	91 (93)	RR + Bt	Feed
DKC 41-57	91	DKC 41-57	91	RR + Bt + CRW	Feed
DKC 35-18	85	DKC 48-52 (48-46)	98	RR (RR + Bt)	Ethanol
DKC 33-11	83	DKC 42-95	92	RR + Bt	Ethanol
DKC 42-91	92	DKC 42-91	92	RR + Bt + CRW	Ethanol
Pioneer 39D81	81			Conventional	

[X] Some varieties were not available in 2008, so changes for 2008 are shown in parenthesis

[Y] RR = Roundup Ready, Bt = Bt gene for corn borer resistance, CRW = gene for corn root worm resistance

[Z] Feed varieties have no special processing characteristics; ethanol varieties are highly fermentable for ethanol processing

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plots were inoculated, six transgenic corn varieties were sown per plot (Table 1) on May 15, 2007, as described above. Plots were treated with Roundup to control weeds. The trial was repeated at Gluek in 2008. Plots were inoculated and sown to corn, as described above, on May 22, 2008. Corn varieties were the same except DKC 43-31 and DKC 48-46 replaced DKC 41-64 and DKC 48-52, respectively.

Corn disease assessment and yields: ***Red River Valley*****.** To determine disease indices and isolate *R. solani* AG 2-2 from corn roots, 20 plants were dug within two rows of each corn variety on September 12 and 13, 2007. Roots were washed with a pressure washer and rated for disease with a 1-5 scale where 1 = less than 2% of roots were discolored or decayed and 5 = root system rotted and plant dead or dying (6). Three, 1-inch length segments of root from each plant were surface-treated in bleach for 15 sec, rinsed twice in sterile deionized water, and placed on a semi-selective medium for isolation of *R. solani*. Cultures of *R. solani* were transferred to potato dextrose agar for further identification.

Corn yield estimates were made by hand-harvesting all ears for 10 feet of the two center rows per plot on October 12. Ears were placed in a bin dryer. Yield was adjusted to 15.5% moisture and calculated based on 56 pounds per bushel.

Southern Minnesota**.** Corn roots were sampled for root rot and recovery of *R. solani* as described above for the Red River Valley. Ears were harvested on October 3, as described above. In the repeated trial, corn roots were sampled for root rot and *Rhizoctonia* recovery on September 10, 2008 and ears were harvested on October 22, 2008.

Sugarbeet disease assessment and yield: ***Red River Valley*****.** In 2008, plots previously sown to corn were fertilized to recommended levels on May 13 and sown to sugarbeet 'VDH 46519' at 1 7/8-inch spacing on May 14. Plots consisted of six 30-ft rows spaced 22 inches apart. The insecticide Counter (9.5 lb/A) was applied over the row at planting. Microrates of the herbicides Betamix (0.5-1.5 pt/A) + UpBeet (1/8 oz/A) + Stinger (30 ml/A) + clethodim (70-130 ml/A) + MSO (1-1.25 pt/A) were applied on June 8, 15, 23 and 30. Stinger was included only in the June 15 and 23 applications. Herbicides were applied with a tractor-mounted sprayer and TeeJet 8003 flat fan nozels at 30 psi. Stands were thinned to the equivalent of 175 plants per 100 feet of row on June 25. Cercospora leaf spot was controlled by applications of SuperTin (5 oz/acre), Eminent (13 oz/acre), and Headline (9 oz/acre) on August 2, 13, and September 9, respectively.

Stands were counted at regular intervals after emergence until plots were thinned. The two middle rows of each plot were harvested October 2, 2008. Twenty roots were randomly selected from each plot and rated for RCRR with a 0 to 7 scale, where 0 = healthy and 7 = root completely rotted and foliage dead. Ten roots were randomly selected and analyzed for yield and quality by American Crystal Sugar Company Quality Laboratory, East Grand Forks, MN.

Southern Minnesota. In 2008, plots previously sown to corn were fertilized to recommended levels and sown to sugarbeet 'HM 2467' at 2.5-inch spacing on May 21. Plots consisted of six 35-ft rows spaced 22 inches apart. Microrates of the herbicides Betamix (0.5-1.5 pt/A) + UpBeet (1/8 oz/A) + Stinger (30 ml/A) + clethodim (70-130 ml/A) + MSO (1-1.25 pt/A) were applied on May 26, June 6, and 17. Herbicides were applied with a tractor-mounted sprayer and TeeJet 8003 flat fan nozzles at 40 psi. Stands were thinned to the equivalent of 190 plants per 100 feet of row on June 20. Cercospora leaf spot was controlled by applications of Eminent (13 oz/A), SuperTin (5 oz/A), and Headline (9 oz/A) on August 8, 20, and September 4, respectively.

Stands were counted at regular intervals after emergence until plots were thinned. The two middle rows of each plot were harvested October 15, 2008. Twenty roots were randomly selected from each plot and rated for RCRR, as previously described. Roots were analyzed for yield and quality by Southern Minnesota Beet Sugar Cooperative, Renville, MN. Sugarbeet will be sown in 2009 in the repeated trial sown to corn in 2008.

Data analysis. Data were subjected to analysis of variance and if significant (P = 0.05), means were separated by Least Significant Difference (LSD).

RESULTS

Corn disease assessment and yields: For both locations (including 2007 and 2008 trials in southern Minnesota), there were no significant interactions between soil inoculum and corn variety, so these main treatments will be presented separately.

***Red River Valley*.** Root rot ratings of corn were low and similar among plots inoculated with *R. solani* AG 2-2 IV, AG 2-2 IIIB, and the non-inoculated control (Table 2). Isolation of *R. solani* from roots was unaffected by soil inoculation with either population of *R. solani* or in the non-inoculated control, although frequency of isolation tended to be highest in plots inoculated with *R. solani* AG 2-2 IIIB (Table 2). Corn yields were unaffected by inoculation of soil with *R. solani* compared to non-inoculated soil (Table 2).

Corn variety had no significant effect on root rot rating or percent isolation of *R. solani* from roots (Table 2). Yields were significantly higher for DKC 42-91 compared to Proseed GVRP80, DKC 33-11, and DKC 35-51 and the other varieties were intermediate (Table 2).

Southern Minnesota. In 2007, corn root rot ratings were slightly higher (Table 3) than at Crookston (Table 2) but overall, were low and similar among plots inoculated with either population of *R. solani* and the non-inoculated control. Rating was difficult because an early killing frost occurred about 4 weeks before plots were assessed for disease, so corn roots were discolored and senesced earlier than expected. Despite this problem, isolation of *R. solani* from roots was significantly higher in plots inoculated with *R. solani* AG 2-2 IIIB (19%) compared to plots inoculated with AG 2-2 IV (4%) and the non-inoculated control (6%) (Table 3). Corn yields were unaffected by inoculation of soil with *R. solani* compared to non-inoculated soil (Table 3).

In 2008, root rot ratings and recovery of *R. solani* from roots were low and there were no significant differences among inoculum treatments (Table 3). Corn yields were unaffected by inoculation of soil with *R. solani* compared to non-inoculated soil (Table 3).

In 2007 and 2008, root rot ratings were significantly different among corn varieties, and tended to follow similar trends in both years (Table 3). Isolation of *R. solani* from roots varied from 4 to 18% in 2007 and from 4 to 7% in 2008, but for each year, there were no significant differences among varieties (Table 3). Corn yields varied in both years, but were not statistically different among varieties (Table 3).

Table 2. Corn - Red River Valley: Disease ratings, isolation of *Rhizoctonia solani* from roots, and yields of corn sown May 17, 2007 in plots previously inoculated (same day) with *R. solani* AG 2-2 IV, *R. solani* AG 2-2 IIIB, or not inoculated at the University of Minnesota, Northwest Research and Outreach Center, Crookston (Red River Valley).

Main treatment[V]	Root rot rating[W]	% Plants with *R. solani* [X]	Yield (bu/A)[Y]
Inoculum			
Non-inoculated (control)	1.5	11	173
R. solani AG 2-2 IV	1.8	17	170
R. solani AG 2-2 IIIB	2.1	20	166
LSD (P = 0.05)[Z]	NS	NS	NS
Corn variety			
Proseed GVRP80	1.8	25	159 b
DKC 35-51	1.7	12	169 b
DKC 41-57	1.8	15	170 ab
DKC 35-18	1.9	17	172 ab
DKC 33-11	1.8	15	164 b
DKC 42-91	1.6	12	183 a
Pioneer 39D81	1.9	19	171 ab
LSD (P = 0.05)[Z]	NS	NS	13.5

V *R. solani* AG 2-2 IV and *R. solani* AG 2-2 IIIB were grown on sterile barley grains for 3 weeks and air-dried. Plots were inoculated on May 17, 2007 by sprinkling infested barley grains onto the soil surface (26.4 oz per 2,310 ft^2; the control was not inoculated) and incorporated with a Melroe multiweeder. Plots were arranged in a randomized block design with four replicates. Corn varieties were sown May 17, 2007 as subplots (6 rows, 22 inches apart and 30 feet long) within each soil inoculum main plot.

W Corn plants were dug from plots on September 12 and 13, 2007; roots were washed and rated with a 1-5 scale where 1 = less than 2% root surface with lesions and 5 = roots completely rotted and plant dead (6). Each value for effect of inoculum is an average of 560 plants. Each value for corn variety is an average of 240 plants.

X Segments of roots (three, ~1-inch long per plant) were excised after disease assessment, surface-treated with bleach, and cultured on a semi-selective medium for isolation of *R. solani*.

Y Plots were harvested October 12, 2007; yields were adjusted to 15.5% moisture and calculated based on 56 pounds per bushel.

Z LSD = Least significant difference, P = 0.05; for each column, values followed by the same letter are not significantly different; NS = not significantly different.

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Table 3. Corn – Southern Minnesota: Disease ratings, isolation of *Rhizoctonia solani* from roots, and yields of corn planted on May 15, 2007 and May 22, 2008 in plots previously inoculated (same day) with *R. solani* AG 2-2 IV, *R. solani* AG 2-2 IIIB, or not inoculated at Gluek in southern Minnesota.

	Root rot rating[W]		% Plants with *R. solani* [X]		Yield (bu/A)[Y]	
Main treatment[V]	2007	2008	2007	2008	2007	2008
Inoculum						
Non-inoculated (control)	2.2	1.9	6	2	145	144
R. solani AG 2-2 IV	2.3	1.8	4	3	152	145
R. solani AG 2-2 IIIB	2.4	2.0	19	4	138	136
LSD (P = 0.05)[Z]	NS	NS	5	NS	NS	NS
Corn Variety						
DKC 38-92	2.6 a	2.3 a	10	4	139	140
DKC 41-64 (43-31)	2.4 ab	2.1 a	14	3	129	159
DKC 41-57	2.2 cd	1.8 b	18	3	142	135
DKC 48-52 (48-46)	2.4 bc	1.8 b	8	7	161	134
DKC 42-95	2.2 d	1.7 b	4	1	151	132
DKC 42-91	2.1 d	1.7 b	4	3	148	149
LSD (P = 0.05)[Z]	0.17	0.21	NS	NS	NS	NS

V *R. solani* AG 2-2 IV and *R. solani* AG 2-2 IIIB were grown on sterile barley grains for 3 weeks and air-dried. Plots were inoculated on May 15, 2007 and May 22, 2008 by sprinkling infested barley grains onto the soil surface (26.4 oz per 2,310 ft^2; the control was not inoculated) and incorporated. Plots were arranged in a randomized block design with four replicates. Corn varieties were sown May 15, 2007 and May 22, 2008 as subplots (6 rows, 22 inches apart and 35 feet long) within each soil inoculum main plot.

W Corn plants were dug from plots on October 3, 2007 and September 10, 2008; roots were washed and rated with a 1-5 scale where 1 = less than 2% root surface with lesions and 5 = roots completely rotted and plant dead (6). Each value for effect of inoculum is an average of 480 plants. Each value for corn variety is an average of 240 plants.

X Segments of roots (three, ~1-inch long per plant) were excised after disease assessment, surface-treated with bleach, and cultured on a semi-selective medium for isolation of *R. solani*.

Y Plots were harvested October 3, 2007 and October 22, 2008; yields were adjusted to 15.5% moisture and calculated based on 56 pounds per bushel.

Z LSD = Least significant difference, P = 0.05; for each column, values followed by the same letter are not significantly different; NS = not significantly different.

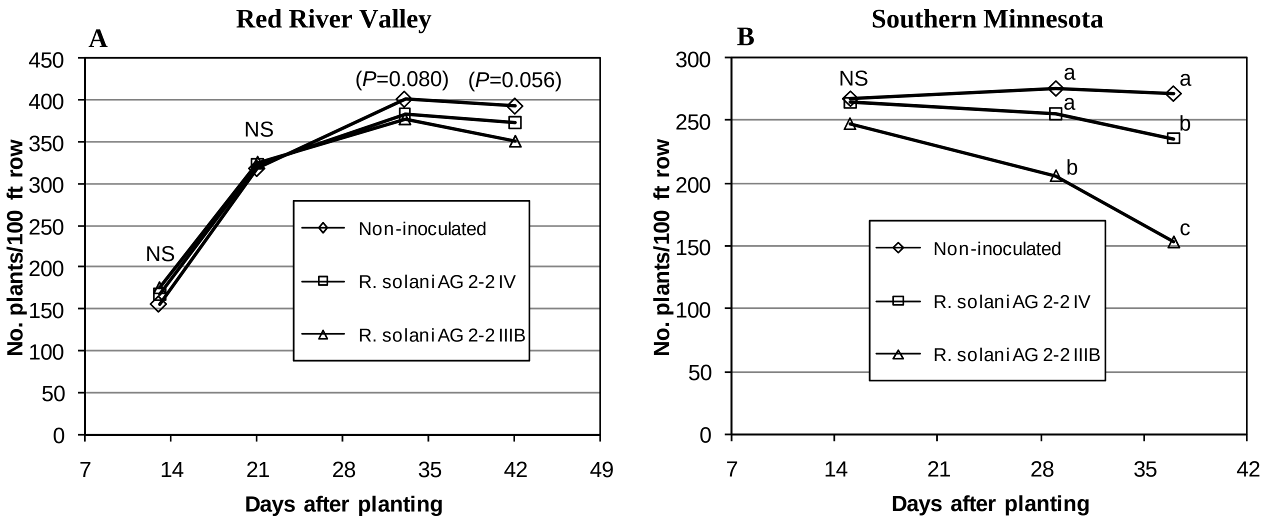

Figure 1. Sugarbeet stand in field trials at **A.**) Crookston, MN (sown May 13, 2008) and **B.**) Gluek, MN (sown May 14, 2008) that had been inoculated with *Rhizoctonia solani* AG 2-2 IV, *R. solani* AG 2-2 IIIB, or not inoculated and planted to corn (six varieties at Gluek and seven at Crookston representing different variety traits) the previous year.

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Sugarbeet disease assessment and yield: For both locations, there were no significant interactions between soil inoculum and previous corn variety, so these main treatments will be presented separately.

Red River Valley. In 2008, sugarbeet seedling stands were statistically the same following 2007 plots that had been inoculated with *R. solani* AG 2-2 IIIB, AG 2-2 IV, or not inoculated and then sown to corn (Fig. 1A). At 6 weeks after planting sugarbeet, there was a trend for decreasing stand in plots previously inoculated with *R. solani* AG 2-2 IIIB, but stands were not quite significantly different (P = 0.056) among the inoculum treatments.

At harvest in 2008, ratings for RCRR were statistically the same, regardless of soil inoculation in 2007, but tended to be equal and somewhat higher in plots inoculated with *R. solani* AG 2-2 IIIB and AG 2-2 IV compared to the non-inoculated control (Table 4). There were no differences for number of sugarbeet roots harvested, root yield, or sucrose yield following soil inoculation with *R. solani* AG 2-2 IIIB, AG 2-2 IV, or the non-inoculated control the previous growing season (Table 4).

The corn variety sown in 2007 had no significant effect on sugarbeet in 2008 for RCRR, number of harvested roots, or sucrose (Table 4). Yield of sugarbeet, however, was significantly higher following Proseed GVRP80 and DKC 35-51 compared with other varieties.

Southern Minnesota. In 2008, by 2 weeks after planting, sugarbeet reached equally high and maximum stands in plots inoculated with *R. solani* AG 2-2 IIIB, AG 2-2 IV, or not inoculated in 2007 (Fig. 1B). Over the next 3 weeks, plants began to die in plots previously inoculated with *R. solani* AG 2-2 IIIB and AG 2-2 IV so that by 5 weeks after planting, seedling stands were lowest in plots inoculated with *R. solani* AG 2-2 IIIB, intermediate in plots inoculated with AG 2-2 IV, and highest in non-inoculated plots (Figure 1B).

At harvest in 2008, plots inoculated in 2007 with *R. solani* AG 2-2 IIIB had more severe RCRR than those inoculated with AG 2-2 IV and the non-inoculated control and also were lower for number of harvested roots, root yield, and sucrose (Table 5). Plots inoculated in 2007 with AG 2-2 IV were significantly lower than the non-inoculated control for root yield and recoverable sucrose/A but were equal to the non-inoculated control for number of harvested roots, RCRR, percent sugar and pounds of sugar per ton (Table 5).

The corn variety sown in 2007 had no significant effect on sugarbeet in 2008 for RCRR or any harvest parameters (Table 5).

Table 4. **Sugarbeet – Red River Valley:** Number of harvested roots, root rot ratings, yield, and quality of sugarbeet sown May 14, 2008 in plots previously inoculated with *Rhizoctonia solani* AG 2-2 IV, *R. solani* AG 2-2 IIIB, or not inoculated and planted (same day) to corn varieties on May 17, 2007 at the University of Minnesota, Northwest Research and Outreach Center, Crookston (Red River Valley).

Main treatments [X]		No. roots Harvested/ 60 ft row	RCRR 0-7 [Y]	Yield (Ton/A)	Sucrose %	Sucrose lb/T	Sucrose lb recov/A
Inoculum							
Non-inoculated (control)		81	2.8	25.8	16.1	301	7757
R. solani AG 2-2 IV		73	3.4	23.6	15.7	292	6893
R. solani AG 2-2 IIIB		74	3.4	24.1	16.1	301	7241
LSD (P = 0.05) [Z]		NS	NS	NS	NS	NS	NS
Previous Corn Variety	Genetics						
Proseed GVRP80	RR, feed	80	3.1	26.4 a	15.8	294	7732
DKC 35-51	RR+Bt, feed	77	3.0	26.1 ab	15.9	297	7777
DKC 41-57	RR+Bt+CRW, feed	77	3.1	23.8 c	16.0	300	7145
DKC 35-18	RR, ethanol	71	3.3	23.5 c	16.0	299	7011
DKC 33-11	RR+Bt, ethanol	78	3.2	24.2 bc	16.0	299	7267
DKC 42-91	RR+Bt+CRW, ethanol	74	3.3	23.6 c	16.1	300	7093
Pioneer 39D81	Conventional	76	3.3	24.0 c	15.8	295	7053
LSD (P = 0.05) [Z]		NS	NS	2.08	NS	NS	NS

[X] Inoculum of *R. solani* AG 2-2 was grown on sterile barley grain; plots were inoculated on May 17, 2007 by sprinkling infested barley grains onto the soil surface (26.4 oz per 2,310 ft^2; the control was not inoculated) and incorporating with a Melroe multiweeder. Plots were arranged in a randomized block design with four replicates. Corn varieties were sown May 17, 2007 as subplots (6 rows, 22 inches apart and 30 feet long) within each soil inoculum main plot. Sugarbeet plots were harvested October 2, 2008.

[Y] Rhizoctonia crown and root rot rating (0-7 scale, 0 = root healthy, 7 = root completely rotted and foliage dead).

[Z] LSD = Least significant difference, P = 0.05; for each column, numbers followed by the same letter are not significantly different; NS = not significantly different.

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Table 5. **Sugarbeet – Southern Minnesota:** Number of harvested roots, root rot ratings, yield, and quality of sugarbeet sown May 21, 2008 in plots previously inoculated with *Rhizoctonia solani* AG 2-2 IV, *R. solani* AG 2-2 IIIB, or not inoculated and planted to corn varieties on May 15, 2007 at Gluek in southern Minnesota.

Main treatments [X]		No. roots Harvested/ 60 ft row	RCRR 0-7 [Y]	Yield (Ton/A)	Sucrose %	Sucrose lb/T	Sucrose lb recov/A
Inoculum							
Non-inoculated (control)		92 a	2.5 a	23.7 a	17.5 a	296 a	6994 a
R. solani AG 2-2 IV		82 a	2.9 a	21.1 b	16.9 a	284 a	6002 b
R. solani AG 2-2 IIIB		30 b	6.2 b	14.8 c	14.5 b	226 b	3385 c
LSD (P = 0.05) [Z]		14	0.6	2.2	0.9	20	649
Previous Corn Variety	Genetics						
DKC 38-92	RR, feed	64	4.0	19.1	16.4	271	5329
DKC 41-64	RR+Bt, feed	69	3.9	20.2	16.2	267	5525
DKC 41-57	RR+Bt+CRW, feed	67	3.8	20.2	16.4	270	5554
DKC 48-52	RR, ethanol	71	3.8	19.3	16.1	264	5284
DKC 42-95	RR+Bt, ethanol	67	3.8	20.3	16.3	270	5556
DKC 42-91	RR+Bt+CRW, ethanol	72	3.7	20.1	16.4	271	5515
LSD (P = 0.05) [Z]		NS	NS	NS	NS	NS	NS

[X] Inoculum of *R. solani* AG 2-2 was grown on sterile barley grain; plots were inoculated on May 15, 2007 by sprinkling infested barley grains onto the soil surface (26.4 oz per 2,310 ft^2; the control was not inoculated) and incorporating. Plots were arranged in a randomized block design with four replicates. Corn varieties were sown May 15, 2007 as subplots (6 rows, 22 inches apart and 35 feet long) within each soil inoculum main plot. Sugarbeet plots were harvested October 15, 2008.

[Y] Rhizoctonia crown and root rot rating (0-7 scale, 0 = root healthy, 7 = root completely rotted and foliage dead).

[Z] LSD = Least significant difference, P = 0.05; for each column, numbers followed by the same letter are not significantly different; NS = not significantly different.

DISCUSSION

At both locations and in both years *R. solani* AG 2-2 IV and AG 2-2 IIIB caused no aboveground symptoms on corn and did not affect yields compared to a non-inoculated control, which confirms results of previous trials in the RRV (7,8,9). The significantly higher isolation of *R. solani* from roots in plots inoculated with *R. solani* AG 2-2 IIIB than in plots inoculated with AG 2-2 IV and the non-inoculated control in the 2007 trial at Gluek also confirms results of previous trials at Crookston (8,9). There were no differences, however, in isolation of *R. solani* from corn in plots inoculated with *R. solani* and the non-inoculated control in the 2007 trial at Crookston or the 2008 trial at Gluek. It is unknown why these inconsistencies occurred but could be related to late planting date and weather conditions that affect infection of roots by *R. solani*. Recovery of the fungus from corn roots also is very difficult because of numerous competitive microbes in soil.

Soil inoculation with *R. solani* AG 2-2 IIIB prior to growing corn in 2007 had a tremendous effect on the following (2008) sugarbeet crop at Gluek, but not at Crookston. Results at Gluek confirm previous trial results in Crookston (8,9) where growing corn in soil inoculated with *R. solani* AG 2-2 IIIB resulted in high levels of RCRR in a following sugarbeet crop compared with soil inoculated with *R. solani* AG 2-2 IV or not inoculated. The lack of significant disease on sugarbeet at Crookston following soil inoculation with *R. solani* AG 2-2 IIIB and growing corn is contrary to previous trial results. Ironically, isolation of *R. solani* from corn roots in plots inoculated with *R. solani* AG 2-2 IIIB in the 2007 trials at Crookston and Gluek were similar and averaged 20 and 19%, respectively. The low ratings of RCRR on sugarbeet in 2008 at Crookston compared to Gluek may be attributable to an earlier planting date in Crookston (May 14) than at Gluek (May 21) and to differences in environmental conditions affecting survival of the fungus, infection, and/or disease development.

Severe RCRR in sugarbeet following corn inoculated with *R. solani* AG 2-2 IIIB compared to AG 2-2 IV may not be solely due to the differences in their ability to infect corn roots. Perhaps, *R. solani* AG 2-2 IIIB has a greater ability to survive the winter (on corn root stubble or in soil) compared to AG 2-2 IV. In addition, *R. solani* AG 2-2 IIIB grows at warmer temperatures (up to 95° F) than AG 2-2 IV, which may give it the ability to infect sugarbeet and favor disease development over a wider range of soil temperatures.

The effects of corn variety on root rot ratings, percent recovery of *R. solani*, and corn yields were variable among both locations and years and showed no conclusive trends. Overall, 2007 results followed previous reports where no aboveground symptoms or yield losses in *Rhizoctonia*-inoculated plots occurred on corn compared to the non-inoculated control. In contrast, Sumner (5) reported that all varieties of dent corn evaluated in the southeastern USA were susceptible to *R. solani* AG 2-2 IIIB. Previous corn variety had no effect on 2008 sugarbeet stand, root rot ratings, or sugar yield, but did affect sugarbeet yield at Gluek.

CONCLUSIONS

1. *R. solani* AG 2-2 IIIB can infect corn roots without causing aboveground symptoms or yield loss.
2. *R. solani* AG 2-2 IIIB can maintain high soil inoculum levels during a corn rotation crop, which may result in disease on a following sugarbeet crop.
3. When high inoculum levels of *R. solani* AG 2-2 IIIB occur, caution should be taken in growing corn in rotation with sugarbeet.

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SMBSC Control of Rhizoctonia in Sugarbeet with Fungicides -2008

Sugarbeets were planted at two locations to test the influence of fungicide products on the control of Rhizoctonia root rot in sugarbeet and their influence on production in sugarbeets. The experiment sites were located at Clara City, MN and south of Milan, MN. The data presented in this report are a combination of the two locations.

Methods:

Tables 1 and 2 show the specifics of activities conducted at each site. Plots were 11 feet (ft.) (6 rows) wide at both locations and 35 ft long at Milan, Mn and 20 ft. long at the Clara City location. Rhizoctonia solani inoculum was applied to the crown of the sugarbeet on dates as indicated in tables 1and 2. Fungicides were applied in a 7 inch band and broadcast (Bcast) at rates in ounces (oz.) per acre and at timings as indicated in the data tables. Experiments were maintained using normal production practices. Stand count and harvest data were collected from rows 3 and 4 of a 6 row plot. Plots were planted to 4 inch spacing and with loss of plants due to disease the sugarbeets were not thinned. Research trials were harvested for root evaluation with a 1 row research harvester. The roots were evaluated on a scale 1-7 (1-disease free, 7-disease infested). Sugarbeet roots from the whole plot were collected for yield calculation and analyzed for quality in SMBSC's quality lab.

Table 1. Site specifics for Clara City, Mn location

Experiment #: 0857

Task	Date	Notes
Planting	5/16/2008	Variety 95RR03
Fungicide application	6/26/2008	8 leaf sugarbeet stage applications
Inoculating	6/28/2008	Inoculated with Rhizoctonia solani to plots with treatments having applications at 8 and 12 leaf sugarbeet stage including 8 and 12 leaf stage applications having an application at canopy stage of sugarbeet.
Fungicide application	7-3-/2008	12 leaf sugarbeet stage applications
Inoculating	7/11/2008	Inoculated with Rhizoctonia solani to plots with treatments having canopy applications only.
Fungicide application	7-16-/2008	Canopy sugarbeet stage applications
Evaluate roots	9/22/2008	
Harvest	9/22/2008	

Table 2. Site specifics for Milan, Mn location

Experiment #: 0856

Task	Date	Notes
Planting	5/16/2008	Variety Hilleshog 4017
Fungicide application	6/26/2008	8 leaf sugarbeet stage applications
Inoculating	6/27/2008	Inoculated with Rhizoctonia solani to plots with treatments having applications at 8 and 12 leaf sugarbeet stage including 8 and 12 leaf stage applications having an application at canopy stage of sugarbeet.
Fungicide application	7-3-/2008	12 leaf sugarbeet stage applications
Inoculating	7/11/2008	Inoculated with Rhizoctonia solani to plots with treatments having canopy applications only.
Fungicide application	7-16-/2008	Canopy sugarbeet stage applications
Evaluate roots	9/22/2008	
Harvest	9/22/2008	

Results and Discussion:

1. One needs to note that the band applications of fungicides were applied at below suggested rates due to a faulty application technique. Broadcast applications at the canopy stage were applied at the full suggested or recommended rates of the fungicides. However all band fungicide application were applied consistently at 66% of the suggested rate for rhizoctonia control.

2. Table 3-6 contain sugarbeet plant stands at the 6 leaf stage and at harvest and root ratings.

3. Sugarbeet plant stand loss from the 6 leaf stage to harvest depended on and was significantly influenced by the fungicide treatment.

4. Root rating for Rhizoctonia infection was significantly influenced by the fungicide treatment

5. Sugarbeet stand and root rot rating at harvest tended to be directly related to yield of the specific treatment, Tables 7-10.

6. Tables 7-10 show the influence of the various treatment timings on sugarbeet production. The timings are indicated in the table with the column labeled timing.

7. Products containing the same active ingredient applied on sugarbeets in the presence of Rhizoctonia root rot are presented in tables 7 (Quadris), 8 (Proline) and 9 (Inspire). The products are compared to the untreated check treatment in each table.

8. Quadris (Table 7) gave significantly higher sugar production regardless of application timing in comparison with untreated sugarbeets. Sugar production differences were a result of significant differences in tons per acre. Quadris did not show a statistical difference when applied alone at 8 and 12 leaf sugarbeet stage or applied at two timings applied early and late. The data empirically showed that Quadris applied at 8 leaf and at canopy stage of sugarbeet gave the highest sugar production.

9. Proline (Table 8) needed to be applied to the sugarbeet at the canopy stage alone or at 8 leaf and canopy stage to give significantly greater sugar production compared to other treatments including Proline or sugarbeets untreated. The data shows that Proline was best applied at the canopy sugarbeet stage.

10. Inspire applied as the SB or XT formulation did not give acceptable sugar production when applied to sugarbeets at the 8 leaf stage of the sugarbeet. Studies conducted by other researchers have shown that Inspire does not appear to have significant efficacy in control of Rhizoctonia solani.

11. Table 10 shows data from sugarbeets treated twice with fungicides in a Rhizoctonia control program. Fungicides were applied at the 8 leaf, 12 leaf and canopy stage of the sugarbeet. A common factor in the fungicide programs influence on sugarbeet production was that the best results occurred when Quadris was applied at the 8 and 12 leaf stages. The only application scenario with Quadris applied at the 8 leaf stage that gave statistically similar sugar production as the best treatments for sugar production was when Quadris was also applied at the canopy stage of sugarbeets. This would not be recommended since you would be making sequential applications of the same product or mode of action.

12. Proline applied early gave reduced sugar production compared to Quadris applied early in the sugarbeet growth. A fungicide application scenario that gave higher sugar production was Quadris applied at the 8 and 12 leaf stage and Proline applied at the canopy stage of the sugarbeets.

13. Tables 11-14 show fungicide application influence on revenue per acre and the cost of each fungicide application scenario. The revenue per acre is directly related to the sugarbeet production data presented in tables 7-10. The direct relationship is due to the fact that the difference in sugarbeet production was a result of significant change in tons per acre. Sugarbeet quality was not consistently influenced by fungicide application.

Table 3. Fungicide - Quadris Influence on Sugarbeet Plant Stand in the Presence of Rhizoctonia Salani

Trt	Treatment	Application Rate	Application Type	Timing	6 LF STD CT.	HARVEST STD CT.	ROOT RATING AVG ALL 9/23/09
1	check	N/A	N/A		255	231	3.7
2	QUADRIS	9.5 oz./acre	7" band	8 LF	269	190	3.1
3	QUADRIS	9.5 oz./acre	7" band	12 LF	254	219	3.0
4	QUADRIS QUADRIS	9.5 oz./acre 9.5 oz./acre	7" band 7" band	8 LF 12 LF	281	208	3.1
5	QUADRIS QUADRIS	9.5 oz./acre 14.3 oz./acre	7" band Bcast	8 LF Canopy	262	232	2.5
6	QUADRIS	14.3 oz./acre	Bcast	Canopy	263	218	2.9
				C.V.%	21.27	20.62	20.42
				Lsd (0.05)	49	37	0.7

Table 4. Fungicide - Proline Influence on Sugarbeet Plant Stand in the Presence of Rhizoctonia Salani

Trt	Treatment	Application Rate	Application Type	Timing	6 LF STD CT.	HARVEST STD CT.	ROOT RATING AVG ALL 9/23/09
1	check	N/A	N/A		255	231	3.7
7	PROLINE + NIS	3.75 oz/acre+0.125%v/v	7" band	8 LF	269	171	4.9
8	PROLINE + NIS	3.75 oz/acre+0.125%v/v	7" band	12 LF	270	203	3.5
9	PROLINE + NIS	3.75 oz/acre	7" band	8 LF	263	181	4.1
	PROLINE + NIS	3.75 oz/acre	7" band	12 LF			
10	PROLINE + NIS	3.75 oz/acre	7" band	8 LF	270	203	3.5
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy			
11	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy	284	239	2.7
				C.V.%	21.27	20.62	20.42
				Lsd (0.05)	49	37	0.7

Table 5. Fungicide - Inspire SB and XT Influence on Sugarbeet Plant Stand in the Presence of Rhizoctonia Salani

Trt	Treatment	Application Rate	Application Type	Timing	6 LF STD CT.	HARVEST STD CT.	ROOT RATING AVG ALL 9/23/09
1	check	N/A	N/A		255	231	3.7
16	INSPIRE SB	0.29 fl oz/1000 rowft	7" band	8 LF	265	154	4.9
17	INSPIRE XT	0.29 fl oz/1000 rowft	7" band	8 LF	260	141	5.0
				C.V.%	21.27	20.62	20.42
				Lsd (0.05)	49	37	0.7

Table 6. Fungicide Programs Influence on Sugarbeet Plant Stand in the Presence of Rhizoctonia Solani

Trt	Treatment	Application Rate	Application Type	Timing	6 LF STD CT.	HARVEST STD CT.	ROOT RATING AVG ALL 9/23/09
1	check	N/A	N/A		255	231	3.7
5	QUADRIS	5 oz./acre	7" band	8 LF	262	232	2.5
	QUADRIS	5 oz./acre	Bcast	Canopy			
10	PROLINE + NIS	5.7 oz/acre	7" band	8 LF	270	203	3.5
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy			
13	QUADRIS	5 oz./acre	7" band	8 LF	256	245	2.6
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy			
14	PROLINE + NIS	5.7 oz/acre	7" band	8 LF	247	209	3.1
	QUADRIS	5 oz./acre	Bcast	Canopy			
15	QUADRIS	5 oz./acre	7" band	12 LF	273	234	2.5
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy			
				C.V.%	21	21	20
				Lsd (0.05)	49	37	0.7

Table 7. Fungicide - Quadris Influence on Sugarbeet Production in the Presence of Rhizoctonia Solani

Trt	Treatment	Application Rate	Application Type	Timing	Tons per acre	Sugar percent	PURITY	Ext. Suc.per ton	Ext. Suc.per acre
1	check	N/A	N/A		11.0	14.4	87.5	229.4	4501.9
2	QUADRIS	9.5 oz./acre	7" band	8 LF	16.7	14.4	87.2	229.9	6394.2
3	QUADRIS	9.5 oz./acre	7" band	12 LF	19.8	14.9	88.7	243.0	6528.9
4	QUADRIS	9.5 oz./acre	7" band	8 LF	20.5	15.5	88.7	252.9	6670.4
	QUADRIS	9.5 oz./acre	7" band	12 LF					
5	QUADRIS	9.5 oz./acre	7" band	8 LF	22.4	14.9	88.1	240.4	7358.3
	QUADRIS	14.3 oz./acre	Bcast	Canopy					
6	QUADRIS	14.3 oz./acre	Bcast	Canopy	15.9	15.3	88.7	249.4	6106.1
				C.V.%	13.91	5.94	2.00	8.6	15.0
				Lsd (0.05)	1.47	0.76	1.55	17.6	972.8

Table 8. Fungicide - Proline Influence on Sugarbeet Production in the Presence of Rhizoctonia Salani

Trt	Treatment	Application rate	Application type	Timing	Tons per acre	Sugar percent	Purity	Ext. Suc.per ton	Ext. Suc.per acre	Revenue per acre
1	check	N/A	N/A		11.0	14.4	87.5	229	4502	445.02
7	PROLINE + NIS	3.75 oz/acre+0.125%v/v	7" band	8 LF	14.0	13.9	86.4	217	4647	458.66
8	PROLINE + NIS	3.75 oz/acre+0.125%v/v	7" band	12 LF	16.2	14.4	87.5	231	5244	534.56
9	PROLINE + NIS	3.75 oz/acre	7" band	8 LF	13.0	14.8	87.7	238	4617	491.41
	PROLINE + NIS	3.75 oz/acre	7" band	12 LF						
10	PROLINE + NIS	3.75 oz/acre	7" band	8 LF	17.6	14.9	88.3	241	6168	647.13
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy						
11	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy	21.3	15.1	89.0	247	7244	784.14
				C.V.%	13.91	5.94	2.00	8.6	15.0	16.87
				Lsd (0.05)	1.5	0.8	1.5	18	973	133.70

Table 9. Fungicide - Inspire SB and XT Influence on Sugarbeet Production in the Presence of Rhizoctonia Salani

Trt	Treatment	Application Rate	Application Type	Timing	Tons per acre	Sugar percent	Purity	Ext. Suc.per ton	Ext. Suc.per acre
1	check	N/A	N/A		11.0	14.4	87.5	229	4502
16	INSPIRE SB	0.29 fl oz/1000 rowft	7" band	8 LF	9.0	13.0	84.6	197	2828
17	INSPIRE XT	0.29 fl oz/1000 rowft	7" band	8 LF	8.1	13.5	85.6	207	2553
				C.V.%	13.91	5.94	2.00	9	15
				Lsd (0.05)	1.47	0.76	1.55	18	973

Table 10. Fungicide Programs Influence on Sugarbeet Production in the Presence of Rhizoctonia Solani

Trt	Treatment	Application Rate	Application Type	Timing	Tons	Sugar percent	Purity	Ext. Suc.per ton	Ext. Suc.per acre
1	check	N/A	N/A		11.0	14.4	87.5	229	4502
5	QUADRIS	5 oz./acre	7" band	8 LF	22.4	14.9	88.1	240	7358
	QUADRIS	5 oz./acre	Bcast	Canopy					
10	PROLINE + NIS	5.7 oz/acre	7" band	8 LF	17.6	14.9	88.3	241	6168
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy					
13	QUADRIS	5 oz./acre	7" band	8 LF	19.9	15.4	89.0	252	7361
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy					
14	PROLINE + NIS	5.7 oz/acre	7" band	8 LF	20.4	14.9	88.2	241	5828
	QUADRIS	5 oz./acre	Bcast	Canopy					
15	QUADRIS	5 oz./acre	7" band	12 LF	21.6	15.5	88.7	253	7334
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy					
				C.V.%	14	6	2	9	15
				Lsd (0.05)	1.47	0.76	1.55	18	973

Table 11. Fungicide - Quadris Influence on Sugarbeet Revenue

Trt	Treatment	Application rate	Application Type	Timing	Revenue per acre	Cost per acre
1	check	N/A	N/A		$445.02	$0.00
2	QUADRIS	9.5 oz./acre	7" band	8 LF	$666.31	$22.42
3	QUADRIS	9.5 oz./acre	7" band	12 LF	$701.59	$22.42
4	QUADRIS	9.5 oz./acre	7" band	8 LF	$745.28	$44.84
	QUADRIS	9.5 oz./acre	7" band	12 LF		
5	QUADRIS	9.5 oz./acre	7" band	8 LF	$781.29	$56.17
	QUADRIS	14.3 oz./acre	Bcast	Canopy		
6	QUADRIS	14.3 oz./acre	Bcast	Canopy	$673.58	$33.75

C.V.% 16.87
Lsd (0.05) 133.70

Table 12. Fungicide - Proline Influence on Sugarbeet Revenue

Trt	Treatment	Application Rate	Application Type	Timing	Revenue per acre	Cost per acre
1	check	N/A	N/A		$445.02	$0.00
7	PROLINE + NIS	3.75 oz/acre+0.125%v/v	7" band	8 LF	$458.66	$13.61
8	PROLINE + NIS	3.75 oz/acre+0.125%v/v	7" band	12 LF	$534.56	$13.61
9	PROLINE + NIS	3.75 oz/acre	7" band	8 LF	$491.41	$27.22
	PROLINE + NIS	3.75 oz/acre	7" band	12 LF		
10	PROLINE + NIS	3.75 oz/acre	7" band	8 LF	$647.13	$34.30
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy		
11	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy	$784.14	$20.69

C.V.% 16.87
Lsd (0.05) 133.70

Table 13. Fungicide - Inspire SB and XT Influence on Sugarbeet Revenue

Trt	Treatment	Application Rate	Application Type	Timing	Revenue per acre	Cost per acre
1	check	N/A	N/A		$445.02	$0.00
16	INSPIRE SB	4.7 oz./acre	7" band	8 LF	$235.97	$9.64
17	INSPIRE XT	4.7 oz./acre	7" band	8 LF	$224.99	$9.64
				C.V.%	16.87	
				Lsd (0.05)	133.70	

Table 14. Fungicide Programs Influence on Sugarbeet Revenue

Trt	Treatment	Application Rate	Application Type	Timing	Revenue per acre	Cost per acre
1	check	N/A	N/A		$445.02	$0.00
5	QUADRIS	9.5 oz./acre	7" band	8 LF	$781.29	$56.17
	QUADRIS	14.3 oz./acre	Bcast	Canopy		
10	PROLINE + NIS	3.75 oz/acre	7" band	8 LF	$647.13	$34.30
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy		
13	QUADRIS	9.5 oz./acre	7" band	8 LF	$819.54	$43.11
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy		
14	PROLINE + NIS	5.7 oz/acre	7" band	8 LF	$626.86	$47.36
	QUADRIS	14.3 oz./acre	Bcast	Canopy		
15	QUADRIS	9.5 oz./acre	7" band	12 LF	$812.72	$43.11
	PROLINE + NIS	5.7 oz/acre	Bcast	Canopy		
				C.V.%	16.87	
				Lsd (0.05)	133.70	

SENSITIVITY OF *CERCOSPORA BETICOLA* TO FOLIAR FUNGICIDES IN 2008.

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Leaf spot, caused by the fungus *Cercospora beticola*, is an endemic disease of sugarbeets produced in the Northern Great Plains area of North Dakota and Minnesota. It causes a reduction in photosynthetic area thereby reducing both yield and sucrose content of the beets. The disease is controlled by crop rotation, resistant varieties and timely fungicide applications. *Cercospora* leaf spot usually appears in the last half of the growing season, and two to four fungicide applications are made during this time for disease control. Fungicides are alternated and the most frequently used fungicides are Tin (triphenyl tin hydroxide), Topsin (thiophanate methyl), Eminent (tetraconazole), and Headline (pyraclostrobin). Tin is usually applied alone, but Topsin is usually applied as a tank mix with Tin. Recently Inspire and Proline were registered and are now being used.

Like many other fungi, *C. beticola* has the ability to adapt and become less sensitive to the fungicides used to control them, especially if they are applied frequently over a period of time. It is important to monitor the *C. beticola* population for changes in sensitivity to these fungicides in order to achieve maximum disease control. We began testing *C. beticola* populations for sensitivity to tin in 1996, and expanded sensitivity testing to additional fungicides in subsequent years. From 1997-2000 we evaluated sensitivity to tin and thiophanate methyl. We utilized our extensive culture collection of *C. beticola* isolates from 1997-2000 to establish baseline sensitivities to Eminent, Headline and Gem and to evaluate shifts in sensitivity to tin and Topsin. Fungicide sensitivity testing of field isolates of *C. beticola* to these five commonly used fungicides in our area were conducted in the years 2003 - 2007. In 2008 sensitivity testing was conducted for tin, three triazole (DMI) fungicides, Eminent, Inspire, Proline, and one strobilurin (QoI) fungicide, Headline.

OBJECTIVES

The 2008 objectives were:

1) Continue to evaluate sensitivity of *Cercospora beticola* isolates collected from fields representing the sugarbeet production area of the Red River Valley region to Tin (triphenyl tin hydroxide), and Eminent (tetraconazole).

2) Evaluate sensitivity of *Cercospora beticola* isolates collected from fields representing the sugarbeet production area of the Red River Valley region to pyraclostrobin (Headline) fungicide and compare sensitivity to previously established baseline.

3) Determine sensitivity of *Cercospora beticola* isolates from fields representing the sugarbeet production areas of ND and MN to two additional triazole (DMI) fungicides: difenaconazole (Inspire), and prothioiconazole (Proline).

4) Distribute results of sensitivity testing in a timely manner in order to make fungicide recommendations for disease management and fungicide resistance management based on test results.

METHODS AND MATERIALS

In 2008, with financial support of the Sugarbeet Research and Extension Board of ND and MN, Nufarm Amearicas, United Phosphorous, BASF Corporation, Syngenta Crop Protection and Bayer Crop Science, we conducted extensive testing of *C. beticola* isolates collected from throughout the sugarbeet production regions of ND/MN for sensitivity to Tin, Eminent, Inspire, Proline and Headline.

Sugar beet leaves with Cercospora leaf spot (CLS) were collected from commercial fields by agronomists from American Crystal Sugar Company, Minn-Dak Farmers Cooperative and Southern Minnesota Beet Sugar Cooperative representing all production areas in ND and MN. Leaves were delivered to our lab, and processed immediately to insure viability of spores. From each field sample *C. beticola*, spores were collected from a minimum of five spots per leaf from five leaves. The spores were mixed in water, and a composite of 200 µl of spores suspension was transferred to each of two Petri plates containing water agar amended with Tin at 1 ug/ml or non-amended (water agar alone).

For Tin sensitivity, a bulk spore germination procedure was used. Germination of 100 random spores on the Tin amended water agar was counted 16 hrs after plating and percent germination calculated. Germination on non-amended media was calculated and this plate was used as a source of single spore sub cultures for subsequent triazole and Headline testing.

For triazole fungicide sensitivity testing, a standard radial growth procedure developed in our lab for *C. beticola* was used. A single spore subculture from the original non-amended media was grown on water agar medium amended with serial ten-fold dilutions of technical grade triazole fungicide from 0.001 – 1.0 ppm. A separate test was conducted for each of the three triazole fungicides. After 15 days, inhibition of radial growth was measured, and compared to the growth on non-amended water agar medium. This data was used to calculate an EC_{50} value for each isolate (EC_{50} is the concentration of fungicide that reduces growth of *C. beticola* by 50% compared to the growth on non-amended media).

For the strobilurin fungicide Headline, the radial growth procedure does not work. Instead, we must use a procedure that measures inhibition of spore germination. A subculture from the original non-amended medium was grown on modified V-8 medium and induced to sporulate abundantly using a procedure developed in our lab for efficient spore production and sensitivity testing. The spores were collected and transferred to water agar amended with serial ten fold dilutions of technical grade pyraclostrobin from 0.001 – 1.0 ppm. Previous studies demonstrated that *C. beticola* spores reach >80% germination in about 16 hours with some variability depending on isolate. Consequently, germination of 100 spores viewed at random was done 16 hrs after plating and percent germination calculated. An EC_{50} was calculated for each isolate (EC_{50} is the concentration of fungicide that inhibits the germination of *C. beticola* by 50% compared to germination on non-amended media).

RESULTS AND DISCUSSION

Disease pressure was generally low and Cercospora disease again developed late in the 2008 season. The majority (87%) of the CLS samples were delivered to our lab in September. Due to the diligent collection efforts of the grower cooperative agronomists, 1141 field samples representing all production areas and factory districts were received. Of these A total of 899 *C. beticola* isolates were tested for sensitivity to five fungicides in 2008. An additional 113 samples from fungicide trial plots of Dr. Mohamed Khan (Foxhome), and 131 samples from the fungicide trial plots of Mark Bredehoft, SMBSC (Clara City) were also tested for sensitivity to these fungicides. For this report, only results from the field samples are included; the fungicide trial plot results are not included. A few samples that were submitted were not done, because the spores did not germinate. We postulate that the fields from which these samples were collected had recently been treated with a fungicide that interfered with spore germination in the lab, or that the lesions may have been bacterial leaf spot and not Cercospora leaf spot.

Tolerance to Tin was first reported in 1994, with tolerance levels between 1-2 ppm. These levels reduced efficacy of control by tin. The incidence of Tin tolerance increased between 1997 and 1999, but incidence of isolates tolerant to tin at 1.0 ppm has been declining since the introduction of Eminent for resistance management in 1999, Gem in 2002 and Headline in 2003. In 1998, the percentage of isolates with tolerance to Tin at 1.0 ppm was 64.6%, in 1999 it was 54.3%, in 2000 it was 17.7%, in 2001 was 14.9%, in 2002 was 9.0%, in 2003 was 1.1%, in 2004 was 1.1%, in 2005 was 0.97%, in 2006 was 0.0%, in 2007 increased to 5.1%, and in 2008 was 0%. (Fig.1). Tin is once again an effective fungicide for managing CLS and an important partner for fungicide resistance management.

A baseline sensitivity curve was developed for Eminent using *C. beticola* isolates from 1997-1999 that had not been previously exposed to Eminent and the year 2000 from our culture collection. Compared to the baseline values there appears to be a slow increase in the average EC50 value of *C. beticola* isolates from 1998 to 2005, but a decrease in EC50 values -n 2006-2008 (Fig 2). The average EC_{50} values of these *C. beticola* isolates from our culture collection are 0.13 (1997), 0.09 (1998), 0.12 (1999), and 0.23 (2000). The average EC_{50} value of field-collected isolates from 2002 was 0.21 ppm, from 2003 was 0.12 ppm, from 2004 was 0.24, and from 2005 was 0.29 (Fig. 2). There was a decline in the EC50 value in 2006 to 0.14, an increase in 2007 to 0.2, and in 2008 remains the same at 0.2 (Fig.2). These values include isolates with an EC_{50} value of >1.0 ug/ml.

In 2002, 1.2 % of the isolates tested had an EC_{50} value of >1 to tetraconazole compared to 6.0% of the isolates in 2003, 10.8% of the isolates in 2004, 12.4% in 2005, and in 2006 was 7.3% (Fig 3). The trend from 2003 - 2005 was for increased resistance to tetraconazole as indicated by an increase in both average EC_{50} values (Fig. 2) and the incidence of isolates with EC_{50} values >1 ppm (Fig. 3), but in 2006 there was a decrease in resistance to Eminent (Figs. 2 and 3).This reduction along with the reduction in Tin resistance, may indicate that our collective resistance management program and recommendations may be working. In 2008 a reduction in the average EC-50 value across all factory districts except for Minn-Dak which showed an increase in resistance. (Fig. 4). In 2007, the opposite was found; the lowest EC50 values were in the Minn-Dak area.

Sensitivity to two additional DMI (triazole) fungicides; difenaconazole (Inspire), and prothioiconazole (Proline) were tested. The average EC50 values of these two triazoles was Proline at 0.765 and Inspire 0.149 compared to Eminent at 0.21 µg/ml (Fig 5). The percent isolates highly resistant (>1.0 µg/ml) of the three triazoles was Proline 15.7%, Inspire 9.7% compared to Eminent at 12.4%. While the EC50 values of Proline are higher than either Eminent or Inspire, this is more of a reflection of intrinsic activity of the fungicide and does not indicate a higher level of resistance. The EC50 values of Proline decreased in 2008, while the EC50 values for Eminent and Inspire remained basically unchanged (Fig. 5).

Baseline sensitivity to the QoI (strobulurin) fungicide Headline was calculated using *C. beticola* isolates from our culture collection that were not previously exposed to Headline. This baseline is used to monitor shifts in sensitivity to this fungicide. Sensitivity of C. *beticola* to Headline has remained relatively stable from 2003-2008 with only an 8-10 fold decrease in sensitivity compared to the baseline (Fig. 6). It should be emphasized that we have found isolates in the population that have an EC_{50} value >1.0 ppm (a 400 fold decrease in sensitivity) for both Headline. In 2008, an increase in the number of isolates with an EC-50 > than 0.001 µg/ml was observed, from 48.8% in 2007 to 53% in 2008, and a decrease in the percent of isolates with an EC-50 < than 0.001, from 26.8% in 2007 to a 21.8% in 2008 (Fig. 7). It is important to know that there are numerous examples in many crops where resistance has developed to strobilurin (QOI) fungicides due to over application and misapplication of these fungicides. Because of the widespread application of Headline to sugar beets at the end of the season, the application to most other crops in the sugar beet production area, and the potential for resistance development, it remains critical to monitor sensitivity of *C. beticola* to Headline.

Because *C. beticola* has a history of developing resistance to fungicides, and has a high degree of variablility in culture, the potential for resistance development to fungicides is always there. This is especially true since we found both mating types of *C. beticola* naturally occurring in the population in ND and MN. We must continue to monitor *C. beticola* populations in our area for fungicide sensitivity/resistance and develop disease management strategies with this goal as a high priority.

SUMMARY

1. Tin tolerance at 1.0 ppm has almost disappeared in our region, because of the use of alternate fungicides that has resulted in the reduction in the number of tin applications from 2.14 in 1998 to less than one each year since 2001. In 2008 no resistant isolates were found.

2. Sensitivity to Eminent is relatively stable, but there has been a slow increase in the number of isolates with an EC_{50} > 1.0 ppm which may indicate the potential for reduced sensitivity to develop. In 2006 for the first time since testing began, there was a decrease in both the number of isolates with an EC_{50} value >1.0 ppm and the overall EC_{50} value across all isolates tested. In 2008, a decrease in resistance to Eminent was observed in all factory districts except Minn-Dak.

3. Sensitivity to Headline remains relatively stable, but there are rare isolates identified with a 400fold decrease in sensitivity. There has been a slight change in sensitivity (approximately 10X) to Headline compared to the baseline since use and testing began five years ago. This change is not a cause for concern, but a few resistant isolates > 1 ppm were found in the survey which has the potential for concern.

5. It appears that the fungicide resistance management plan that we are following is working since resistance is stable since there have been no fungicide failures in our area due to fungicide resistance.

6. Disease pressure has been low, and higher disease pressure may change fungicide sensitivity patterns.

7. Alternation and combinations of fungicides with different modes of actions will continue to be necessary to prevent reduced sensitivity of *C. beticola* to currently registered fungicides.

8. Continue to use disease control recommendations currently in place including:

- Fungicide rotation
- Only one triazole per season
- Only one strobilurin per season
- A good three spray program is triazole, tin, strobilurin
- Scout at end of the season to decide the necessity of a late application; CLS developed late in recent years
- NDAWN daily infection values, row closure, first appearance of disease and the calendar are all used to determine first fungicide application
- Use fungicide resistance maps for fungicide selection
- Use a variety with resistance to CLS; KWS rating of 5. 0 or less
- Spray intervals of 14 days
- Use 15-20 gpa at 100-125 psi for ground application of fungicides and 5 gpa for air application

Fig 1. Sensitivity to TPTH of *C. beticola* isolates collected in ND and MN from 1998 to 2008 at 1.0 ppm as measured by bulk spore germination

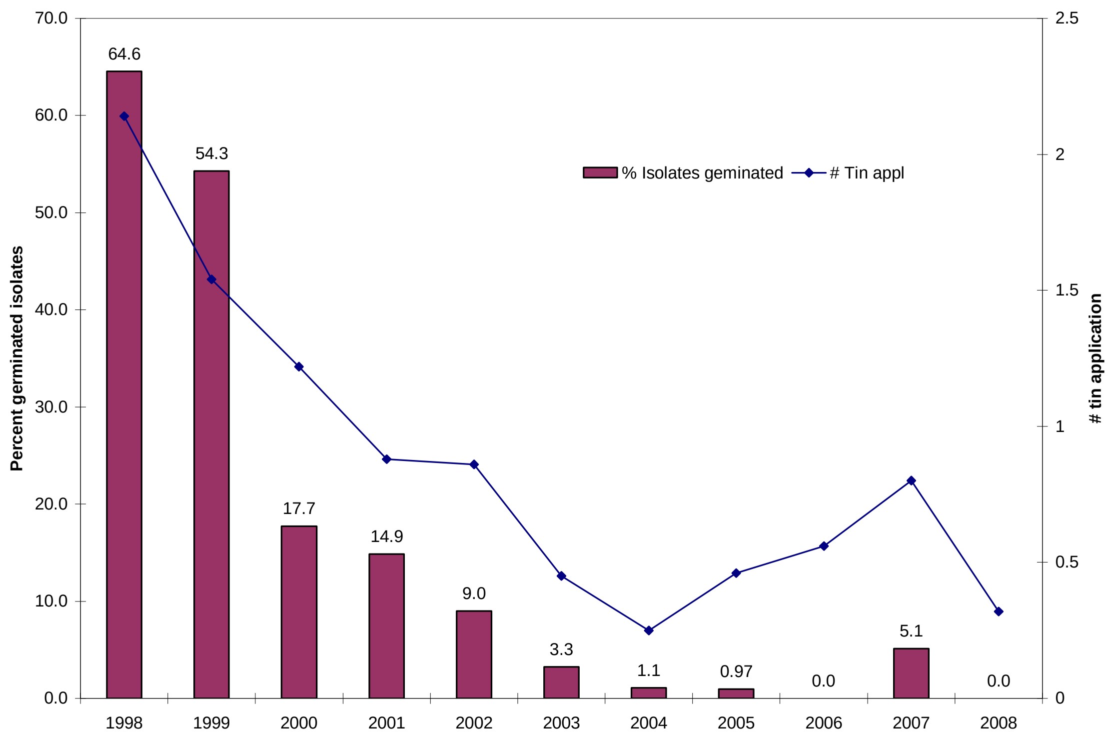


Fig 2. Average EC-50 value of *Cercospora beticola* isolates collected from 1997-2008 to tetraconazole.

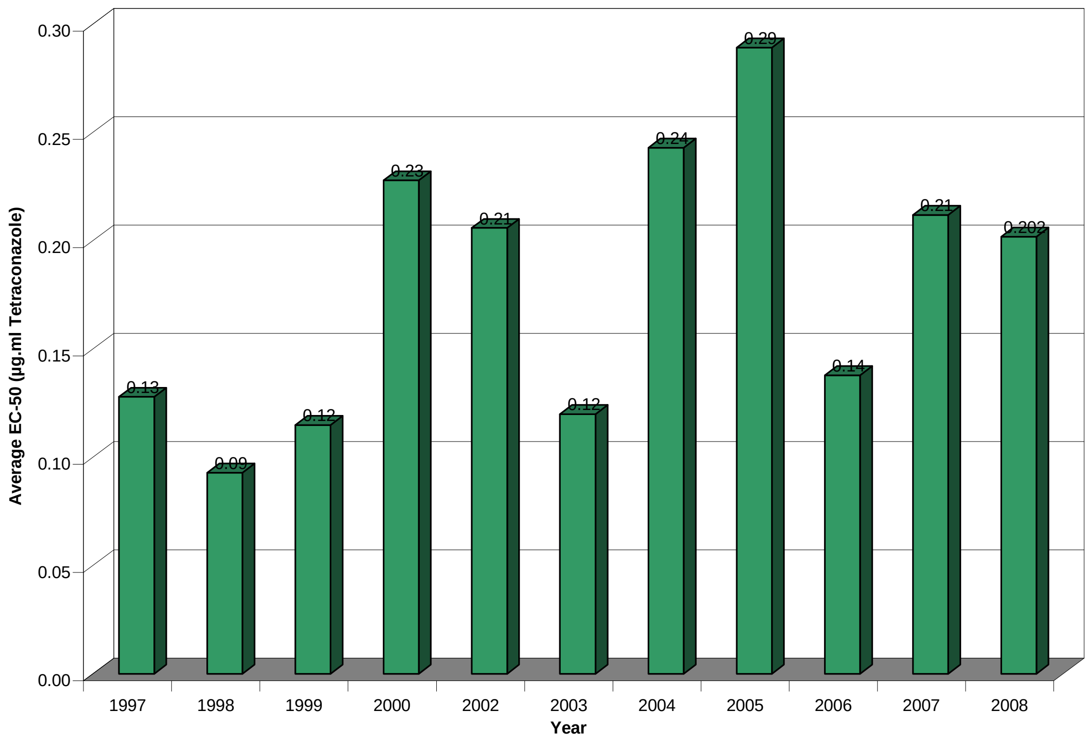


Fig.3 Sensitivity of *C. beticola* isolates collected in ND and MN from 1997-2008 to tetraconazole

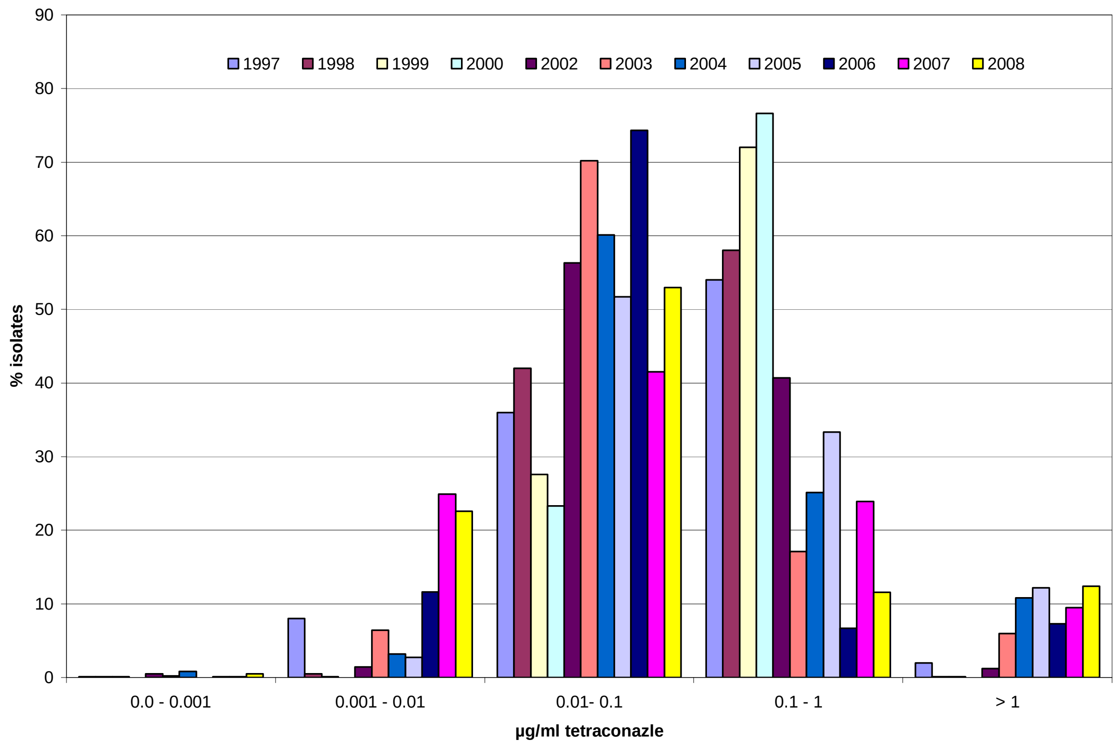


Fig 4. Sensitivity of *C. beticola* to tetraconazole by factory district 2005-2008

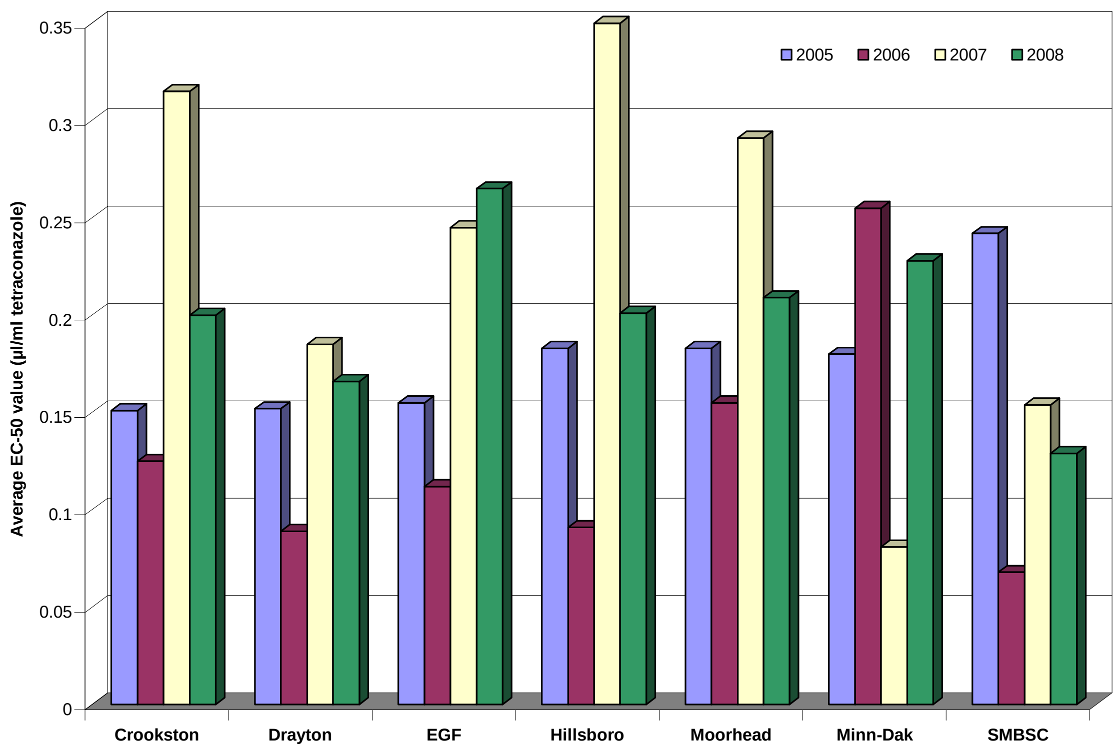


Fig 5. EC-50 values of C. beticola isolates collected in 2007-2008 to three triazole fungicides

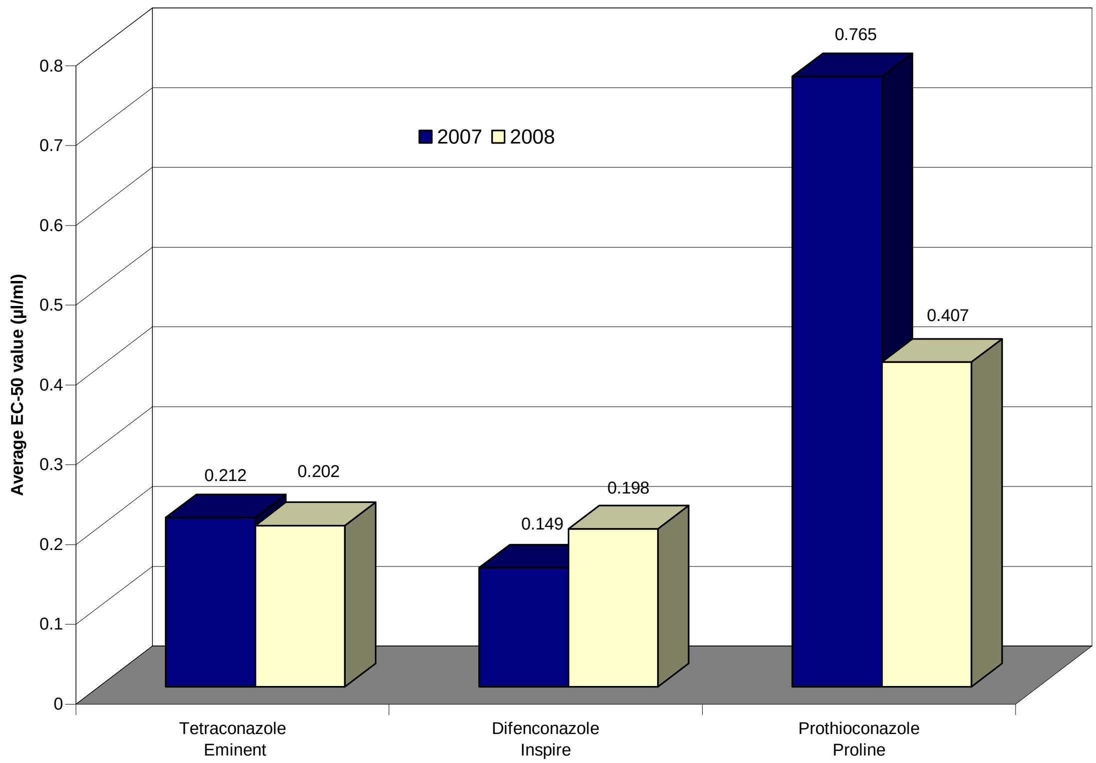


Fig. 6. Average EC-50 (µg/ml) values of *C. beticola* isolates collected in ND and NM to pyraclostrobin (Headline) from 2003 to 2008

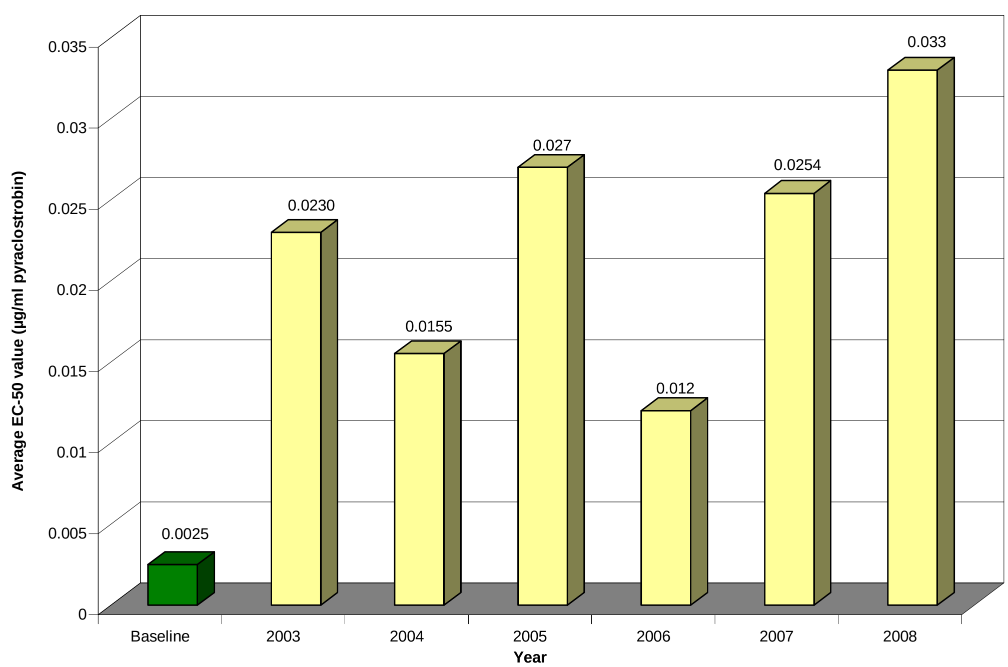
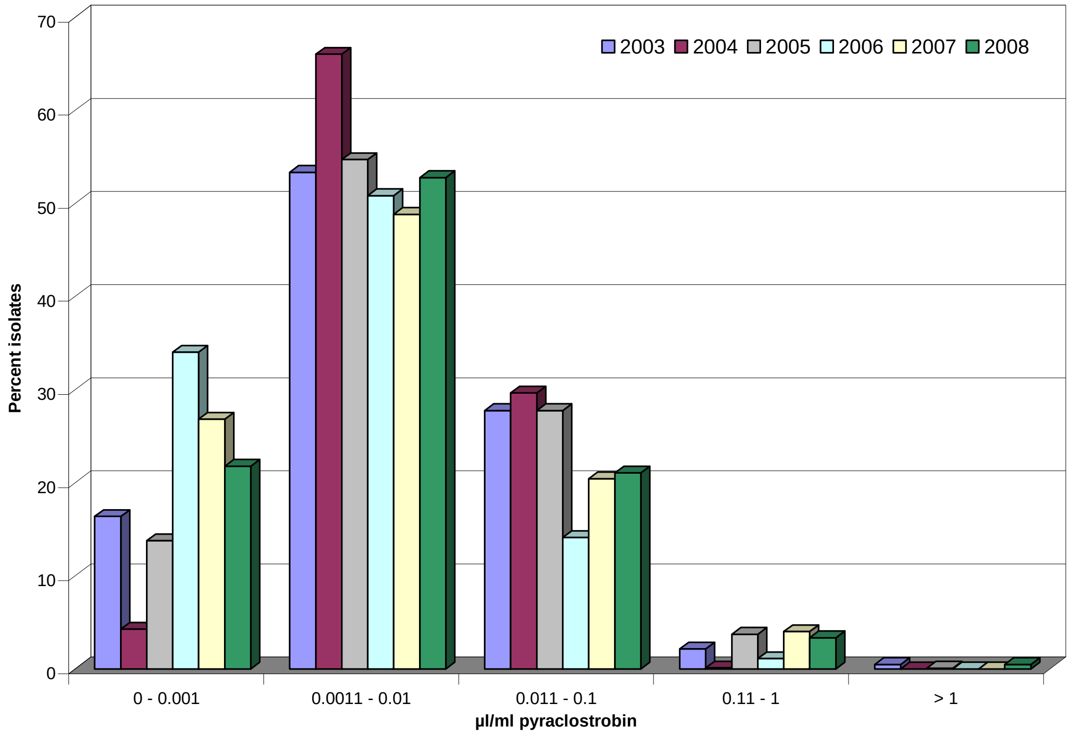


Fig. 7 Sensitivity of *C. beticola* isolates collected in ND and MN from 2003 to 2008 to pyraclostrobin (Headline)



SMBSC Evaluation of Single Mode of Action Fungicide Treatments for Control of Cercospora Leaf Spot

Methods

Sugarbeets were planted at a location near Renville, MN. The site was planted by the cooperator at a 5 inch spacing and 180 to 200 sugarbeets per 100 ft. of row was achieved. Sugarbeets were not thinned. The site south of Renville was taken to harvest but the cercospora leaf disease level was very low. The site north of Renville had medium to high cercospora leaf spot disease pressure and was taken to harvest. The data will only be presented in this report on the north site.

Table 1 shows the specifics of activities conducted at the site for evaluating fungicides for cercospora leaf spot control. Applications were made every 14 days or as close to 14 days as the weather would allow. A subsample of the sugarbeets harvested was analyzed for quality in the SMBSC quality lab.

Table 1. Site Specifics for SMBSC Renville Site, 2008

Task	Date	Notes	Harvest date
plant	*5/3/2008*	*Hilleshog 4017RR*	*10/9/2008*
			Evaluation dates
			8/7/2008
sprayed Roundup	*6/28/2008*	*Roundup*	*8/14/2008*
inoculate	*7/2/2008*		*8/21/2008*
inoculate	*7/10/2008*		*9/4/2008*
spray	*7/23/2008*	*CLS program*	*9/12/2008*
spray	*8/6//2008*	*CLS program*	
spray	*8/20//2008*	*CLS program*	

Fungicide chemistry class

- **Triazole – Eminent, Inspire, Proline, Enable**
- **Triphenyl Tin Hydroxide – Supertin, Agritin**
- **Strobilurin – Headline, Gem**

Results and Discussion

The results will be discussed in bullet points by location.

1. The untreated check gave significantly higher cercospora leaf spot disease (Table 2) and significantly lower sugarbeet production and revenue per acre (Table 3) compared to treatments with fungicide applied.

2. Enable applied every 10 days gave significantly better control of cercospora leaf spot and sugar production than when Enable was applied every 14 days.

3. Fungicides Proline and Inspire XT gave significantly better control of cercospora leaf spot than all other treatments.

4. Strobilurin fungicides Headline and Gem and Triazole fungicides Eminent, Proline and Inspire SB and Strobilurin/Triazole mixture Quadris tops gave similar cercospora leaf spot control.

5. Most of the treatments gave similar cercospora leaf spot control through the month of August, but separation of treatments occurred in the month of September.

6. All fungicide treatments gave significantly higher sugarbeet production compared to untreated sugarbeets.

7. Sugarbeet production tended to be directly related to cercospora leaf spot control.

8. The highest sugarbeet production was achieved with sugarbeets treated with Proline, although not significantly higher than some fungicide treatments.

Table 2. Cercospora leaf spot ratings as influence by fungicide treatments with the same mode of action

FUNGICIDE	Rate oz./acre	Spray Interval	8/6/2008	8/15/2008	8/21/2008	9/3/2008	9/11/2008
			Avg. CLS rating				
Check	N/A	N/A	4.02	6.00	6.92	8.17	9.00
ENABLE (3X)	8	14	3.33	4.31	5.13	5.97	7.81
ENABLE (3X)	8	10	2.98	3.06	3.71	4.38	5.75
HEADLINE (3X)	9.2	14	2.50	2.38	2.94	3.50	4.81
PROLINE+INDUCE (3X)	5 + 0.125%	14	2.08	2.13	2.78	2.50	3.69
GEM 500 SC (3X)	3.5	14	2.47	2.44	2.75	3.28	4.19
INSPIRE-XT (3X)	7	14	1.94	1.94	2.34	2.31	3.25
QUADRIS TOPS (3X)	8.5	14	2.45	2.50	2.83	2.92	4.56
INSPIRE SB (3X)	7	14	2.23	2.50	3.00	3.09	4.68
EMINENT (3X)	13	14	2.20	2.33	2.92	3.08	4.58
SUPERTIN (3X)	5	14	3.26	3.63	4.13	4.47	6.13
Check	N/A		4.61	6.75	7.22	7.97	9.00
		CV%	32	13	11	13.00	13.00
		LSD (0.05)	0.40	0.60	0.60	0.75	0.99

Table 3. Sugarbeet production and revenue as influence by fungicide treatments with the same mode of action

FUNGICIDE	Rate oz./acre	Spray Interval	Tons per acre	Sugar percent	Extractable sucrose per acre	revenue per acre
Check	N/A	N/A	23.8	15.0	5776	621
ENABLE (3X)	8	14	26.4	17.2	7530	935
ENABLE (3X)	8	10	30.4	17.5	8819	1109
HEADLINE (3X)	9.2	14	33.6	18.2	9799	1275
PROLINE+INDUCE (3X)	5 + 0.125%	14	33.4	18.2	10237	1336
GEM 500 SC (3X)	3.5	14	31.9	17.6	9361	1187
INSPIRE-XT A8122 (3X)	7	14	32.9	17.9	9865	1269
QUADRIS TOPS-A13703 (3X)	8.5	14	31.9	17.6	9306	1173
INSPIRE SB-A7402 (3X)	7	14	31.7	18.2	9825	1291
EMINENT (3X)	13	14	31.1	18.4	9646	1269
SUPERTIN (3X)	5	14	29.1	17.5	8435	1060
Check	N/A		21.8	15.0	5207	549
		CV %	5.4	2.77	7.77	9.58
		LSD (0.05)	2.4	0.69	977	152.28

SMBSC Evaluation of Fungicide Program
Treatments for Control of Cercospora Leaf Spot

Methods

Sugarbeets were planted at a location near Renville, MN. The site was planted by the cooperator at 5 inch spacing and 180 to 200 sugarbeets per 100 ft. of row was achieved. Sugarbeets were not thinned.

Table 1 shows the specific activities for the fungicide control of cercospora leaf spot evaluation site. A subsample of the sugarbeets harvested was analyzed for quality in the SMBSC quality lab.

Table 1. Site Specifics, 2008

Task	Date	Notes	Harvest date
plant	*5/3/2008*	*Hilleshog 4017RR*	*10/9/2008*
			Evaluation dates
			8/7/2008
sprayed Roundup as needed		*Roundup*	*8/14/2008*
inoculate	*7/2/2008*		*8/21/2008*
inoculate	*7/10/2008*		*9/4/2008*
spray	*7/23/2008*	*CLS program*	*9/12/2008*
spray	*8/6//2008*	*CLS program*	
spray	*8/20//2008*	*CLS program*	

Fungicide chemistry class

Triazole – Eminent, Inspire, Proline, Enable
Triphenyl Tin Hydroxide – Supertin, Agritin
Strobilurin – Headline, Gem
Topsin-M – Benzimidizole
Triazole & strobilurin mix - JAU6476&TRIFLOXYSTROBIN

Results and Discussion

1. The cercospora leaf spot control with the untreated check either tended or was significantly less and sugarbeet production was significantly lower than all other treatments.

2. All triazole performed similarly as the first fungicide in the spray program for control of cercospora leaf spot and sugarbeet production.

3. Strobilurins, Gem and Headline performed similarly when applied as the last fungicide in the spray program.

4. The inclusion of Topsin-M tended to give better cercospora leaf spot control but tended to give lower sugar production compared to similar treatments without Topsin-M.

5. Delayed fungicide applications resulted in reduced sugarbeet production. Sugarbeet production was higher and cercospora leaf spot control tended to be better when the initial fungicide applications were made at or before cercospora leaf spot onset compared to making the initial fungicide application at or after onset of cercospora leaf spot.

6. The data showed that three versus four sequential fungicide applications gave similar Cercospora leaf spot control and sugarbeet production.

7. Proline gave greater sugarbeet production than Quadris when applied at canopy sugarbeet stage for Rhizoctonia root rot control. This application was made in the absence of Rhizoctonia root rot and thus, the primary benefit relative to sugarbeet production is due to cercospora leaf spot control or an inherent benefit to the production of sugarbeet by the fungicide application.

Table 2. Cercospora leaf spot ratings as influence by fungicide treatments with the same mode of action

FUNGICIDE	Rate oz./acre	Spray Interval	8/7/2008	8/14/2008	8/21/2008	9/4/2008	9/12/2008
			avgerage cercospora leaf spot rating				
Check	N/A		3.48	3.94	5.38	5.25	7.69
EMINENT	13	14	2.59	2.72	3.92	4.33	5.64
SUPER TIN 80 WP	5	14					
HEADLINE	9.2	14					
INSPIRE SB	7	14	2.66	2.52	3.41	4.16	5.33
SUPER TIN 80 WP	5	14					
HEADLINE	9	14					
PROLINE SC+NIS*	5+0.125	14	3.17	2.99	3.92	4.25	4.97
SUPER-TIN 80 WP	5	14					
HEADLINE	9	14					
INSPIRE XT	7	14	2.25	2.53	3.38	3.66	4.85
SUPER TIN	5	14					
HEADLINE	9	14					
QUADRIS TOPS	8.5	14	2.44	2.43	3.13	3.59	4.42
SUPER TIN 80 WP	5	14					
QUADRIS TOPS	8.5	14					
PROLINE SC+NIS*	5+0.125%	14	2.44	2.76	3.59	4.03	5.27
SUPER-TIN 80WP	3.75	14					
GEM 500 SC	3.5	14					
PROLINE SC+NIS*	5+0.125%	14	2.46	2.49	3.59	3.88	5.29
SUPER-TIN 80WP	3.75	14					
HEADLINE	7	14					
PROLINE SC+NIS*	5+0.125%	14	2.58	2.31	3.31	3.41	4.85
SUPER-TIN 80WP+TOPSIN M	3.75+6.1	14					
GEM 500 SC	3.5	14					
PROLINE SC+NIS*	5+0.125%	14	2.53	2.41	3.19	3.69	4.71
SUPER-TIN 80WP+TOPSIN M	3.75+6.1	14					
HEADLINE	7	14					
JAU6476&TRIFLOXYSTROBIN	11	14	2.48	2.44	3.47	4.00	4.94
SUPER-TIN 80WP	3.75	14					
GEM 500 SC	3.5	14					
PROLINE SC+NIS*	5+0.125%	Rhiz.**	2.62	2.83	4.19	4.84	6.46
PROLINE SC+NIS*	5+0.125%	14					
SUPER-TIN 80WP	3.75	14					
GEM 500 SC	3.5	14					
QUADRIS TOPS	8.5	Rhiz.**	2.27	2.43	3.63	4.25	6.02
PROLINE SC+NIS*	5+0.125%	14					
SUPER-TIN 80WP	3.75	14					
GEM 500 SC	3.5	14					
QUADRIS	8.5	Rhiz.**	2.97	3.71	5.16	5.47	6.27
PROLINE SC+NIS*	5+0.125%	14					
SUPER-TIN 80WP	3.75	14					
GEM 500 SC	3.5	14					
SUPER TIN 80 WP	5	14	2.94	3.38	4.81	5.41	6.98
EMINENT	13	14					
SUPER TIN 80 WP	5	14					
HEADLINE	9.2	14					
EMINENT	13	14	2.20	2.33	3.06	3.59	4.50
SUPER TIN 80 WP	5	14					
HEADLINE	9.2	14					
EMINENT	13	14	2.74	2.78	3.22	3.78	4.50
SUPER TIN 80 WP	5	14					
HEADLINE	9.2	14					
SUPER TIN 80 WP	5	14					
EMINENT	13	14	3.06	3.55	4.81	5.44	6.69
SUPER TIN 80 WP	5	as needed					
HEADLINE	9.2	as needed					
EMINENT	13	as needed	2.46	2.93	3.78	4.13	5.73
SUPER TIN 80 WP	5	as needed					
HEADLINE	9.2	as needed					
		CV%	18.68	25.02	32.43	31.91	28.09
		LSD (0.05)	0.69	0.99	0.77	0.95	1.21

*NIS = Non Ionic Surfactant
-as needed determine by disease index values and disease onset.
Rhiz.** - application was made 1 week prior to full canopy.

Table 3. Sugarbeet production and revenue as influence by fungicide treatment with the same mode of action

FUNGICIDE	Rate oz./acre	Spray interval	Tons per acre	Sugar percent	Extractable sucrose per acre	Revenue per acre
Check	N/A		23.62	16.12	6222.79	723.30
EMINENT	13	14	30.64	17.91	9225.69	1190.36
SUPER TIN 80 WP	5	14				
HEADLINE	9.2	14				
INSPIRE SB	7	14	31.53	17.65	9320.79	1187.10
SUPER TIN	5	14				
HEADLINE	9	14				
PROLINE SC+NIS*	5+0.125	14	31.18	17.29	8474.13	1110.11
SUPER-TIN 80 WP	5	14				
HEADLINE	9	14				
INSPIRE XT	7	14	31.39	17.99	9494.92	1229.13
SUPER TIN	5	14				
HEADLINE	9	14				
QUADRIS TOPS	8.5	14	29.71	17.88	8931.05	1151.10
SUPER TIN	5	14				
QUADRIS TOPS	8.5	14				
PROLINE SC+NIS*	5+0.125%	14	32.50	17.78	9678.26	1239.08
SUPER-TIN 80WP	3.75	14				
GEM 500 SC	3.5	14				
PROLINE SC+NIS*	5+0.125%	14	31.94	17.85	9542.37	1224.49
SUPER-TIN 80WP	3.75	14				
HEADLINE	7	14				
PROLINE SC+NIS*	5+0.125%	14	31.69	17.53	9162.35	1148.33
SUPER-TIN 80WP+TOPSIN M	3.75+6.1	14				
GEM 500 SC	3.5	14				
PROLINE SC+NIS*	5+0.125%	14	31.80	17.27	9069.25	1125.00
SUPER-TIN 80WP+TOPSIN M	3.75+6.1	14				
HEADLINE	7	14				
JAU6476&TRIFLOXYSTROBIN	11	14	33.32	18.39	10318.75	1356.93
SUPER-TIN 80WP	3.75	14				
GEM 500 SC	3.5	14				
PROLINE SC+NIS*	5+0.125%	Rhiz.**	33.07	17.52	9646.89	1216.96
PROLINE SC+NIS*	5+0.125%	14				
SUPER-TIN 80WP	3.75	14				
GEM 500 SC	3.5	14				
QUADRIS TOPS	8.5	Rhiz.**	29.16	17.47	8447.45	1060.13
PROLINE SC+NIS*	5+0.125%	14				
SUPER-TIN 80WP	3.75	14				
GEM 500 SC	3.5	14				
QUADRIS	8.5	Rhiz.**	28.05	17.36	8103.38	1014.89
PROLINE SC+NIS*	5+0.125%	14				
SUPER-TIN 80WP	3.75	14				
GEM 500 SC	3.5	14				
SUPER TIN 80 WP	5	14	28.27	17.34	8058.93	999.27
EMINENT	13	14				
SUPER TIN 80 WP	5	14				
HEADLINE	9.2	14				
EMINENT	13	14	30.78	17.59	9002.84	1137.90
SUPER TIN 80 WP	5	14				
HEADLINE	9.2	14				
EMINENT	13	14	31.65	17.60	9285.65	1176.32
SUPER TIN 80 WP	5	14				
HEADLINE	9.2	14				
SUPER TIN 80 WP	5	14				
EMINENT	13	14	29.33	16.75	8106.11	981.14
SUPER TIN 80 WP	5	as needed				
HEADLINE	9.2	as needed				
EMINENT	13	as needed	19.92	16.49	5390.71	641.22
SUPER TIN 80 WP	5	as needed				
HEADLINE	9.2	as needed				
*NIS = Non Ionic Surfactant		CV%	13.12	3.185	14.265	15.62
-as needed determine by disease index values and disease onset.		LSD (0.05)	2.53	0.785	742.7	139.96

Rhiz.** - application was made 1 week prior to full canopy.

Studies on Detection and Intra-Plant Spread of Resistance-Breaking BNYVV

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Over the last few years, there has been much speculation as to whether inoculum density of *Polymyxa betae*, the vector for BNYVV, affected development of Rhizomania. Using traditional methods, detection of BNYVV and its vector in infested fields is a time consuming task. Field soil is planted with seeds of a susceptible sugar beet variety and the resulting bait plants are grown for 8 - 12 weeks and then tested by Enzyme-linked Immunosorbent Assay (ELISA) for presence of the target virus or vector. Also, there has been considerable debate concerning resistance breaking (RB) isolates of BNYVV in Minnesota/North Dakota production areas. Research on resistance breaking isolates of BNYVV is a complex and expensive endeavor. However, in our estimation, determining how/why RB isolates of BNYVV evolve and whether they will become dominant in infested fields is crucial in breeding efforts to develop cultivars with durable resistance to Rhizomania. Therefore, a series of studies were initiated to develop a faster method of identifying viruliferous *P. betae* in field soils, to determine if inoculum density of *P. betae* was associated with appearance of rhizomania in resistant cultivars, and to determine how different resistance genes impact mutation in BNYVV.

Materials and Methods

Impact of P. betae inoculum density on disease severity. In a preliminary study, infested soil was collected from a sugar beet field known to contain viruliferous *P. betae*. Infested soil was combined with non-infested soil to create a dilution series of 1:10, 1:100, 1:1000, and 1:10,000 (w:w) soil treatments. Five seeds of a susceptible sugar beet cultivar (AC 725) were planted in pots containing 50g of each soil dilution. After emergence, seedlings were thinned to 3 per pot and after approximately 10 weeks plants were harvested. Total RNA was extracted from roots using the RNeasy Plant Mini Kit. After RNA extraction, samples were quantified and tested by Relative Quantification Real-time PCR. Real-time PCR was conducted using TaqMan One-Step RT-PCR. Relative quantification was used to reduce error between samples during extraction procedures. Relative quantification uses both a primer and probe set specific for the target sequence, in this case BNYVV and the 18s Ribosomal sequence within each sample. An endogenous 18s ribosomal control was used to normalize quantification of an internal RNA target (BNYVV sequence) for differences in the amount of total RNA added to each reaction, thereby limiting variation among samples. Results were displayed for each individual sample by determining the virus content of a sample as 10X greater than that of a calibrator sample which contains a low target virus content.

Following the preliminary study, soil was collected from inside and outside of Rhizomania "disease spots" from several fields planted to a Rhizomania resistant variety. Soils were potted and seed of AC 725 were planted. After 12 weeks, plants were harvested and tested by quantitative real time PCR (described above) to determine whether virus titer was different for plants grown in soils from inside or outside of Rhizomania spots.

Development of rapid detection method for BNYVV in infested soils. Infested rhizosphere soil was collected from three sugar beet varieties, from a variety trial in Crookston MN. Samples were collected from a Vanderhave Tandom Technology variety, which showed the greatest resistance to Rhizomania, Beta 46519 with strong resistance, and AC 725 a susceptible variety. Half the soil from the susceptible plants was air dried, while the other half, and soil samples from the other varieties, were sealed in a zip-lock bag to keep the soil moist. The moist soil from the Tandom Technology variety, Beta 46519, and the susceptible variety were used as 3 individual treatments. Dried soil from the susceptible was divided into 100g subsamples, in three separate beakers, and augmented with .5g, 1.0g, and 1.5g of dried roots infected with BNYVV, thereby creating three more soil treatments, for a total of 6 treatments. Four replicate Petri plates were filled with 25g of each soil and 75 ml of sterile distilled water was added to each plate. Susceptible sugar beet seedlings were then floated in each Petri dish for 24 hr, 4 days, or 7 days. After 24 hours, seedlings from two of the four replicates were harvested, the third rep was harvested at 4 days and the 4th rep was harvested after 7 days of incubation. Roots of three plants within one treatment were separated from their stems and combined as one composite sample. The roots were then washed with distilled water to remove any remaining soil and frozen at -80C until RNA extraction and detection by Real-time PCR could be performed. RNA extraction was conducted as described below.

Characterization and dynamics of zoosporic inoculum production. As an initial step to characterize the dynamics of zoosporic inoculum production, a lab protocol was developed to isolate zoospores from liquid media. Roots of susceptible and *Rz2*-resistant plants, grown in soil infested with viruliferous or non-viruliferous *P betae*, were harvested 4-6 weeks after seeded. The infectious inoculum consisted of wild type BNYVV previously propagated during three host-passages through susceptible or *Rz2*-plants. These two virus lineages were referred as W or B, respectively. Thus, the treatments were W-inoculum in susceptible (W/S) or *Rz2*-plants (W/R), B-inoculum in susceptible (B/S) or *Rz2*-plants (B/R), and non-viruliferous in susceptible plants (NV). Four to five plants were soil-inoculated by treatment. Individual plants were analyzed by realtime RT-PCR for virus content, and composite samples of 0.5 g of dry root tissue were prepared for zoospore isolation. The release of zoospores was induced by adding 5 ml of distilled water to the composite root samples.

Impact of host resistance genotype on mutation in BNYVV. Three sugar beet varieties, a susceptible check, one with *Rz1* resistance, and one with *Rz2* resistance, were used in this test. A sterilized potting soil was infested with a well characterized isolate of BNYVV and plants of each variety were then grown in the infested soil. After approximately 12 weeks, plants were harvested, total RNA extracted, and traditional PCR performed. BNYVV amplicons from the PCR were cut from the gel, purified and cloned. Clones were then sequenced and analyses were performed to quantify the amount and type of mutation in clones of BNYVV isolated from the different host plants.

Results and Discussion

Impact of P. betae inoculum density on disease severity. Results from this study demonstrated a positive correlation between soil inoculum density and virus titer in plants growing in the different soil treatments (Fig. 1). These findings verify that higher inoculum densities do result in more severe disease, as evidenced by higher virus titers. They also suggest that differences in inoculum densities from soils inside and outside of rhizomania spots should be detectable, if the rhizomania spots are a result of higher inoculum density. Although the methods used in this study are valid, a more rapid and precise method for determination of the number of infectious *P. betae* sporosori in the soil is needed.

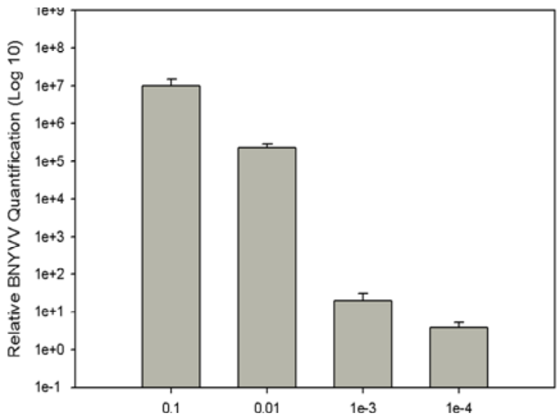

Fig. 1. Relation between inoculum density and virus titer.

Development of rapid detection method for BNYVV in infected soils. Beet necrotic yellow vein virus was detected in all treatments amended with infected roots as well as the susceptible control soil that remained wet after 24 hrs, 4 days and the 7 day period. Inexplicably, the susceptible control dry soil, amended with .5g of roots, tested negative after 7 days. Soil from one replication of the Beta 46519 treatment tested positive for BNYVV after 24 hrs, but the other replication was negative. All Tandom soil treatments tested negative for BNYVV at all incubation periods. This study demonstrated that BNYVV can be detected from bait plants after 24 hr incubation in an infested field soil solution. This method needs to be fine tuned but it has potential to greatly reduce the time and expense to test soil samples for the presence of viruliferous *P. betae*.

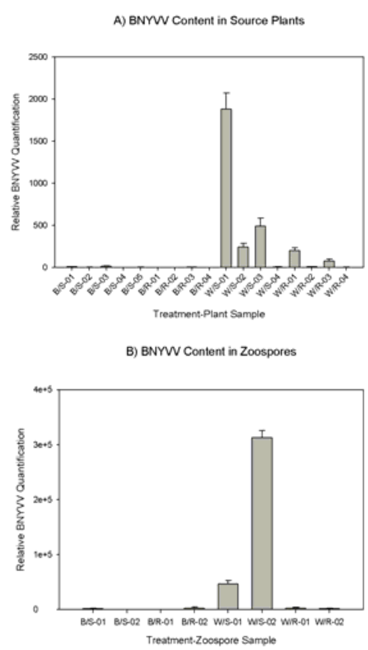

Fig. 3. Content of BNYVV detected by realtime RT-PCR in susceptible (S) and Rz2-resistant (R) source plants (A) and zoospores of *P. betae* (B).

Characterization and dynamics of zoosporic inoculum production Motile cells were abundant after 2-3 h at room temperature and remained viable up to 2 days in liquid. Zoospores contained in 3 ml of recovered liquid were concentrated in 50-100 µL by centrifugation at 4000 g by 5 min after removal of plant debris by filtration. Non-concentrated zoospore suspensions from each treatment were also used as inocula. Susceptible and *Rz2*-plantlets, germinated in a sterile substrate (Agrolite), were immersed by 2 h in the same zoospore suspension in parallel. Extraction of total RNA from plant and zoospores was performed using the RNeasy kit (Qiagen Inc.), but zoospores first were disrupted by vortexing in 10 mM TRIS plus 0.5% SDS, pH 8.0.

The content of BNYVV in sugarbeet plants used as source of zoospores was affected by the original source of the inocula and the genotype of the infected plant from which zoospores were collected. Thus, wild type BNYVV that was propagated in resistant *Rz2*-plants caused mild virus infections (low virus titer) in both susceptible and resistant plants. By contrast, the same strain maintained in susceptible plants caused severe virus infections in susceptible plants and moderate infections in Rz2-plants (Fig.2A). The virus content in the source plants paralleled the virus content in zoospores released from those plants (Fig. 2B). The low virus titer in the B/S treatment could be explained by a loss of virus fitness in susceptible plants after passage through resistant plants, or by a reduced amount of initial inocula generated in the rhizosphere of resistant plants. In fact, previous assays indicate that inoculum density in the soil is directly correlated with BNYVV titer in the bait plants (Fig. 1).

DNA sequencing of viral RNA from zoospores was possible only from samples where significant amount of viral RNA was detectable by PCR. Preliminary data revealed that the predominant haplotypes present in the source plants were also present in the corresponding zoopspore populations. However, we have not yet determined whether mutant haplotypes of BNYVV that are acquired by zoospores from resistant plants are biologically fit and can be transmitted to another plant.

Impact of host resistance genotype on mutation in BNYVV. As expected, virus titer in the different varieties was directly proportional to strength of resistance, so titer was highest in the susceptible control, intermediate in the *Rz1* variety, and lowest in the *Rz2* variety. In total, 385 cDNA fragments, representing 26 single-plant populations (isolates), were sequenced in both directions. The number of clones, mutation frequency (μ), number of segregating sites per nucleotide site [θ(S)], and nucleotide diversity (π) per host genotype and serial passage was determined (Table 1). The overall nucleotide diversity (π) detected in host-passage populations (*i.e.*, a population composed of all isolates that belong to the same host passage and plant genotype, for instance, *1Rz1* population, was higher in resistant than in susceptible plants ($P = 0.07$). The intraplant viral π was statistically significant only between plant genotypes of the second host passage. However, most of the differences between plant genotypes were explained by the interplant virus diversity, which was up to ten times higher in the most resistant *Rz2*-plants than in the susceptible control. The results of this study suggest that host genotype affected the genetic diversity of BNYVV by the amount and frequency of different mutations in the population, and that mutation was significantly and positively correlated to strength of genetic resistance.

TABLE 1. Host effect on the genetic diversity of BNYVV populations during the first and second serial host passage.

Serial Passage	R-gene	Clones/ Isolates	μ [a]	θ (S) [b]	$\pi \pm SE \times 10^{-3}$ [c]		
					Intraplant	Interplant	Total
1	*Rz1*	32/4	14/31,168	3.23 ± 1.3	0.98 ± 0.3	0.51 ± 0.3	1.49 ± 0.5 a
	Rz2	40/4	12/38,960	3.29 ± 1.3	0.63 ± 0.2	0.83 ± 0.5	1.46 ± 0.6 a
	S	42/4	9/40,908	1.86 ± 0.8	0.57 ± 0.2	0.12 ± 0.1	0.69 ± 0.3 b
2	*Rz1*	80/5	41/113,040	8.08 ± 2.4	0.85 ± 0.1	0.15 ± 0.1	1.00 ± 0.2 a
	Rz2	114/5	87/161,082	16.20 ± 4.2	1.25 ± 0.1	0.63 ± 0.4	1.88 ± 0.4 a
	S	77/4	27/108,801	5.49 ± 1.7	0.61 ± 0.1	0.02 ± 0.03	0.63 ± 0.1 b

[a] Number of mutations (nucleotide substitutions) over total sequenced nucleotides of the p25 (RNA 3) region. The sequenced fragment was 974 and 1413 nucleotides long for the first and second host passage, respectively.
[b] Number of segregating sites per nucleotide site and standard deviation estimated by the Kimura 2-parameter (Schneider *et al*., 2000).
[c] Nucleotide diversity estimated by the Kimura 2-parameter model as implemented in MEGA 3.1 software (Kumar *et al*., 2004), and SE estimated by 500 replicates bootstrapping. Calculations corroborated using DnaSP v4.10.7 software (Rozas *et al*., 2003). Total π values with the same letter were statistically identical (Tukey HSD Test, $P = 0.07$).

Previous Crop Effects on Sugarbeet Response to Nitrogen Fertilizer

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Nitrogen guidelines for increased sugar beet root quality were revised in 2000. The current recommendation is 130 pounds N per acre as soil nitrate-N in the surface 4 feet of soil plus fertilizer N. The research used for development of the guidelines for the SMBSC area came from locations where the previous crop in the rotation was corn. Since then many growers have adopted corn varieties that have been genetically modified for insect and herbicide protection. Growers have commented that these modified corn varieties do not break down as fast as the non-genetically alter varieties. The concern is whether growers change the N applied to make up for slower N mineralized from the plant material.

Information about the effect of other previous crops grown in the SMBSC is also limited. In the past is has proposed to use spring wheat as a previous crop to improve sugar beet yield and quality. No information exists from the Southern Minnesota growing area about how spring wheat as a previous crop affects N rate. Sweet corn is a crop grown in the eastern growing area before sugar beet. It is general knowledge that sweet corn is over fertilized and prediction of N contribution for the sugar beet is difficult because of early harvest date of an immature plant. Finally soybean is the previous crop in about 15 % of the acres that sugar beet is grown in the SMBSC area. When the sugar beet crop is not greatly affected by diseases, sugar beet root yield and quality tend to be decreased when soybean is a previous crop. Little information exists on the effect of soybean as a previous crop on the N mineralization during the following sugar beet growing season. A study was established to determine the effect of previous crops on N required for optimum sugar beet yield and quality.

Methods and Materials

Six sites have been established to achieve the objective of the study. These sites are located and established near Hector and Gluek in 2005, Buffalo Lake and Clara City in 2006, and New Auburn and Clara City in 2007. Each site was established a year before they were cropped to sugar beet. The site established near Gluek in 2005 was lost in 2006, the sugar beet year, to drought while the site near Clara City established in 2006 was lost in 2007, the sugar beet year, to disease. The Clara City and New Auburn sites established in 2007 were cropped to sugar beet in 2008. The results for the New Auburn site can not be reported because it was accidently planted to a Roundup tolerant sugar beet variety. In the initial set up year, four large replicated blocks (35 X 66 ft.) of corn, genetically modified corn (round up ready and Bt or BtRR corn), sweet corn, soybean, and spring wheat were grown. Each crop was fertilized according to U of MN guidelines. Deep soil samples for nitrate-N were taken late fall of the initial year to characterize the sites before being cropped to sugar beet. The large crop blocks were subdivided into 11 X 35 ft. subplots to accommodate six N rates (0, 30, 60, 90, 120, and 150 lb N per acre) that were applied late fall before the sugar beet crop was grown. In the second year, sugar beet was grown with root yield and quality measured.

During the sugar beet production at the Hector (2006) and Buffalo Lake (2007). sites, three replications of the previous crop treatments of the genetically modified corn and sweet corn and N rates of 0 and 90 pounds N per acre applied before sugar beet production were established to measure nitrogen mineralization during the season. At the Clara City (2008) the previous crops used for the measurement of N mineralization were conventional corn and sweet corn. This measurement involved the placement of 24 soil cores per plot that were encased in poly carbonate tube with a resin bag at a depth of 10 inches in the soil. The resin has the ability to trap soil ammonium and nitrate-N before it moves out of the soil core. The cores are placed in the sugar beet crop exposed to the same temperatures and moisture as the sugar beet crop. A four times during the growing season, initial, two times during the growing season, and at harvest, six cores are removed and analyzed for ammonium and nitrate-N. This gives an estimate of soil mineralization.

Results

Soil test results prior to sugar beet production:

The previous crops of spring wheat, sweet corn, conventional corn, BtRR corn, and soybean were fertilized according to University of Minnesota fertilizer recommendations. Soil nitrate-N to a depth of four feet was measured the fall before sugar beet production in each of the previous crops. The results are reported in Table 1. The residual soil nitrate-N at the Hector site, fall 2005, was on the average low at 31 pounds per acre. The residual soil nitrate-N was elevated for the soil when the previous crop was sweet corn or soybean. At the Buffalo Lake site, fall 2006, the residual soil nitrate-N was the least following spring wheat while the rest were very similar. The average residual soil nitrate-N for the Buffalo Lake site was 22 pounds per acre. The average residual nitrate-N at the Clara City site, fall 2007, was elevated to 95 pounds per acre. Where the previous crop was spring wheat, the residual soil nitrate-N was considerably less than the average, 59 pounds per acre, while the residual soil nitrate-N when the soybean was the previous crop, was greater than the average at 122 pounds per acre.

Table 1. The soil residual nitrate-N to a depth of four feet, as affected by the previous crop.

	Hector 2006	Buffalo Lake 2007	Clara City 2008
Previous crop	Soil residual nitrate-N to a depth of four feet, pounds per acre		
BtRR corn	25	18	94
Convention corn	21	33	100
Soybean	42	23	122
Sweet corn	41	31	99
Spring wheat	27	8	59
Site average	31	22	95

Sugar beet yield and quality:

In 2006, there was no previous crop by nitrogen rate interaction for any reported parameter, Table 2. The lack of an interaction means that nitrogen rate guidelines are not affected by the previous crop at this location. Root yield and extractable sucrose per acre were significantly affected by previous crop and nitrogen application rate, Table 3. Sugar beet grown after BtRR corn had the lowest root yield and extractable sucrose per acre, followed by corn. Sugar beet grown after soybean and sweet corn had similar root yield and extractable sucrose per acre while sugar beet grown after spring wheat had to largest. At this site the optimum root yield and extractable sucrose per acre were obtained at the 90 lb per acre nitrogen application, Table 4.

Purity was not affected by previous crop or nitrogen application. Extractable sucrose per ton was reduced by a previous crop of genetically modified corn for Bt and RR. The other previous crops had similar extractable sucrose per ton.

In 2006, there was no evidence to adjust nitrogen application rates for sugar beet because of previous crop.

Table 2. Statistical analysis for root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2006.

	Root yield	Purity	Extractable sucrose per ton	Extractable sucrose per acre
Previous crop	0.007	NS	0.07	0.02
N rate	0.002	NS	NS	0.004
Previous crop X Nrate	NS	NS	NS	NS
C.V. (%)	11.5	1.9	7.8	13.4

Table 3. The means for the effect of previous crop on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2006.

	Root yield	Purity	Extractable sucrose	
Previous crop	ton/A	%	lb/ton	lb/acre
BTRR corn	28.9	89.4	255	7386
Corn	29.3	90.3	273	8001
Soybean	31.6	90.1	267	8463
Sweet corn	31.9	90.2	272	8668
Spring wheat	33.1	90.1	271	8976

Table 4. The means for the effect of nitrogen fertilizer application on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2006.

N rate	Root yield	Purity	Extractable sucrose	
lb/A	ton/A	%	lb/ton	lb/acre
0	28.0	89.9	267	7478
30	30.8	89.6	266	8196
60	30.4	90.4	271	8257
90	31.8	89.6	265	8484
120	31.7	90.4	265	8405
150	32.8	90.1	272	8973

In 2007, there was only one parameter with a N rate by previous crop interaction, extractable sucrose per acre, Table 5. Root yield was significantly affected by the previous crop and N rate. Root yields were affected with the least yield from the greatest root yield as follows: BtRR corn similar to corn < soybean < sweet corn < spring wheat, Table 6. Increasing N rate increased root yield up to 120 pounds N per acre, Table 7. The residual nitrate-N in 2007 was between 20 and 35 pounds nitrate-N per acre in the surface four feet.

Purity was decreased on the average by the application of nitrogen fertilizer, Tables 5 and 6. Previous crop did not affect purity in 2007, Tables 5 and 7. Extractable sucrose per ton of sugar beet refined integrates the sucrose concentration and the impurities in the sugar beet. Extractable sucrose per ton was not significantly affected by previous crop or N rate application, Table 5, 6, and 7.

Extractable sucrose per acre was affected by previous crop and N rate in 2007, Table 5. There was also an interaction between previous crop and N rate. The interaction is graphed in Figure 1. The main reason for the interaction is because of the response of extractable sucrose per acre to N rate application when soybean is the previous crop. In general, the extractable sucrose per acre increased with increasing N application in 2007. Extractable sucrose per acre was the least for sugar beet grown after BtRR corn and corn. Soybean was greater than the corn except at the 150 pound N per acre application. Sweet corn and spring wheat were the best.

In 2007, there was not evidence that N applications needed to be adjusted by previous crop.

Table 5. Statistical analysis for root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2007.

	Root yield	Purity	Extractable sucrose per ton	Extractable sucrose per acre
Previous crop	0.0011	NS	NS	0.02
N rate	0.0001	0.06	NS	0.0001
Previous crop X Nrate	NS	NS	NS	0.06
C.V. (%)	6.6	1.4	3.9	6.9

Table 6. The means for the effect of previous crop on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2007.

	Root yield	Purity	Extractable sucrose	
Previous crop	ton/A	%	lb/ton	lb/acre
BTRR corn	30.6	90.9	259	7927
Corn	30.7	90.5	256	7887
Soybean	33.7	89.7	254	8512
Sweet corn	34.6	89.8	252	8739
Spring wheat	35.2	90.4	259	9087

Table 7. The means for the effect of nitrogen fertilizer application on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2007.

N rate	Root yield	Purity	Extractable sucrose	
lb/A	ton/A	%	lb/ton	lb/acre
0	30.8	90.9	259	7967
30	31.3	89.9	254	7975
60	33.3	90.4	255	8431
90	33.0	89.8	255	8414
120	34.2	90.4	258	8833
150	34.5	90.2	255	8797

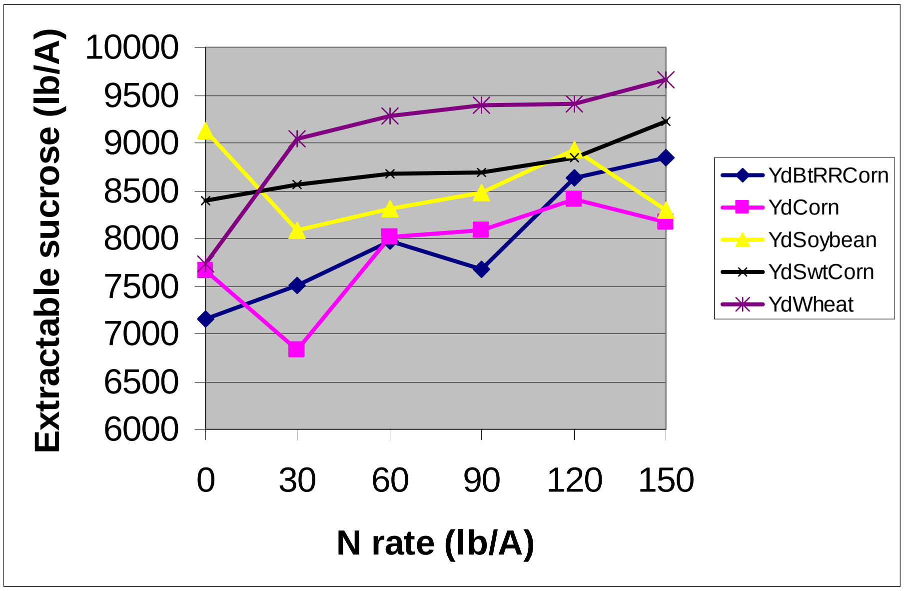

Figure 1. Extractable sucrose as affected by previous crop and N rate application in 2007.

In 2008, there were no differences in root yield, purity, and extractable sucrose cause by the previous crop or nitrogen rate, Tables 8, 9, and 10. These results were caused by the relatively high residual soil nitrate-N values , 95 pounds N per acre 0-4ft., in the fall of 2007 at this site.

Table 8. Statistical analysis for root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2008.

	Root yield	Purity	Extractable sucrose per ton	Extractable sucrose per acre
Previous crop	NS	NS	NS	NS
N rate	0.08	NS	NS	NS
Previous crop X Nrate	NS	NS	NS	NS
C.V. (%)	7.6	1.3	6.0	8.9

Table 9. The means for the effect of previous crop on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2008.

	Root yield	Purity	Extractable sucrose	
Previous crop	ton/A	%	lb/ton	lb/acre
BTRR corn	29.6	90.7	306	9058
Corn	30.2	90.4	301	9106
Soybean	29.1	90.5	310	9005
Sweet corn	30.8	90.3	300	9213
Spring wheat	30.1	90.4	305	9179

Table 10. The means for the effect of nitrogen fertilizer application on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2008.

N rate	Root yield	Purity	Extractable sucrose	
lb/A	ton/A	%	lb/ton	lb/acre
0	29.5	90.9	307	9052
30	29.9	90.3	300	8953
60	30.2	90.3	301	9109
90	30.7	90.3	307	9447
120	28.8	90.5	306	8817
150	30.6	90.5	304	9291

Soil nitrogen mineralization:

In-season nitrogen mineralization during sugar beet production was measured in 2006 and 2007 for the treatments with BtRR corn and sweet corn as previous crop at the 0 and 90 pounds N per acre applications and on conventional corn and sweet corn as previous crop at 0 and 90 pounds N per acre applications in 2008. The results for 2006 are presented in Figure 2.

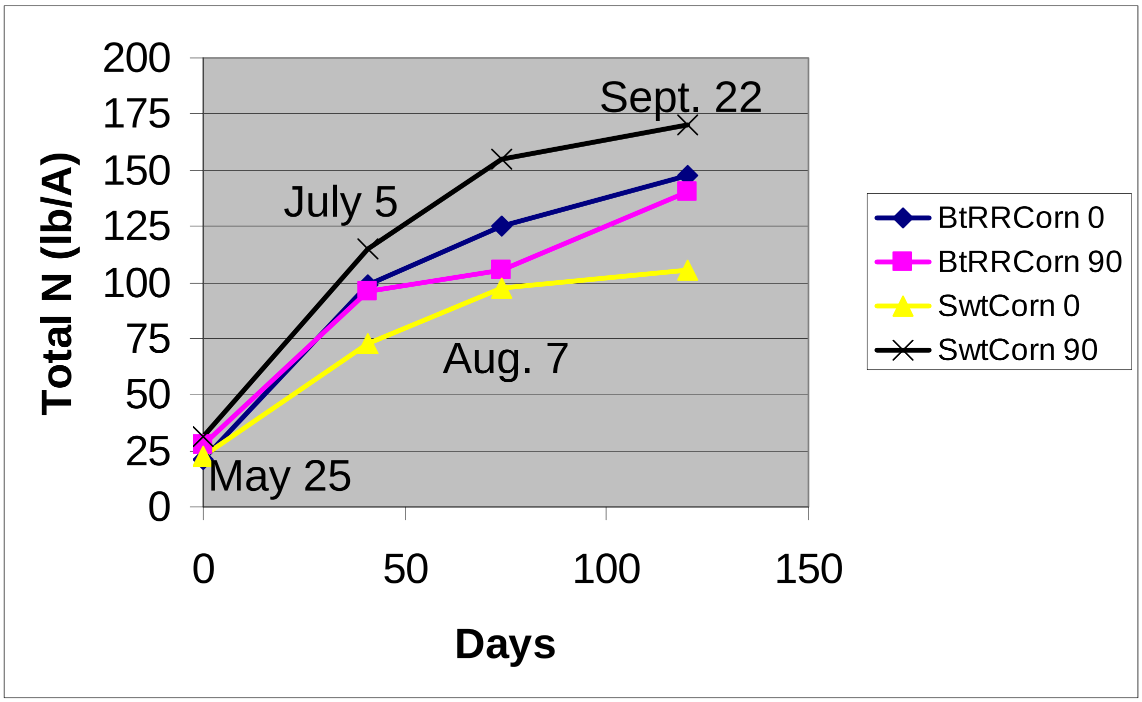

Figure 2. Total N in the surface 10 inches in a sugar beet crop in 2006 with a previous crop of BtRR corn and sweet corn with 0 and 90 pounds N applied.

In 2006, the addition of 90 pounds N per acre to sugar beet with a previous crop of BtRR corn did not affect the amount of N mineralization or the amount of mineral N measured. The addition of 90 pounds N per acre to sugar beet with a previous crop of sweet corn increased the amount of mineral N. The amount of mineral N during the growing season for BtRR corn was between the amounts found for the 0 and 90 pound N per acre with sweet corn as previous crop. The difference in mineralized N at the end of the season between sweet corn 0 pounds N per acre and sweet corn and 90 pounds N per acre was 56 pounds per acre, Table 11. This difference is because of the slower mineralization by the soil where sweet corn was a previous crop and 0 pounds of N per acre was applied. The differences in mineralized N between the other treatments in 2006 were not large.

Table 11. Mineralization rates during 2006, 2007, and 2008 for soil with sugar beet grown after BtRR or conventional corn and sweet corn with 0 and 90 pounds N per acre.

	N rate	Sept. 22 – May 25, 2006	Sept. 27 – May 25, 2007	Sept. 29 – May 27, 2008
Previous crop	pounds N/acre			
BtRR or Conventional corn	0	126	49	100
BtRR or Conventional corn	90	114	61	100
Sweet corn	0	83	100	188
Sweet corn	90	139	114	134

In 2007, the mineralization was larger for the sweet corn compared to the BtRR corn, Figure 3. Compared to 2006, mineralization for less for the BtRR corn in 2007. This could be from the drier weather in 2007 compared to 2006. The mineralization for the soil where sweet corn was the previous crop was similar to 2006.

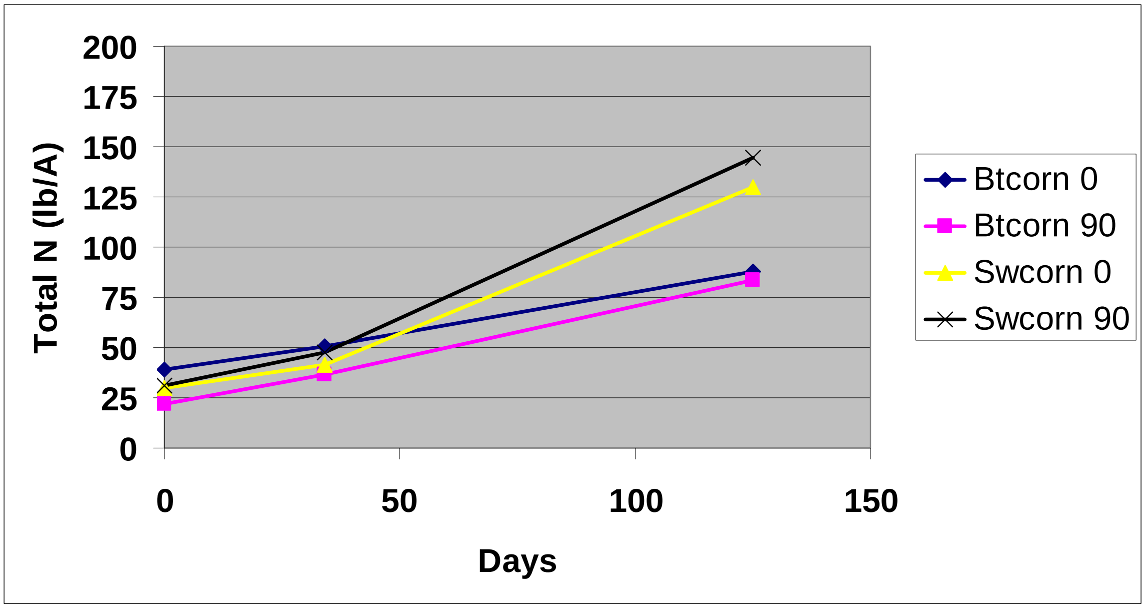

Figure 3. Total N in the surface 10 inches in a sugar beet crop in 2007 with a previous crop of BtRR corn and sweet corn with 0 and 90 pounds N applied.

In 2008, the mineralization was greater than 2007 for both sweet corn and the conventional corn, Figure 4. The soil where the previous crop was sweet corn mineralized more nitrogen than when conventional corn was the previous crop. There were few differences between the application of 0 and 90 pounds N per acre.

In general, N mineralization from the soil in this study was significant. The mineralization occurred during the whole growing season each year and thus could be a major contributor to the quality concerns encountered in the Southern Minnesota Beet Sugar Cooperative growing area.

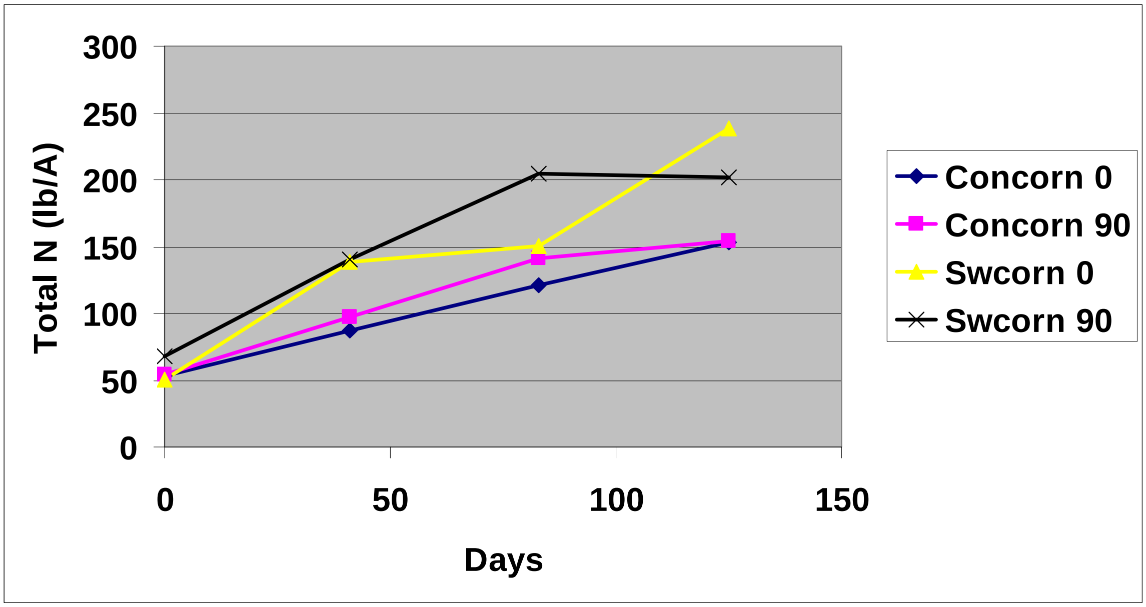

Figure 4. Total N in the surface 10 inches in a sugar beet crop in 2008 with a previous crop of corn and sweet corn with 0 and 90 pounds N applied.

Summary

Root yield and extractable sucrose per acre were affected by the previous crop and nitrogen application in 2006 and 2007. Corn and genetically modified corn had least root yield and extractable sucrose. Spring wheat had the greatest root yield and extractable sucrose per acre in each year. In 2008, previous crop and nitrogen application did not affect any parameter measured. This was because of the high soil residual nitrate, 95 lb N/A. The previous crop did not affect the optimum nitrogen application rate in any year of this study. Mineralization of nitrogen from organic matter was affected by the amount of N fertilizer applied when sweet corn was the previous corn in 2006. The sweet corn with 90 lb N/A applied had the greater mineralization then BrRR corn in 2006. Nitrogen rate did not affect the amount of N mineralized from either previous crop in 2007 and 2008. In all three years, the amount of N mineralized was greater when sweet corn was the previous compared to BtRR or conventional corn.

Turkey Litter Effects on Sugar beet Production

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Livestock operations, mainly poultry and swine, are increasing in size and impact in the Southern Minnesota sugar beet growing area. Many sugar beet producers own or have interest in these operations; thus have manure available to use on their fields. Manure research data concludes that manure has a positive effect on crop production from its effects on soil nutrient availability and soil physical properties. A concern has been raised about the effect of late season nitrogen mineralized from the manure on sugar beet quality. Grower observations indicate better growth in fields that have had manure applied. With the large amount of manure available, the question has changed from whether to use manure but when in the sugar beet crop rotation should manure be applied to minimize quality concerns and realize benefits? Turkey manure has a considerable amount of litter in it, thus slowing initial release of poultry manure-N. The implication of the manure-N release is critical, especially to sugar beet growers. Therefore, recommendations need to be evaluated with sugar beets. This research project has been designed to: 1) determine when in a three-year rotation, should turkey litter be applied and 2) determine nitrogen fertilizer equivalent of turkey litter applied two and three years in advance of sugar beet production.

Materials and Methods

To meet the objectives of this experiment the first of three sites was established near Raymond, Minnesota in the fall of 2006 while a second site was established in the fall of 2007 near Olivia, Minnesota. The Raymond site was cropped to soybean in 2007. Turkey manure was applied fall 2006 and soybean grain yields were harvested by a plot combine in the fall of 2007. The treatments for the second year were applied to the first site near Raymond in the fall of 2007 with corn grown in 2008. A second site was established near Olivia, Minnesota in the fall of 2007 with soybean grown in 2008. Below is a complete description of this project.

Each site of this study will have five replications of the treatments list in Table 1. Turkey litter treatments of 3 and 6 tons per acres are applied 2 and 3 years ahead in the three year rotation of soybean/corn/sugar beet. This rotation is the most common rotation is this growing area. Treatment 5 is the check treatment for the whole experiment while treatments 8 and 15 are checks for different parts of the rotation. Treatments 6 through 14 are the N fertilizer rates plus the two turkey litter rate applied the fall before the sugar beet production year. During the corn production year, 120 lb N per acre will be applied for treatments 6 through 14. This is the current U of MN N guideline for corn following soybean. In the soybean production year, grain yield will be measured. Soil samples to and depth of 4 feet will be analyzed for nitrate-N while soil samples to a 6 inch depth will be analyzed for phosphorous, potassium, organic matter, and pH. The soil test phosphorus, potassium, and pH will be additional information to assess the effect of turkey litter on other soil chemical properties besides nitrogen. The year 2 manure and fertilizer treatments will be applied in the late fall. During the corn production year, biomass will be measured using a hand held sensor to assess early growth. Basal stalk samples will be taken at a week after grain black layer and analyzed for nitrate. This is a good tool to determine the effect of the nitrogen management treatments. Grain will be harvested and similar to year 1 soil samples will be taken. The year 3 treatments will be applied late fall of year 2. Sugar beet late season leaf growth will be assessed with a sensor. Root yield and quality will be determined in the fall. Final soil samples for nitrate-N, phosphorus, potassium, and pH will be taken after harvest. In each of the production years, optimum production practices for pests control and nutrient management besides nitrogen will be used.

Table 1. Treatment List

Treatment Number	Year 1 (soybean)	Year 2 (corn)	Year 3 (sugar beet)
1	3 ton litter	0 N	0 N
2	6 ton litter	0 N	0 N
3	0 N	3 ton litter	0 N
4	0 N	6 ton litter	0 N
5	0 N	0N	0 N
6	0 N	120 N	3 ton litter
7	0 N	120 N	6 ton litter
8	0 N	120 N	0 N
9	0 N	120 N	30 N
10	0 N	120 N	60 N
11	0 N	120 N	90 N
12	0 N	120 N	120 N
13	0 N	120 N	150 N
14	0 N	120 N	180 N
15	0 N	0 N	90 N

Table 2. Timeline for crops at each of three locations.

2007-08	2008-09	2009-10	2010-2011	2011-2012
Location 1 - soybean	Location 1 - corn	Location 1 – sugar beet		
	Location 2 - soybean	Location 2 - corn	Location 2 – sugar beet	
		Location 3 - soybean	Location 3 - corn	Location 3 - sugarbeet

Results

Soybean grain yields where significantly increased by the application of manure in 2007 at the Raymond site, Table 3. This increase was small. There were no differences in grain yield between 3 and 6 tons of turkey litter application. Soil samples were taken after the soybean production year in the fall of 2007. The application of 3 and 6 tons of turkey litter, fall 2006, increased the soil residual nitrate-N, soil test P, and soil test K at the fall 2007 soil sampling, Table 4.

Table 3. Soybean grain yields as affected by the application of 3 and 6 tons of turkey litter in fall 2006 at Raymond, Minnesota in 2007.

Treatment	Soybean grain yield (bushels per acre)
Zero (check)	50.0
3 tons turkey litter	51.8
6 tons turkey litter	53.5
Statistics	P>F
Zero vs turkey litter application	0.005
Manure (3 vs 6 tons turkey litter)	NS
C.V. (%)	5.3

Table 4. Soil test results fall 2007 after soybean production as affected by the application of 3 and 6 tons of turkey litter in fall 2006 at Raymond, Minnesota.

Treatment	pH	Organic matter (%)	Nitrate-N 0-4 ft. (lb/A)	Olsen-P (ppm)	Potassium (ppm)
Zero (check)	7.6	4.3	45	30	157
3 tons turkey litter	7.3	4.4	98	38	178
6 tons turkey litter	7.4	4.4	172	45	187

Corn grain yields in 2008 were measured at the Raymond site, Table 5. The only significant difference in corn grain yield was between the check, with no N fertilizer or turkey litter applied and the corn grain yield from the 120 pounds N per acre and the turkey litter treatments. Sugar beets will be planted in 2009 with N rate treatments and 3 and 6 turkey litter applications made fall 2008.

Table 5. Corn grain yields as affected by the application of 120 pounds N per acre, 3 and 6 tons of turkey litter in fall 2006, and 3 and 6 tons of turkey litter in fall 2007 at Raymond, Minnesota in 2008.

Treatment	Corn grain yield (bushels per acre)
Zero N (check)	102
120 pounds N per acre applied fall 2007	150
3 tons turkey litter applied fall 2006	130
6 tons turkey litter applied fall 2006	146
3 tons turkey litter applied fall 2007	150
6 tons turkey litter applied fall 2007	144
Statistics	P > F
Check vs rest	0.0001
120 lb N per acre vs turkey litter	NS
2006 vs 2007 turkey litter	NS
2006 3 ton vs 6 ton turkey litter	NS
2007 3 ton vs 6 ton turkey litter	NS

A second site was established south of Olivia fall of 2007. Soybean was planted and harvested in 2008. The soybean grain yields were not affected by the 3 and 6 tons turkey litter application in the fall of 2007, Table 6. Corn will be grown in 2009 with treatments added of 120 pounds N per acre and 3 and 6 tons turkey litter applied fall 2008.

Table 6. Soybean grain yields as affected by the application of 3 and 6 tons of turkey litter in fall 2007 at Olivia, Minnesota in 2008.

Treatment	Soybean grain yield (bushels per acre)
Zero (check)	49.8
3 tons turkey litter	50.1
6 tons turkey litter	50.7
Statistics	P>F
Zero vs turkey litter application	NS
Manure (3 vs 6 tons turkey litter)	NS
C.V. (%)	6.0

Fertility Zones Generated Using Satellite Imagery

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Satellite imagery can be a useful tool to manage crops and identify problem areas within a field. It may also be used as a tool to identify organic matter levels. Organic matter then may be used to identify fertility zones. Information relating satellite imagery to organic matter is limited. A study has been established to determine if available bare soil imagery can be used to identify organic matter and fertility zones in the SMBSC growing area.

Methods and Materials

Satellite imagery of the SMBSC growing was acquired from the US Geological Survey (USGS) with assistance from South Dakota State University (SDSU) for the years, 2000, 2003 and 2008. Imagery was acquired using LandSat satellites. For those three years imagery was available that were free of clouds, snow and growing crops. For each year there were seven different color bands of imagery available for use. The human eye sees a combination of red, blue and green. LandSat measures only one color or a combination of two colors. For example; Band 1 is a measurement of only the blue and green reflectance. Band 2 is only green. Band 5 is mid-infrared which is not seen with the human eye and band 7 is short-wave infrared, also not seen by humans. Image maps are gridded into 93.5 foot cells. Cells are called pixels and each pixel has a numeric value derived from its place on the color spectrum. Clay hills have more light reflectance therefore having a higher value whereas black soils have less reflectance producing a lower value. Using geo-referenced soil test information from current zone research, organic matter levels were compared to the corresponding pixel values for each of the seven color bands and differing combinations of those bands. The zone research fields represent a majority of the SMBSC growing area. There are eight research fields. Fields are located in Districts 2, 5, 6, 7 and 8.

Results

The relationship of organic matter to satellite imagery is encouraging. The data indicates bands five and seven from the years 2000 and 2008 added together proved to have the closest relationship to organic matter. Using the LandSat imagery, current data analysis shows organic matter can be predicted accurately 93 percent of the time (Table 1). As of this writing more research is being conducted. The maximum and minimum pixel values of the imagery and the corresponding organic matter percentages need to be identified (Table 2). The information will be used to draw fertility zones and previous soil sample information will be used to prove whether or not the association is valid.

Table 1. Probability of accurate estimation of Om using pixel values from LandSat imagery.

	Band 1	**Band 2**	**Band 3**	**Band 4**	**Band 5**	**Band 6**	**Band 7**	**5 plus 7_2000_2008**
Prob	-0.72	-0.71	-0.72	-0.70	-0.86	-0.63	-0.86	-0.93
Pr > F	0.0003	0.0005	0.0003	0.0005	<.0001	0.0032	<.0001	<.0001

Table 2. Pixel values and standard deviation of differing organic matter percentages for bands five plus seven for the years 2000 and 2008.

	<3	**3-4**	**4-5**	**5-6**	**6-7**	**>7**
Pixel Mean	226	223	197	194	191	183
Stdev	16.3	16.3	22.3	15.2	13.4	16.1

Summary

It is likely satellite imagery can be used to identify organic matter percentages. Those in turn can be used to identify fertility zones in any given field. The zones can then be sampled to measure residual N, P and K and nutrient levels can be adjusted in each zone for optimum yield and quality in sugar beets as well as corn and other nutrient dependent crops.

SMBSC Evaluation of Phosphorus, Turkey Ash and Turkey Manure Influence on Sugarbeet Growth-2008

Sugarbeets were planted at two locations to test phosphorus, turkey manure (TM) and turkey manure ash (NAF) on sugarbeet production. The locations were at Wood Lake and Bird Island, MN. The data will be presented combined over the two locations. Analysis of the data was conducted for homogeneity of combinability and determined that the data could be combined across environments or locations

Methods

Table 1 shows the specifics of activities conducted at each site. Plots were 11 ft. (6 rows) wide and 50 ft long. Phosphorus fertilizer source 0-46-0 was used so that only phosphorus could be applied in the fertilizer analysis. Phosphorus fertilizer, TM and NAF were applied prior to planting time and field cultivated in to the soil. Sugarbeets were planted with a 6 row planter. Stand count and harvest data were collected from the middle two rows of a 6 row plot. Plots were thinned as the sugarbeet stands did not warrant thinning. Research trials were harvested on 10/1/08 at the Wood Lake site and 10/4/08 at the Bird Island site with a 1 row research harvester. Two quality sub-samples were collected from each plot and analyzed for quality and weighed for yield calculation. Each sample was collected from 10 feet of row.

Table 1. Site specifics for starter products testing

	Location	
Task	***Wood Lake***	***Bird Island***
Sugarbeet variety	Beta 95RR03	Hilleshog 9027
Planting date	19-May-08	19-May-08
Roundup Powermax applied as needed at all locations		
Fertility		
Nitrogen (0-4 ft)	65	79
Phosphorus (Olsen- 0-.5 ft)	6.5	2.4
Potassium (0-.5 ft)	159	191
pH	7.85	7.86
O.M.	4.45	5.18
Fertilizer applied		
Nitrogen	40	30
Phosphorus	0	0
Potassium	0	0
Harvest	1-Oct-08	4-Oct-08

Table 2. Turkey Manure analysis

Nutrient	lb/ton
Total Nitrogen (N):	36
Phosphate (P205):	42
Potash (K20):	22
Sodium:	3.7
Calcium:	20
Magnesium:	7.5
Zinc:	0.24
Iron:	0.53
Manganese:	0.34
Copper:	0.42
Sulfur:	5.3

Table 3. Turkey Ash (NAF) analysis spring 2008

Guaranteed Analysis

Available Phosphate (P_2O_5)	8%
14% Total Phosphate (P_2O_5)	
Soluble Potash (K_2O)	5%
8% Total Potash (K_2O)	
Sulfur (S)	1.3%
Zinc (Zn)	.05%

Table 4. Sugarbeet stand count as influenced by phosphorus fertilizer, TM and NAF

Locations - COMBINED			
TRT #	PRODUCT	RATE	Stand average
1	Phosphorus	0	219
2	Phosphorus	45	194
3	Phosphorus	60	213
4	Phosphorus	90	206
5	Phosphorus	120	204.5
6	TM	4 ton	219.5
7	NAF	350 lbs	214
8	NAF	500 lbs	218.5
9	NAF	700 lbs	195
10	NAF	1000 lbs	212.5

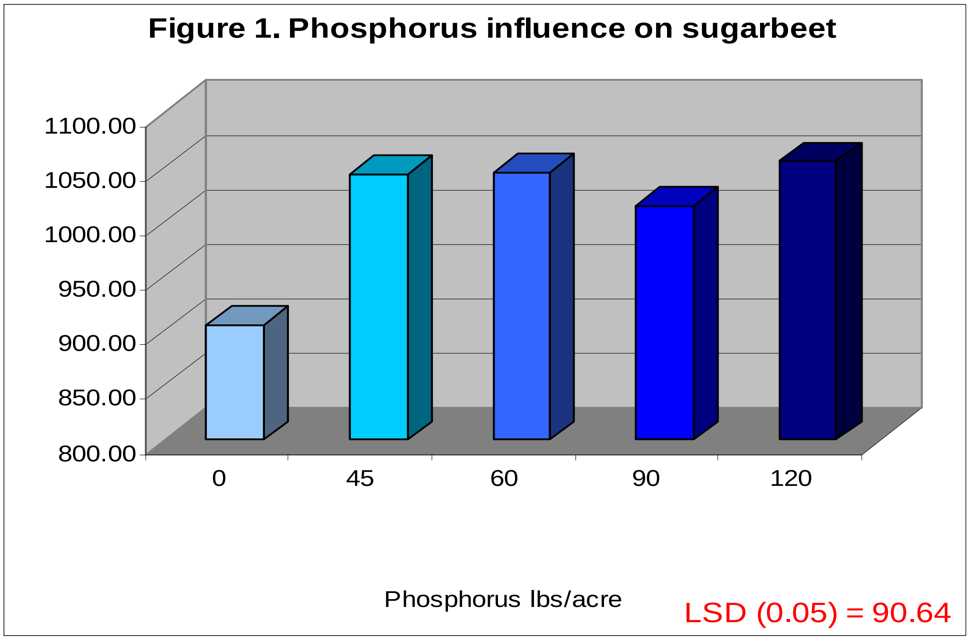


Figure 1. Phosphorus influence on sugarbeet
1100.00
1050.00
1000.00
950.00
900.00
850.00
800.00
0
45
60
90
120
Phosphorus lbs/acre
LSD (0.05) = 90.64

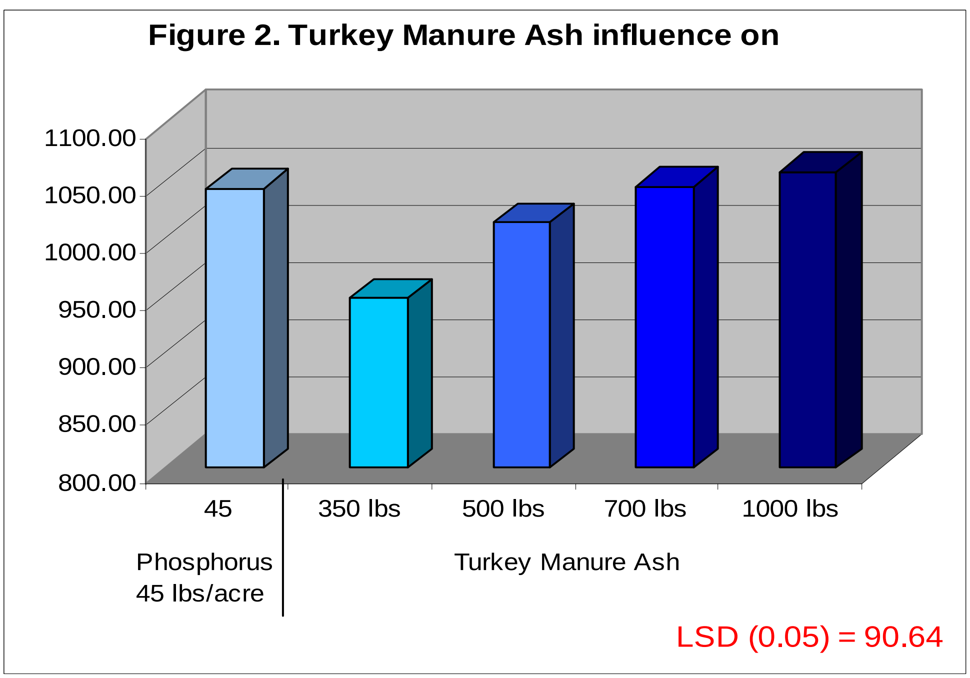
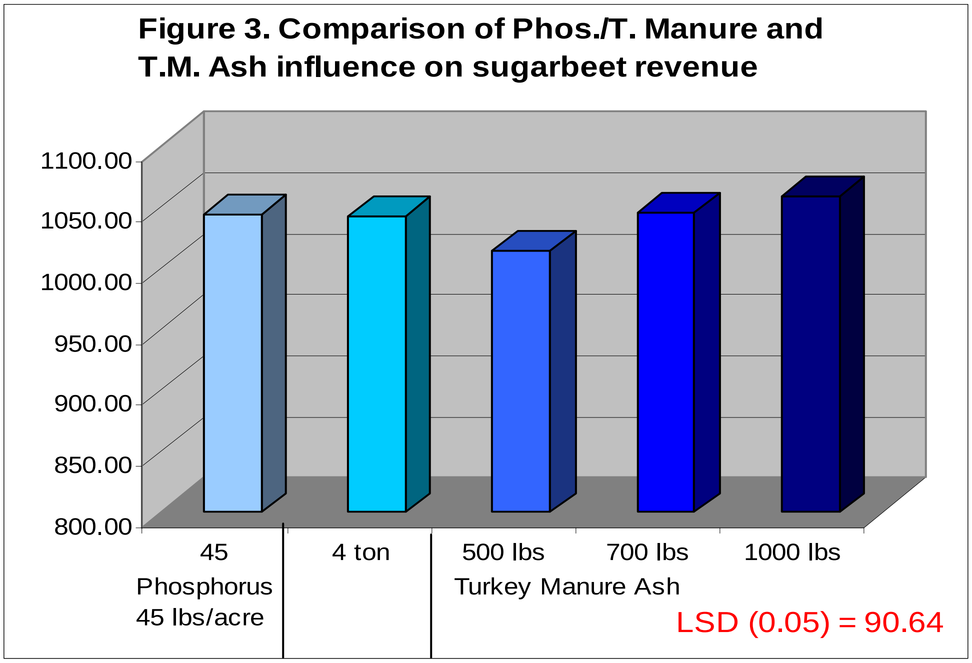


Figure 2. Turkey Manure Ash influence on
1100.00
1050.00
1000.00
950.00
900.00
850.00
800.00
45
350 lbs
500 lbs
700 lbs
1000 lbs
Phosphorus
45 lbs/acre
Turkey Manure Ash
LSD (0.05) = 90.64



Results and Discussion

1. Revenue per acre was significantly influenced by phosphorus commercial fertilizer rate, turkey manure and NAF.

2. Phosphorus commercial fertilizer rates of 45, 60, 90, and 120 statistically influenced revenue per acre similarly. This is why in figure 2 and 3, 45 lbs. phosphorus was compared to all non-commercial phosphorus fertilizer treatments.

3. Revenue per acre was influenced by NAF at rates of 500, 750 and 1000 lbs. per acre. These rates of NAF performed statistically similar and were statistically greater than 350 lbs. per acre.

4. Turkey Manure at 4 ton per acre gave statistically similar results compared to commercial phosphorus fertilizer at 45 lbs. per acre or greater and NAF at 500 lbs. or greater.

SMBSC Pop-up Fertilizers Influence on Nitrogen Efficiency for Enhancement of Sugarbeet Growth-2008

Sugarbeets were planted at three locations to test nitrogen use efficiency (NUE) for sugarbeet production as influenced by popup fertilizer. Popup fertilizer is the term used in this report to describe the generic term of starter fertilizer. Popup fertilizer in this report is fertilizer 10-34-0 applied in furrow on the sugarbeet seed. Locations were at Gluek, Bird Island and Clara City, MN. The data will be presented combined over the Three locations. Analysis of the data was conducted for homogeneity of combinability and determined that the data could be combined across environments or locations

Methods

Table 1 shows the specifics of activities conducted at each site. Plots were 11 ft. (6 rows) wide and 50 ft long. Phosphorus fertilizer source 10-34-0 was used as a popup fertilizer. Phosphorus fertilizer 10-34-0 was applied in furrow on seed at 3 gal per acre. Treatments included with and without popup fertilizer. Nitrogen was applied to the plots with and with without pop-up fertilizer at the rates of 0, 20, 40, 60, and 80 lbs per acre. Sugarbeets were planted with a 6 row planter. Harvest data was collected from the middle two rows of a 6 row plot. Plots were not thinned as the sugarbeet stands did not warrant thinning. Research trials were harvested at Bird Island and Gluek with a 1 row research harvester and at Clara City site with a 2 row research harvester. Two quality sub-samples were collected at Bird Island and Gluek from each plot and analyzed for quality and weighed for yield calculation. Each sample was collected from 10 feet of row. One quality sub-sample was collected at Clara City from each plot and analyzed for quality. At Clara City, the weights were collected and weighed on the harvester for yield calculation and a subsample was analyzed in the SMBSC quality lab.

Results and Discussion

The rate of nitrogen will be discussed as total nitrogen. The total nitrogen is the soil test or residual nitrogen plus applied nitrogen. Data presented are tons per acre, sugar per acre and sugarbeet revenue in Figures 1, 2 and 3, respectively. This test will be continued in 2009.

1. Tons per acre was not significantly influenced by nitrogen rate when Total N was 84 lbs. per acre or greater, except when the nitrogen was applied at 144 lbs. per acre without pop-up fertilizer.
2. Tons per acre tended or did increase significantly with pop-up fertilizer compared to treatments without pop-up fertilizer.
3. Sugar per acre did not significantly increase with the use of pop-up fertilizer, although there was a consistent trend for substantial increase with the use of pop-up fertilizer at all total nitrogen rates.
4. The general trend at total nitrogen rates above 84 lbs. per acre was for a reduction in sugar per acre. The reduction in sugar per acre tended to be greater than the reduction observed in tons per acre at total nitrogen rates exceeding 84 lbs. per

acre. This trend indicates a greater reduction in quality than tons per acre at the total nitrogen above 84 lbs. per acre.

5. Revenue per acre was optimized at approximately the 100 lbs. per acre total nitrogen rate.
6. Pop-up fertilizer either tended or did increase revenue per acre at all total nitrogen rates

Table 1. Site specifics for starter products testing

Task	***Location*** Clara City	Bird Island	***Gluek***
Sugarbeet variety	Hilleshog 4017	Hilleshog 9027	Hilleshog 4017
Planting date	19-May-08	9-May-08	21-May-08
Roundup Powermax applied as needed at all locations			
Fertility			
Nitrogen (0-4 ft)	101	74	56
Phosphorus (Olsen- 0-.5 ft)	24	7.4	17.3
Potassium (0-.5 ft)	401	189	155
pH	8	7.7	8
O.M.	5.6	5.3	5.1
Fertilizer applied			
Nitrogen	0	0	0
Phosphorus	0	45	0
Potassium	0	0	0
Harvest	1-Oct-08	4-Oct-08	10-Oct-08

Figure 1. Tons per acre as influenced by nitrogen rate with and without starter

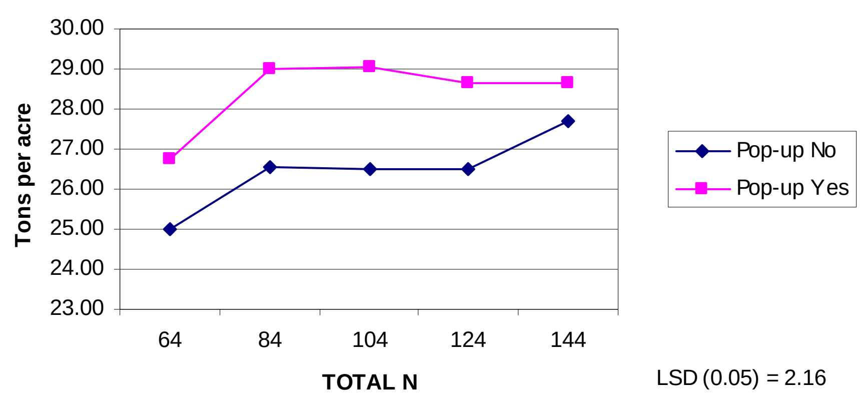


Figure 2. Sugar per acre as influenced by nitrogen rate with and without starter

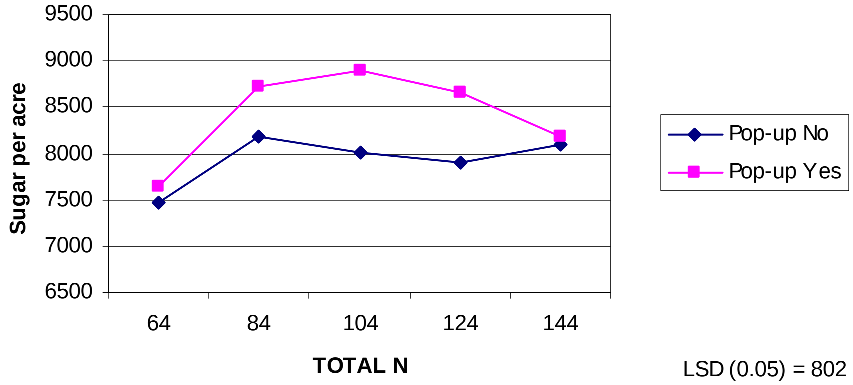
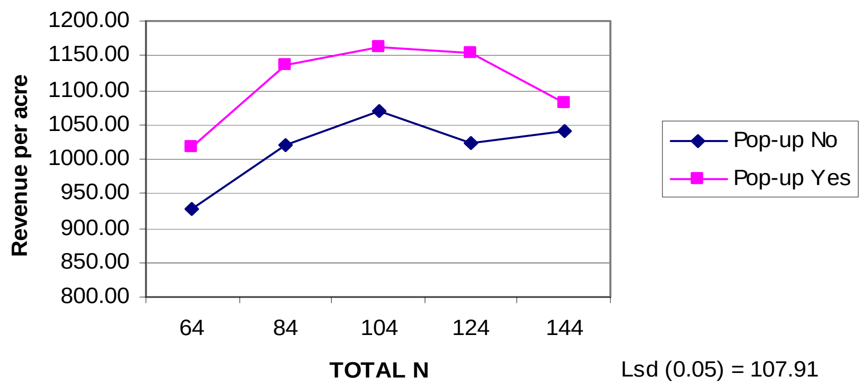


Figure 3. Sugarbeet revenue per acre as influenced by nitrogen rate with and without starter



SMBSC In-furrow Application of Pop-up Fertilizers and Amendment Products for Enhancement of Sugarbeet Growth-2008

Sugarbeets were planted at three locations to test the influence of pop-up fertilizer and amendment products on sugarbeet production. The locations were at Clara City, Wood Lake and Hector, MN. The data will be presented combined over the three locations. Analysis of the data for homogeneity of combinability was determined that the data could be combined across environments or locations

Methods

Table 1 shows the specifics of activities conducted at each site. Plots were 11 feet (6 rows) wide and 35 feet long. Pop-up fertilizers and amendments were applied at planting time with a 6 row planter. Harvest data were collected from rows 3 and 4 of a 6 row plot. The research trial was harvested with a 1 row research harvester at Wood Lake. Two quality sub samples were collected from each plot and analyzed for quality and weighed for yield calculation. Each sample was collected from 10 feet of row. Research trials were harvested with a 2 row research harvester at Clara City and Hector and the whole plot length was harvested. One quality sub-sample was collected from each plot and analyzed for quality.

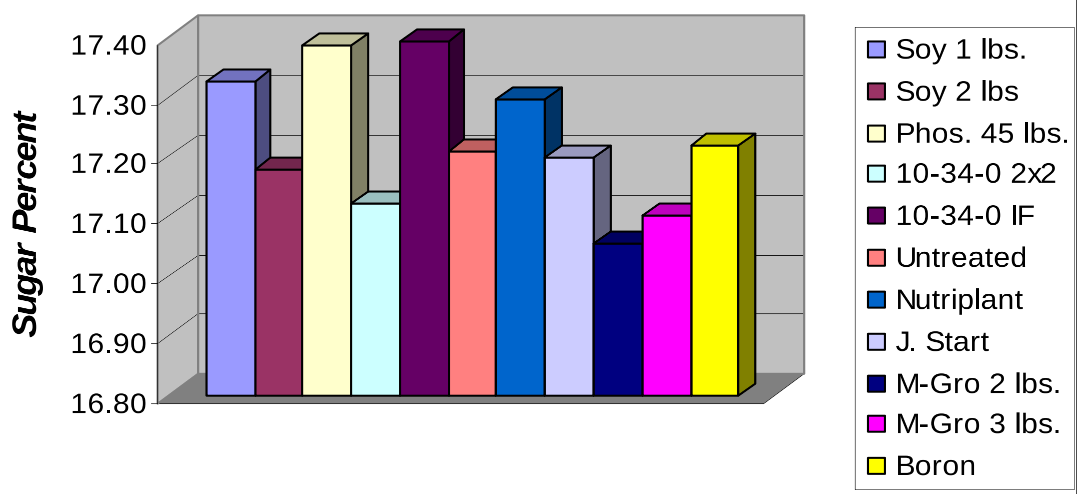
Table 1. Site specifics for starter products testing sites

	Location		
Task	***Wood Lake***	***Clar City***	***Hector***
Sugarbeet variety	Hilleshog 4017RR	Hilleshog 4017RR	Beta SM RR01
Planting date	19-May-08	19-May-08	9-May-08
Roundup Powermax applied as needed at all locations			
Fertility			
Nitrogen (0-4 ft)	77	75	No soil data
Phosphorus (Olsen- 0-.5 ft)	5	19	↓
Potassium (0-.5 ft)	165	244	↓
pH	7.9	8	↓
O.M.	4.3	5.2	No soil data
Fertilizer applied			
Nitrogen	30	30	30
Phosphorus	0	0	0
Potassium	0	0	0
Harvest	1-Oct-08	4-Oct-08	29-Sep-08

Table 2. Treatment descriptions for 2008 starter product testing

TRT #	Product	Rate	Timing	Treatment desciotion
1	Soygreen	1 lbs.	at planting in furrow	Soy 1 lbs.
2	Broadcast P	45 lbs	at planting incorporated	Phos. 45 lbs.
3	Soygreen	2 lbs.	at planting in furrow	Soy 2 lbs
4	Pop-up (10-34-0)	3 gal	at planting 2X2	10-34-0 2x2
5	Pop-up (10-34-0)	3 gal	at planting in furrow	10-34-0 IF
6	Untreated	N/A	N/A	Untreated
7	Nutriplant(4-15-12)	4 oz	at planting in furrow	Nutriplant
8	Jump Start		at planting	J. Start
9	ManGro DF	2 lbs	In-Furrow	M-Gro 2 lbs.
10	ManGro DF	3 lbs	In-Furrow	M-Gro 3 lbs.
11	Boron	1.81 gal	In-Furrow	Boron

Figure 1. 2008 Starter type product testing



LSD (0.05) = 0.5 NS

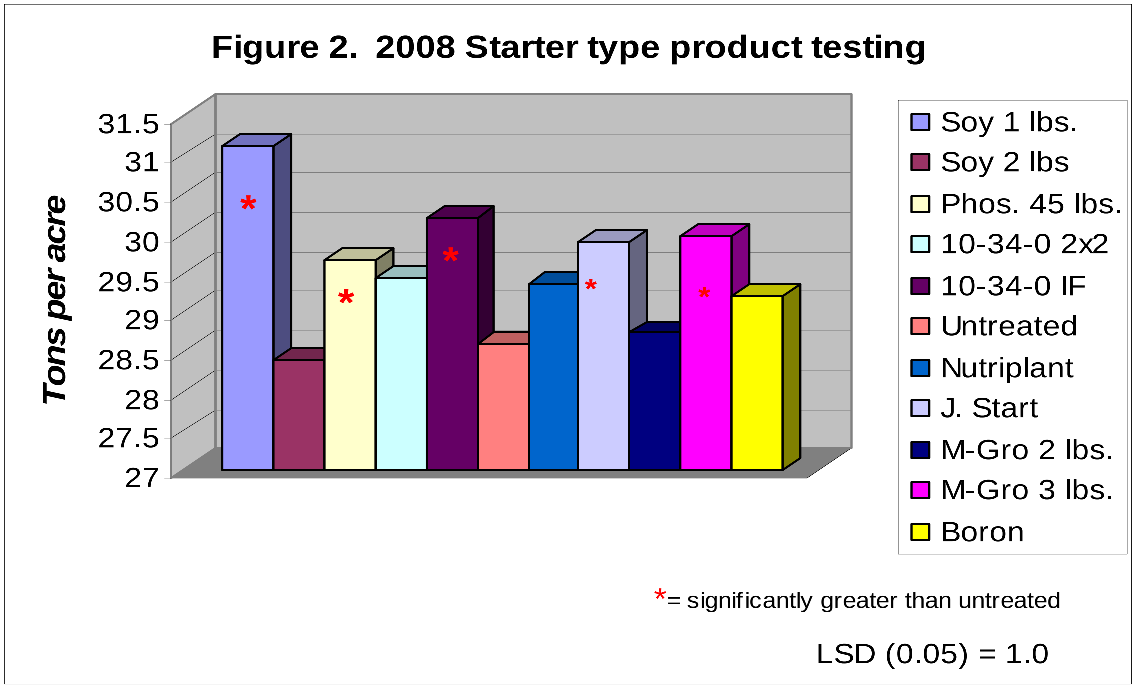


Figure 2. 2008 Starter type product testing
Tons per acre
31.5
31
30.5
30
29.5
29
28.5
28
27.5
27
Soy 1 lbs.
Soy 2 lbs
Phos. 45 lbs.
10-34-0 2x2
10-34-0 IF
Untreated
Nutriplant
J. Start
M-Gro 2 lbs.
M-Gro 3 lbs.
Boron
*= significantly greater than untreated
LSD (0.05) = 1.0

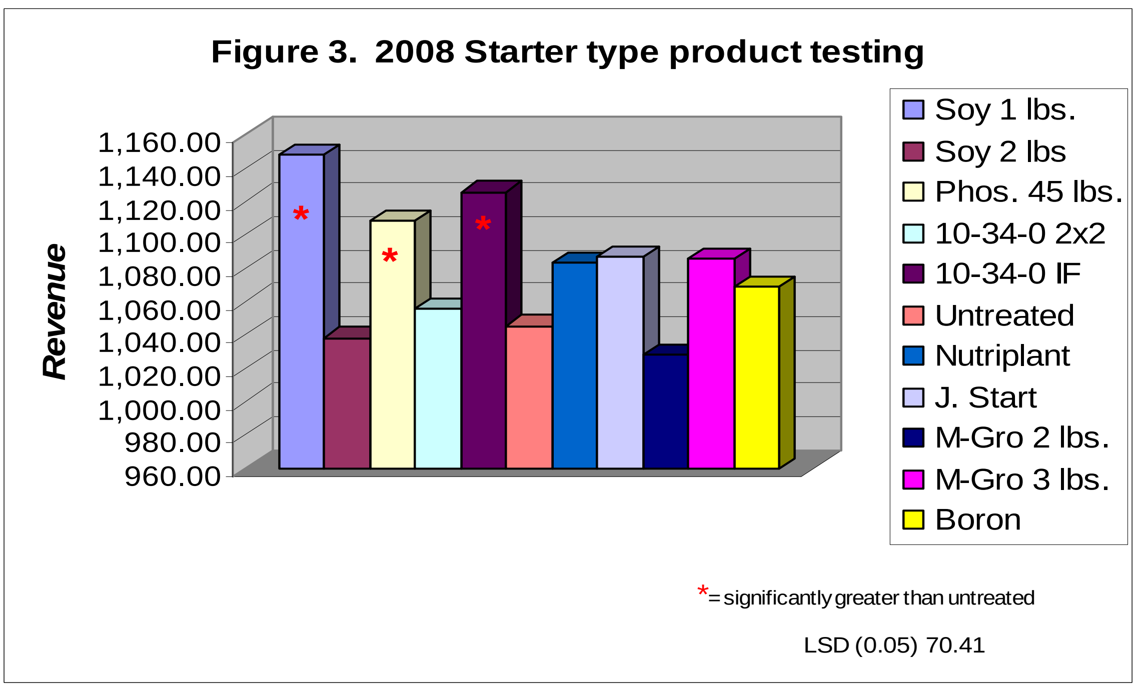


Figure 3. 2008 Starter type product testing
Revenue
1,160.00
1,140.00
1,120.00
1,100.00
1,080.00
1,060.00
1,040.00
1,020.00
1,000.00
980.00
960.00
Soy 1 lbs.
Soy 2 lbs
Phos. 45 lbs.
10-34-0 2x2
10-34-0 IF
Untreated
Nutriplant
J. Start
M-Gro 2 lbs.
M-Gro 3 lbs.
Boron
*= significantly greater than untreated
LSD (0.05) 70.41

Results and Discussion

1. Table 2 describes the treatments tested in 2008 for starter type products. These products are treatments that are applied in-furrow or to the seed that claim to enhance sugarbeet production. The products are presented in this report in reference to their influence on sugar percent (Figure 1), tons per acre (Figure 2) and sugarbeet revenue (Figure 3).

2. Sugar content was not significantly influenced by treatments.

3. Tons per acre were significantly influenced by Soygreen at 1 lbs. per acre, Broadcast Phosphorus applied at 45 lbs. per acre, 10-34-0, Jump Start and ManGro at 3lbs. per acre.

4. Revenue per acre was significantly influenced by Soygreen applied at 1 lbs. per acre, Phosphorus applied at 45 lbs. per acre and 10-34-0.

5. Currently there is no clear explanation of why Soygreen significantly influenced tons per acre and revenue per acre. Research in 2009 will investigate plant and soil aspects to attempt to determine the mechanics behind the influence that Soygreen has on tons per acre and revenue per acre.

6. Research in 2009 will investigate various nutrient needs of the sugarbeet that have traditionally been considered insignificant to the sugarbeet.

2008 University of Minnesota and North Dakota State University
Weed Science Research Report for Southern Minnesota Beet Sugar Cooperative

Demonstration research was conducted at three Southern Minnesota locations in 2008. One location was northeast of New Auburn, another location was southwest of Hutchinson, and the final location was just south of Hazel Run.

At the New Auburn location, six treated strips (6.7 feet wide by approximately 80 feet in length) were established in a grower's field. Glyphosate-resistant sugarbeet were planted. Treatments were applied on June 2 and on June 17, 2009 as listed in the table below. Roundup WeatherMAX was used as the glyphosate formulation. Lambsquarters and waterhemp were the dominate weed species at this location. The lambsquarters were up to 5" tall and the waterhemp were up to 3" tall at the June 2nd application. Fifty lambsquarters plants were flagged prior to the initial application of the first three treatments and 25 plants were flagged in the last three treatments. Eight additional surviving plants were flagged in the first treatment on June 17th.

Treatment	Rate lb ae/A	Control – June 17 (15 DAT) lambsquarters	 waterhemp	Control – July 23 (51 DAT) lambsquarters	 waterhemp
		%			
Glyphosate + AMS	0.75 + 2.5 lb/A	88	97	80	70
Glyphosate + AMS	3.0 + 2.5 lb/A	100	100	70	50
Glyphosate + AMS **fb** glyphosate + AMS	1.1 + 2.5 lb/A **fb** 0.75 + 2.5 lb/A	94	100	95	95
Glyphosate + NIS + AMS **fb** Glyphosate + NIS + AMS	1.1 + 0.25%v/v + 2.5 lb/A **fb** 0.75 + 0.25 %v/v + 2.5 lb/A	100	100	97	95
Glyphosate + Nortron + AMS **fb** glyphosate + AMS	0.75 + 7.5 pt/A + 2.5 lb/A **fb** 0.75 + 2.5 lb/A	98	100	98	95
Glyphosate + Progress + Destiny HC + AMS **fb** glyphosate + AMS	0.75 + 8.5 fl oz/A + 1%v/v + 2.5 lb/A **fb** 0.75 + 2.5 lb/A	20	20	75	90

* lb ae/A = pounds acid equivalent per acre; DAT = days after treatment; fb = followed by; NIS = nonionic surfactant (P90); AMS = ammonium sulfate

Glyphosate applied at 3.0 lb ae/A, 1.1 lb ae/A plus NIS, or at 0.75 lb ae/A plus Nortron at 7.5 pt/A plus AMS on June 17th maximized lambsquarters control at 15 DAT. Lambsquarters and waterhemp were poorly controlled by the glyphosate plus Progress treatment. The exact reason for the poor control is unknown although it may be due to antagonism of glyphosate by the Progress. This theory needs further testing to confirm. Glyphosate at 3.0 lb ae/A and Nortron at 7.5 pt/A can not legally be applied to glyphosate-resistant sugarbeet. Lambsquarters and waterhemp control declined during the season when glyphosate was applied once. This was due to substantial germination of these two species after the initial glyphosate application. On July 23rd, glyphosate plus NIS applied twice and glyphosate plus Nortron followed by glyphosate provided the greatest lambsquarters control. The sequential glyphosate application following glyphosate plus Progress did not effectively control all lambsquarters. Five percent of the flagged lambsquarters were still alive on July 23rd in the first treatment. Four percent of the flagged lambsquarters were alive on July 23rd in the last treatment. No surviving flagged plants were observed in the other treatments.

This demonstration indicates that the application of glyphosate at 1.1 lb ae/A and the addition of NIS to a loaded glyphosate formulation may improve lambsquarters control. The addition of Nortron at 7.5 pt/A to glyphosate at the recommended (0.75 lb ae/A) rate may improve the control of lambsquarters compared to glyphosate alone. However, this rate of Nortron is currently not a legal application and increases total herbicide costs.

At the Hutchinson location, 100 giant ragweed plants were flagged prior to the commercial application of glyphosate at 1.04 lb ae/A (Touchdown Total) plus FirstRate at 0.3 oz/A in glyphosate-resistant soybean. This treatment was applied on June 20, 2008. The flagged giant ragweed plants were less than 8" in height with other plants in the field up to 14" in height at the time of application. Only one percent of the flagged giant ragweed plants were controlled by the application of glyphosate plus FirstRate at 13 days after treatment. On July 3rd, a 12 ft wide by 100 ft length strip was sprayed with glyphosate at 3.0 lb ae/A. Fifteen surviving giant ragweed plants were flagged in this strip. Flexstar at 1.0 pt/A plus MSO plus AMS was applied on July 10th to the remainder of the field. Giant ragweed were up to 24” in height at the time of application. On September 29, 2008, 33% of the newly flagged plants were controlled by glyphosate at 3.0 lb ae/A and 17% of the original flagged plants were controlled with the Flexstar application.

Based upon the results at the Hutchinson location, the giant ragweed appears to be resistant to glyphosate and FirstRate, an ALS-inhibiting herbicide. The level of glyphosate resistance appears to be quite high in this population based upon the poor control with glyphosate applied at 3.0 lb ae/A. Giant ragweed surviving a glyphosate application will be too large to effectively be controlled by an application of Flexstar or Cobra and likely will cause the selection of giant ragweed with resistance to PPO-inhibiting herbicides.

At the Hazel Run location, glyphosate was applied at 0.75 lb ae/A, 1.1 lb ae/A, and 3.0 lb ae/A to two 6.67 ft wide by 100 ft length strips in glyphosate-resistant corn on June 17, 2008. The giant ragweed at this location ranged from 0.5 to 9 inches in height at time of the application. At least 50 giant ragweed plants were flagged in each treatment prior to the initial application. Glyphosate was applied at 0.75 lb ae/A on July 3rd to the strips initially treated with 1.1 lb ae/A of glyphosate. Nothing additional was applied to the other treatments. Twelve surviving giant ragweed plants were flagged on July 3rd in the strips initially treated with glyphosate at 1.1 lb ae/A. On July 23rd, 13, 30, and 70% of the flagged giant ragweed plants were controlled by glyphosate at 0.75 lb ae/A, 1.1 lb ae/A followed by 0.75 lb ae/A, and 3.0 lb ae/A, respectively. On October 2nd, 68, 98, and 98% of the flagged giant ragweed plants were controlled by glyphosate at 0.75 lb ae/A, 1.1 lb ae/A followed by 0.75 lb ae/A, and 3.0 lb ae/A, respectively. However, only 58% of the July 3rd flagged giant ragweed plants were controlled by the 1.1 lb ae/A followed by 0.75 lb ae/A glyphosate treatment.

In conclusion, glyphosate-resistant giant ragweed exists within the Hazel Run population. The level of resistance in this population appears to be lower than the Hutchinson population.

In addition to these three research locations, three samples of giant ragweed, three samples of waterhemp, and two samples of common ragweed were collected from within the Southern Minnesota Beet Sugar Cooperative’s growing region. These additional samples are believed to be resistant to glyphosate at a minimum, but may also be resistant to other types of herbicides. Western McLeod, Northeastern Renville, and Southern Meeker Counties likely have the greatest frequency of glyphosate-resistant giant ragweed and waterhemp within the Cooperative’s growing region.

Careful attention to herbicide usage within the crop rotation will be necessary to reduce the selection of glyphosate- and multiple-resistant weed biotypes. The use of many herbicides with differing modes of action throughout the rotation will be necessary. Lengthening the rotation to sugarbeets and adding other crops in the rotation should assist in reducing the build-up of resistant weed biotypes. Maximizing glyphosate activity is essential to reducing the selection of glyphosate-resistant weed biotypes. The best way to maximize glyphosate activity is to apply a high labeled rate to small (<3”) annual weeds. The future success of glyphosate-resistant sugarbeets will depend upon proper management of glyphosate and other herbicides within the cropping rotation.

WEED CONTROL IN GLYPHOSATE-RESISTANT SUGARBEET IN 2008

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Weeds continue to be named as one of the most serious production problems by respondents to the annual survey of sugarbeet producers in Minnesota and eastern North Dakota. Glyphosate-resistant sugarbeets were commercially available for the first time in Minnesota and eastern North Dakota in 2008. Nearly 45% of the sugarbeet acres were planted to glyphosate-resistant sugarbeets in Minnesota and eastern North Dakota in 2008.

The major objectives of research in 2008 were to evaluate control of volunteer Roundup Ready® crops in Roundup Ready sugarbeets with various conventional sugarbeet herbicides and to evaluate weed control from glyphosate applied alone at various application timings, in combination with conventional sugarbeet herbicides, and in sequence with conventional sugarbeet herbicides. Roundup Ready sugarbeets were not planted in any plots in 2008 due to failed negotiations of a research agreement between the University and Monsanto, and the sugarbeet seed companies. With no planted crop, maximum weed pressure was obtained at most locations with multiple late weed flushes. Therefore weed control ratings are reduced, but provide very accurate results for season-long weed control.

The Roundup Ready Crop study was conducted at one location, near Prosper, ND. The weed control studies were conducted at Cavalier, Kindred, and Mayville, ND. The studies are presented separately with materials and methods and an experimental summary in the above order. Glyphosate-resistant common ragweed is present at the Mayville, ND location. There were almost no weeds present in the Roundup Ready Crop study.

Control of Roundup Ready crops in Roundup Ready sugarbeet, Prosper, 2008.

Roundup Ready sugarbeet was not planted in the study. Roundup Ready canola, soybean and corn were seeded in separate 8 foot wide strips across the herbicide plots on May 7th. All herbicide treatments were applied in 17 gpa water at 40 psi through 8002 nozzles to the center 6.67 feet of 11 foot wide plots on June 19th and July 1st. On June 19th, the air temperature was 74ºF, relative humidity was 39%, six inch soil temperature was 61ºF, wind was 4 mph, cloud cover was 5%, soil moisture was good, canola was 4 leaf to 16 inches tall, soybean was 3-6 inches tall and corn was 2-4 leaf (4-8 inches tall). On July 1st, the air temperature was 87ºF, relative humidity was 48%, six inch soil temperature was 80ºF, wind was 3 mph, cloud cover was 10%, soil moisture was good, canola was flowering, soybean was 4-10 inches tall and corn was 4-7 leaf (8-14 inches tall). Control of Roundup Ready canola, soybean and corn was evaluated on July 2nd, July 15th and July 20th. All evaluations are a visual estimate of percent fresh weight reduction in the treated plot compared to the adjacent untreated strips.

		July 2			July 15			July 20		
		Cano	Soyb	Corn	Cano	Soyb	Corn	Cano	Soyb	Corn
Treatment*	Rate	cntl	cntl	cntl	cntl	cntl	cntl	cntl	cntl	cntl
	(lb ai/A)	%	%	%	%	%	%	%	%	%
Glyt+AMS	1+2.5	0	0	0	0	0	0	0	0	0
Glyt+AMS+Tfsu	1+2.5+0.008	10	15	14	11	43	28	6	31	19
Glyt+AMS+Tfsu+P90	1+2.5+0.008+0.25%	23	23	45	24	58	65	14	39	55
Glyt+AMS+Tfsu+MSO	1+2.5+0.008+1.5%	48	56	80	40	81	81	25	74	69
Glyt+AMS+Tfsu+DestinyHC	1+2.5+0.008+1%	46	45	81	40	76	77	22	71	67
Glyt+AMS+Clpy	1+2.5+0.03	0	81	0	0	87	0	0	95	0
Glyt+AMS+Clpy	1+2.5+0.06	0	89	0	0	100	0	0	100	0
Glyt+AMS+Clpy+P90	1+2.5+0.03+0.25%	0	82	0	0	97	0	0	96	0
Glyt+AMS+Clpy+MSO	1+2.5+0.03+1.5%	3	82	0	1	97	0	0	97	0
Glyt+AMS+Clpy+DestinyHC	1+2.5+0.03+1%	0	82	0	0	97	0	0	99	0
Glyt+AMS+CletM	1+2.5+0.03	0	0	95	0	0	100	0	0	99
Glyt+AMS+CletM	1+2.5+0.06	0	0	98	0	0	100	0	0	96
Glyt+AMS+CletM+P90	1+2.5+0.03+0.25%	0	0	93	0	0	100	0	0	93
Glyt+AMS+CletM+MSO	1+2.5+0.03+1.5%	0	0	96	0	0	100	0	0	96
Glyt+AMS+CletM+DestinyHC	1+2.5+0.03+1%	0	0	95	0	0	100	0	0	96
Glyt+AMS+Quiz-T	1+2.5+0.03	0	0	99	0	0	100	0	0	100
Glyt+AMS+Quiz-T	1+2.5+0.06	0	0	100	0	0	100	0	0	94
Glyt+AMS+Quiz-T+P90	1+2.5+0.03+0.25%	0	0	98	0	0	100	0	0	93
Glyt+AMS+Clet	1+2.5+0.03	0	0	71	0	0	73	0	0	68
Glyt+AMS+Clet	1+2.5+0.06	0	0	94	0	0	100	0	0	97
Glyt+AMS+Clet+P90	1+2.5+0.03+0.25%	0	0	86	0	0	94	0	0	86
Glyt+AMS+De&Ph&Et+Tfsu	1+2.5+0.33+0.008	53	58	33	57	80	63	43	69	40
Glyt+AMS+De&Ph&Et+Tfsu+P90	1+2.5+0.33+0.008+0.25%	47	60	51	44	77	61	28	68	44
Glyt+AMS+De&Ph&Et+Tfsu+MSO	1+2.5+0.33+0.008+1.5%	61	67	75	60	83	81	46	76	67
Glyt+AMS+De&Ph&Et+Tfsu+DestinyHC	1+2.5+0.33+0.008+1%	59	70	70	53	84	75	48	79	60
Untreated Check	0	0	0	0	0	0	0	0	0	0
EXP MEAN		13	31	57	13	41	61	9	38	55
C.V. %		33	19	12	42	8	10	59	11	12
LSD 5%		6	8	10	7	4	8	7	6	9
LSD 1%		8	11	13	10	6	11	10	8	12
# OF REPS		4	4	4	4	4	4	4	4	4

*Glyt=Roundup WeatherMax formulation of glyphosate (1.0lbae/A=28floz/A); Tfsu=UpBeet; Clpy=Stinger; Quiz-T=Targa formulation of quizalofop; CletM=Select Max; Clet=Select formulation of clethodim; P90=Premier 90 non-ionic surfactant from West Central; MSO=methylated seed oil from Loveland; DestinyHC=methylated seed oil from Winfield; AMS=Am-Stik liquid ammonium sulfate from West Central; Cano=canola; Soyb=soybean.

Experiment continued on next page.

Summary: On July 2nd, after the first application, maximum control of all three crops was usually obtained from the addition of MSO with Tfsu (UpBeet) or De&Ph&Et (Progress) plus UpBeet. There was no difference with Stinger rates or adjuvants for control of soybean, although the highest rate provided the greatest control. Quiz-T (Targa) controlled the most corn. Rate and adjuvant was important for improving control of corn with Clet (Select 2EC).

On July 20th, 19 days after the last application, maximum control of canola was obtained with Progress (0.33 lb ai/A) plus UpBeet (0.008 lb ai/A) in combination with MSO, DestinyHC, or no additional adjuvant. The addition of NIS caused a reduction in canola control with this herbicide combination. There was no difference in soybean control based upon Stinger rates or adjuvants, although the highest rate of Stinger provided complete control. The addition of MSO and DestinyHC to UpBeet and Progress plus UpBeet maximized soybean control compared to NIS or no adjuvant, although not to the level of Stinger. There was no difference in control of corn with Targa, Select MAX, and the maximum rate of Select 2EC. However, corn control was reduced when NIS was included with the Select 2EC and further reduced if no adjuvant was included. UpBeet and Progress plus UpBeet in combination with MSO or DestinyHC maximized control of corn compared to NIS and no adjuvant, although not as effective as the ACCase inhibiting herbicides.

Sugarbeet weed control, Cavalier, 2008. Roundup Ready sugarbeets were not planted in the study. Soil was tilled and preemergence ethofumesate was applied May 1. Postemergence treatments were applied May 27, June 3, June 16, June 23 and June 30. All treatments were applied in 17 gpa water at 40 psi through 8002 nozzles to the center 6.67 feet of 11 foot wide plots. Powell amaranth/redroot pigweed, kochia, common lambsquarters, common mallow and pale smartweed control were evaluated July 13 and July 28. All evaluations are a visual estimate of percent fresh weight reduction in the treated plot compared to the adjacent untreated strips.

Date of Application	**May 1**	**May 27**	**June 3**	**June 16**	**June 23**	**June 30**
Time of Day	3:30 pm	1:30 pm	10:30 am	11:30 am	10:45 am	11:00 am
Air Temperature (^{o}F)	62	60	62	68	75	81
Relative Humidity (%)	10	12	27	41	35	40
Soil Temp. (^{o}F at 6″)	44	50	54	55	64	66
Wind Velocity (mph)	16	5	11	3	6	7
Cloud Cover (%)	60	5	95	0	80	50
Soil Moisture	Good	Good	Good	Good	Good	Good
Powell amaranth / Redroot Pigweed	PRE	Cot	Cot-2 leaf	Cot-6 leaf	2-8 leaf	4-10 leaf
Kochia	PRE	0.25-0.5″ diameter	0.25-1″ diameter	0.5″ diam. – 3″ tall	4-6 inches tall	10-14 inch. tall
Common Lambsquarters	PRE	Cot-2 leaf	2-8 leaf	2-5″ tall	4-8″ tall	12-16″
Common Mallow	PRE	Cot	Cot-2 leaf	2-6 leaf	4-8 leaf	4-8″ tall
Pale Smartweed	PRE	Cot	2-4 leaf	2-6 leaf	6-10 leaf	6-10″ tall

Summary: On July 13th, ethofumesate + glyphosate followed by glyphosate and Outlook and UpBeet combined with glyphosate improved control of Powell amaranth and redroot pigweed. On July 28th, Outlook and UpBeet combined with glyphosate still improved control of Powell amaranth and redroot pigweed. Glyphosate applied on June 3rd and June 30th provided the greatest control of kochia, common lambsquarters, common mallow, pale smartweed, and Powell amaranth and redroot pigweed. Two applications of conventional herbicides followed by glyphosate provided nearly the same control of kochia, common lambsquarters, common mallow, pale smartweed, and Powell amaranth and redroot pigweed. Glyphosate applied on June 3rd and June 30th controlled more Powell amaranth and redroot pigweed compared to three glyphosate applications because the larger weed biomass on June 3rd created a mulch layer that reduced germination of pigweed species. Glyphosate controlled more kochia and common mallow compared to conventional herbicides applied only.

Experiment continued on the next page.

Sugarbeet weed control, Cavalier, 2008. (Continued)

July 13 Evaluation

Treatment (Date of Application)	Rate	Poam Rrpw cntl	Kocz cntl	Colq cntl	Coma cntl	Pasw cntl
	(lb ai/A)	%	%	%	%	%
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 27, June 3, 16, 23)	0.08+0.004+0.03+0.03+1.5%	68	28	77	78	80
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 27)	0.12+0.004+0.03+0.03+1.5%					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 3, 16)	0.16+0.004+0.03+0.03+1.5%					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 23)	0.25+0.004+0.03+0.03+1.5%	73	38	89	84	86
De&Ph&Et+Tfsu+Clpy+CletM (May 27)	0.25+0.008+0.06+0.03					
De&Ph&Et+Tfsu+Clpy+CletM (June 3, 16)	0.33+0.008+0.06+0.03					
De&Ph&Et+Tfsu+Clpy+CletM (June 23)	0.5+0.008+0.06+0.03	91	69	99	79	95
Ethofumesate(PRE) (May 1)	3.75					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 27)	0.12+0.004+0.03+0.03+1.5%					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 3, 16)	0.16+0.004+0.03+0.03+1.5%					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 23)	0.25+0.004+0.03+0.03+1.5%	82	65	92	82	84
Glyphosate+AMS (May 27, June 16)	1+2.5	61	92	89	95	93
Glyphosate+AMS (May 27, June 23)	1+2.5	86	99	95	100	100
Glyphosate+AMS (June 3, 23)	1+2.5	86	100	96	98	100
Glyphosate+AMS (June 3, 30)	1+2.5	98	99	98	99	100
Glyphosate+AMS (May 27, June 16, 30)	1+2.5	95	100	99	99	100
Ethofumesate (POST)(May 27)	3.75	21	20	23	20	19
Etho+Glyt+AMS (May 27)	3.75+1+2.5					
Glyt+AMS (June 23)	1+2.5	90	99	99	97	98
Glyt+AMS (May 27)	1+2.5					
Glyt+AMS+Dime (June 16)	1+2.5+0.98	74	92	91	94	89
Glyt+AMS+Tfsu (June 3, 23)	1+2.5+0.008	94	99	98	98	99
Glyt+AMS+Clpy (June 3, 23)	1+2.5+0.06	85	98	99	98	99
Glyt+AMS (June 3)	1+2.5					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 23)	0.5+0.015+0.09+0.08+1.5%	69	72	87	85	94
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 3)	0.25+0.008+0.06+0.06+1.5%					
Glyt+AMS (June 23)	1+2.5	86	98	98	96	100
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 27)	0.16+0.008+0.06+0.06+1.5%					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 16)	0.25+0.008+0.06+0.06+1.5%					
Glyt+AMS (June 30)	1+2.5	96	98	98	99	100
Glyt+AMS (May 27, June 16)	1+2.5					
Glyt+AMS+Headline (June 30)	1+2.5+0.1	95	100	98	99	99
Glyt+AMS (May 27, June 16)	1+2.5					
Glyt+AMS+SuperTin (June 30)	1+2.5+0.25	95	100	99	97	100
EXP MEAN		81	82	91	89	91
C.V. %		3	5	5	5	5
LSD 5%		3	6	7	6	6
LSD 1%		4	8	9	8	8
# OF REPS		4	4	4	4	4

*Glyt=Roundup WeatherMAX; De&Ph&Et=Progress; Tfsu=UpBeet; Clpy=Stinger; CletM=Select Max; Etho=Nortron; Dime=Outlook; AMS=Am-Stik liquid ammonium sulfate from West Central; MSO=methylated seed oil from Loveland; Poam&Rrpw=Powell amaranth and redroot pigweed.

Experiment continued on the next page.

Sugarbeet weed control, Cavalier, 2008. (Continued)

July 28 Evaluation

Treatment (Date of Application)	Rate	Poam Rrpw cntl	Kocz cntl	Colq cntl	Coma cntl	Pasw cntl
	(lb ai/A)	%	%	%	%	%
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 27, June 3, 16, 23)	0.08+0.004+0.03+0.03+1.5%	44	21	61	68	84
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 27)	0.12+0.004+0.03+0.03+1.5%					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 3, 16)	0.16+0.004+0.03+0.03+1.5%					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 23)	0.25+0.004+0.03+0.03+1.5%	45	30	81	70	78
De&Ph&Et+Tfsu+Clpy+CletM (May 27)	0.25+0.008+0.06+0.03					
De&Ph&Et+Tfsu+Clpy+CletM (June 3, 16)	0.33+0.008+0.06+0.03					
De&Ph&Et+Tfsu+Clpy+CletM (June 23)	0.5+0.008+0.06+0.03	77	49	94	59	88
Ethofumesate(PRE) (May 1)	3.75					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 27)	0.12+0.004+0.03+0.03+1.5%					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 3, 16)	0.16+0.004+0.03+0.03+1.5%					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 23)	0.25+0.004+0.03+0.03+1.5%	59	44	91	54	86
Glyphosate+AMS (May 27, June 16)	1+2.5	28	81	81	90	87
Glyphosate+AMS (May 27, June 23)	1+2.5	62	91	89	95	95
Glyphosate+AMS (June 3, 23)	1+2.5	63	95	95	88	96
Glyphosate+AMS (June 3, 30)	1+2.5	85	95	94	94	93
Glyphosate+AMS (May 27, June 16, 30)	1+2.5	77	96	91	91	93
Ethofumesate (POST)(May 27)	3.75	15	16	18	19	13
Etho+Glyt+AMS (May 27)	3.75+1+2.5					
Glyt+AMS (June 23)	1+2.5	66	91	93	88	92
Glyt+AMS (May 27)	1+2.5					
Glyt+AMS+Dime (June 16)	1+2.5+0.98	48	78	86	86	86
Glyt+AMS+Tfsu (June 3, 23)	1+2.5+0.008	76	88	92	93	93
Glyt+AMS+Clpy (June 3, 23)	1+2.5+0.06	65	86	92	93	97
Glyt+AMS (June 3)	1+2.5					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 23)	0.5+0.015+0.09+0.08+1.5%	40	44	88	93	91
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 3)	0.25+0.008+0.06+0.06+1.5%					
Glyt+AMS (June 23)	1+2.5	67	88	91	92	97
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 27)	0.16+0.008+0.06+0.06+1.5%					
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 16)	0.25+0.008+0.06+0.06+1.5%					
Glyt+AMS (June 30)	1+2.5	85	94	93	96	97
Glyt+AMS (May 27, June 16)	1+2.5					
Glyt+AMS+Headline (June 30)	1+2.5+0.1	77	94	92	93	97
Glyt+AMS (May 27, June 16)	1+2.5					
Glyt+AMS+SuperTin (June 30)	1+2.5+0.25	78	95	94	91	97
EXP MEAN		61	72	85	82	87
C.V. %		8	10	8	8	7
LSD 5%		7	10	9	9	8
LSD 1%		9	14	12	13	11
# OF REPS		4	4	4	4	4

*Glyt=Roundup WeatherMAX; De&Ph&Et=Progress; Tfsu=UpBeet; Clpy=Stinger; CletM=Select Max; Etho=Nortron; Dime=Outlook; AMS=Am-Stik liquid ammonium sulfate from West Central; MSO=methylated seed oil from Loveland; Poam&Rrpw=Powell amaranth and redroot pigweed; Kocz=kochia; Colq=lambsquarters; Coma=common mallow; Pasw=pale smartweed.

Sugarbeet weed control, Kindred, 2008. Sugarbeets were not planted in this study. Soil was tilled and preemergence ethofumesate was applied May 8. Postemergence treatments were applied May 22, May 29, June 17, June 24 and July 1. All treatments were applied in 17 gpa water at 40 psi through 8002 nozzles to the center 6.67 feet of 11 foot wide plots. Ladysthumb, wild buckwheat and redroot pigweed were evaluated July 15 and July 29. All evaluations are a visual estimate of percent fresh weight reduction in the treated plot compared to the adjacent untreated strips.

Date of Application	**May 8**	**May 22**	**May 29**	**June 17**	**June 24**	**July 1**
Time of Day	10:00 am	12:15 pm	11:00 am	9:00 am	10:45 am	11:00 am
Air Temperature (^{o}F)	49	67	61	69	83	81
Relative Humidity (%)	24	24	50	40	42	40
Soil Temp. (^{o}F at 6”)	44	52	53	56	66	66
Wind Velocity (mph)	4	11	12	5	2	7
Cloud Cover (%)	100	10	100	0	0	50
Soil Moisture	Good	Good	Good	Good	Good	Good
Ladysthumb	PRE	Cot	Cot-1 leaf	Cot-6 leaf	2-8 leaf	2 leaf-5”
Wild Buckwheat	PRE	Cot-1 leaf	Cot-2 leaf	Cot-10 lf	4-12 leaf	Vining
Redroot Pigweed	PRE	Cot	Cot-1 leaf	Cot-6 leaf	2-8 leaf	4-10 leaf

Summary: Based upon the July 29th evaluation, Outlook, UpBeet, and Stinger combined with glyphosate improved ladysthumb control compared to glyphosate applied alone at the same application timings. UpBeet combined with glyphosate improved wild buckwheat control compared to glyphosate applied alone at the same application timings. Glyphosate applied three times provided the greatest (92%) wild buckwheat control. Ethofumesate applied POST with and without glyphosate and Outlook and Upbeet combined with glyphosate improved control of Powell amaranth and redroot pigweed (Rrpw) compared to glyphosate applied alone at the same application timings. Ethofumesate applied PRE and followed by the mid-rate of conventional sugarbeet herbicides controlled ladysthumb, wild buckwheat, Powell amaranth, and redroot pigweed similarly to glyphosate applied lastly on July 7th two and three times and greater than glyphosate applied on May 22nd followed by June 17th and May 29th followed by June 24th. Conventional sugarbeet herbicides applied on May 29th followed by glyphosate improved ladysthumb and wild buckwheat control compared to glyphosate applied at the same application timings.

Experiment continued on next page.

Sugarbeet weed control, Kindred, 2008. (Continued)

Treatment* (Date of Application)	Rate	July 15 Lath cntl	July 15 Wibw cntl	July 15 Rrpw cntl	July 29 Lath cntl	July 29 Wibw cntl	July 29 Rrpw cntl
	(lb ai/A)	%	%	%	%	%	%
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 22, 29, June 17, 24)	0.08+0.004+0.03+0.03+1.5%	63	79	38	62	63	39
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 22)	0.12+0.004+0.03+0.03+1.5%						
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 29, June 17)	0.16+0.004+0.03+0.03+1.5%						
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 24)	0.25+0.004+0.03+0.03+1.5%	67	88	44	67	72	41
De&Ph&Et+Tfsu+Clpy+CletM (May 22)	0.25+0.008+0.06+0.03						
De&Ph&Et+Tfsu+Clpy+CletM (May 29, June 17)	0.33+0.008+0.06+0.03						
De&Ph&Et+Tfsu+Clpy+CletM (June 24)	0.5+0.008+0.06+0.03	80	85	75	75	75	56
Ethofumesate(PRE) (May 8)	3.75						
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 22)	0.12+0.004+0.03+0.03+1.5%						
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 29, June 17)	0.16+0.004+0.03+0.03+1.5%						
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 24)	0.25+0.004+0.03+0.03+1.5%	94	95	90	90	89	87
Glyphosate+AMS (May 22, June 17)	1+2.5	77	79	38	75	75	28
Glyphosate+AMS (May 22, June 24)	1+2.5	75	73	66	82	75	48
Glyphosate+AMS (May 29, June 24)	1+2.5	74	88	56	72	70	53
Glyphosate+AMS (May 29, July 1)	1+2.5	86	80	96	94	88	92
Glyphosate+AMS (May 22, June 17, July 1)	1+2.5	97	95	85	91	92	73
Ethofumesate (POST)(May 22)	3.75	45	15	90	28	10	69
Etho+Glyt+AMS (May 22)	3.75+1+2.5						
Glyt+AMS (June 24)	1+2.5	87	76	83	86	69	66
Glyt+AMS (May 22)	1+2.5						
Glyt+AMS+Dime (June 17)	1+2.5+0.98	90	85	90	87	78	83
Glyt+AMS+Tfsu (May 29, June 24)	1+2.5+0.008	89	88	85	87	83	80
Glyt+AMS+Clpy (May 29, June 24)	1+2.5+0.06	83	92	64	82	76	39
Glyt+AMS (May 29)	1+2.5						
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 24)	0.5+0.015+0.09+0.08+1.5%	60	92	41	59	75	39
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 29)	0.25+0.008+0.06+0.06+1.5%						
Glyt+AMS (June 24)	1+2.5	86	86	70	84	82	56
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 22)	0.16+0.008+0.06+0.06+1.5%						
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 17)	0.25+0.008+0.06+0.06+1.5%						
Glyt+AMS (July 1)	1+2.5	89	81	93	90	83	81
Glyt+AMS (May 22, June 17)	1+2.5						
Glyt+AMS+Headline (July 1)	1+2.5+0.1	97	94	88	91	89	74
Glyt+AMS (May 22, June 17)	1+2.5						
Glyt+AMS+SuperTin (July 1)	1+2.5+0.25	98	96	96	96	95	95
EXP MEAN		81	82	73	79	76	63
C.V. %		8	7	12	8	11	19
LSD 5%		9	9	13	9	12	17
LSD 1%		12	11	17	12	16	23
# OF REPS		4	4	4	4	4	4

*Glyt=Roundup WeatherMAX; De&Ph&Et=Progress; Tfsu=UpBeet; Clpy=Stinger; CletM=Select Max; Etho=Nortron; Dime=Outlook; AMS=Am-Stik liquid ammonium sulfate from West Central; MSO=methylated seed oil from Loveland; Lath=ladysthumb; Wibw=wild buckwheat.

Sugarbeet weed control, Mayville, 2008. Roundup Ready sugarbeet was not planted in this study. Soil was tilled and preemergence ethofumesate was applied May 1st. Postemergence treatments were applied on June 4th, June 13th, June 20th, June 26th and July 3rd. All treatments were applied in 17 gpa water at 40 psi through 8002 nozzles to the center 6.67 feet of 11 foot wide plots. Glyphosate + AMS at 1.5 lb ae/A + 1.7 lbs/A was sprayed over the entire experiment on August 7th. Common ragweed and common lambsquarters were evaluated on June 20th, July 17th, July 30th and October 8th. Volunteer soybean was evaluated October 8th. All evaluations are a visual estimate of percent fresh weight reduction in the treated plot compared to the adjacent untreated strips.

Date of Application	**May 1**	**June 4**	**June 13**	**June 20**	**June 26**	**July 3**
Time of Day	10:30 am	12:45 pm	9:00 am	10:45 am	9:15 am	9:00 am
Air Temperature (°F)	50	65	61	76	76	67
Relative Humidity (%)	30	50	44	29	39	40
Soil Temp. (°F at 6”)	42	58	55	68	71	66
Wind Velocity (mph)	17	3	10	15	0	2
Cloud Cover (%)	100	100	60	0	95	30
Soil Moisture	Good	Good	Good	Good	Good	Good
Common Ragweed	---	Cot-4 leaf	Cot-8 leaf	4lf-3”tall	4lf-6”tall	6lf-8”tall
Common Lambsquarters	---	Cot-6 leaf	Cot-10 lf	6lf-3”tall	6lf-6”tall	6lf-8”tall

Summary: On June 20th, ethofumesate (3.75 lb ai/A) plus glyphosate improved control of common lambsquarters compared to a single application of glyphosate. As time progresses, common lambsquarters control declined with little advantage to adding ethofumesate to glyphosate. Full rates of conventional sugarbeet herbicides applied four times provided the same control as glyphosate applied lastly on July 3rd.

Based upon the July 30th evaluation, common ragweed was not controlled with glyphosate at this location even with three glyphosate applications. Therefore, glyphosate-resistant common ragweed biotypes exist within this common ragweed population. Glyphosate applied three times provided greater common ragweed control compared to two glyphosate applications, demonstrating glyphosate resistance is low-level. Ethofumesate plus glyphosate followed by glyphosate and glyphosate followed by glyphosate plus Outlook improved common ragweed control compared to glyphosate applied twice at the same times, although control was fair and poor, respectively. The number of applications and the rate of Stinger influenced common ragweed control. Stinger applied four times at 0.06 lb ae/A controlled all common ragweed while two applications of Stinger at 0.06 lb ae/A only controlled 90% of common ragweed. Single applications of Stinger even at high rates and two applications of Stinger at low rates controlled even fewer common ragweed.

On October 8th, common ragweed control was similar for all glyphosate treatments applied prior to July 4th, although still ineffectively controlled. This was due to an August 7th application of glyphosate at 1.5 lb ae/A as the common ragweed was beginning to flower. Only treatments including Stinger provided effective control of volunteer Roundup Ready soybeans at this location. Ethofumesate applied POST controlled 55% of volunteer Roundup Ready soybeans. Common lambsquarters control was the same for all treatments and nearly complete after the August 7th glyphosate application.

Experiment continued on next page.

Sugarbeet weed control, Mayville, 2008. (Continued)

Treatment*	(Date of Application)	Rate	June 20 Cora cntl	June 20 Colq cntl	July 17 Cora cntl	July 17 Colq cntl	July 30 Cora cntl	July 30 Colq cntl
		(lb ai/A)	%	%	%	%	%	%
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 4, 13, 20, 26)	0.08+0.004+0.03+0.03+1.5%	94	82	100	71	99	51
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 4)	0.12+0.004+0.03+0.03+1.5%						
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 13, 20)	0.16+0.004+0.03+0.03+1.5%						
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 26)	0.25+0.004+0.03+0.03+1.5%	97	95	100	91	96	78
De&Ph&Et+Tfsu+Clpy+CletM	(June 4)	0.25+0.008+0.06+0.03						
De&Ph&Et+Tfsu+Clpy+CletM	(June 13, 20)	0.33+0.008+0.06+0.03						
De&Ph&Et+Tfsu+Clpy+CletM	(June 26)	0.5+0.008+0.06+0.03	99	99	100	98	100	84
Ethofumesate(PRE)	(May 1)	3.75						
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 4)	0.12+0.004+0.03+0.03+1.5%						
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 13, 20)	0.16+0.004+0.03+0.03+1.5%						
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 26)	0.25+0.004+0.03+0.03+1.5%	98	93	98	95	96	74
Glyphosate+AMS	(June 4, 20)	1+2.5	87	89	51	89	34	74
Glyphosate+AMS	(June 4, 26)	1+2.5	89	89	75	94	53	74
Glyphosate+AMS	(June 13, 26)	1+2.5	73	98	65	89	51	69
Glyphosate+AMS	(June 13, July 3)	1+2.5	70	99	63	100	54	93
Glyphosate+AMS	(June 4, 20, July 3)	1+2.5	86	93	84	100	70	89
Ethofumesate (POST)	(June 4)	3.75	78	89	33	85	26	67
Etho+Glyt+AMS	(June 4)	3.75+1+2.5						
Glyt+AMS	(June 26)	1+2.5	96	100	84	95	70	85
Glyt+AMS	(June 4)	1+2.5						
Glyt+AMS+Dime	(June 20)	1+2.5+0.98	84	88	69	98	44	82
Glyt+AMS+Tfsu	(June 13, 26)	1+2.5+0.008	71	98	74	94	61	70
Glyt+AMS+Clpy	(June 13, 26)	1+2.5+0.06	81	100	98	94	90	71
Glyt+AMS	(June 13)	1+2.5						
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 26)	0.5+0.015+0.09+0.08+1.5%	76	100	89	95	78	81
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 13)	0.25+0.008+0.06+0.06+1.5%						
Glyt+AMS	(June 26)	1+2.5	89	82	95	88	81	71
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 4)	0.16+0.004+0.03+0.03+1.5%						
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 20)	0.25+0.004+0.03+0.03+1.5%						
Glyt+AMS	(July 3)	1+2.5	85	79	93	97	79	83
Glyt+AMS	(June 4, 20)	1+2.5						
Glyt+AMS+Headline	(July 3)	1+2.5+0.1	85	88	85	100	70	83
Glyt+AMS	(June 4, 20)	1+2.5						
Glyt+AMS+SuperTin	(July 3)	1+2.5+0.25	87	88	84	99	72	87
EXP MEAN			85	92	81	93	70	77
C.V. %			5	6	10	5	9	9
LSD 5%			6	7	12	7	9	10
LSD 1%			8	10	15	9	12	14
# OF REPS			4	4	4	4	4	4

*Glyt=Roundup WeatherMAX formulation of glyphosate (1.0 lb ae/A = 28 fl oz/A of WeatherMAX); De&Ph&Et=Progress formulation of desmedipham & phenmedipham & ethofumesate; Tfsu=UpBeet formulation of triflusulfuron; Clpy=Stinger formulation of clopyralid; CletM=Select Max formulation of clethodim; Etho=Nortron formulation of ethofumesate; Dime=Outlook formulation of dimethenamid-P; AMS=Am-Stik liquid ammonium sulfate from West Central; MSO=methylated seed oil from Loveland; Cora=common ragweed; Colq=lambsquarters.

Experiment continued on next page.

Sugarbeet weed control, Mayville, 2008. (Continued)

Treatment*	(Date of Application)	Rate	October 8 Soyb cntl	Cora cntl	Colq cntl
		(lb ai/A)	%	%	%
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 4, 13, 20, 26)	0.08+0.004+0.03+0.03+1.5%	96	98	99
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 4)	0.12+0.004+0.03+0.03+1.5%			
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 13, 20)	0.16+0.004+0.03+0.03+1.5%			
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 26)	0.25+0.004+0.03+0.03+1.5%	100	96	99
De&Ph&Et+Tfsu+Clpy+CletM	(June 4)	0.25+0.008+0.06+0.03			
De&Ph&Et+Tfsu+Clpy+CletM	(June 13, 20)	0.33+0.008+0.06+0.03			
De&Ph&Et+Tfsu+Clpy+CletM	(June 26)	0.5+0.008+0.06+0.03	96	98	97
Ethofumesate(PRE)	(May 1)	3.75			
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 4)	0.12+0.004+0.03+0.03+1.5%			
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 13, 20)	0.16+0.004+0.03+0.03+1.5%			
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 26)	0.25+0.004+0.03+0.03+1.5%	96	91	99
Glyphosate+AMS	(June 4, 20)	1+2.5	0	61	99
Glyphosate+AMS	(June 4, 26)	1+2.5	0	63	99
Glyphosate+AMS	(June 13, 26)	1+2.5	0	59	99
Glyphosate+AMS	(June 13, July 3)	1+2.5	0	60	99
Glyphosate+AMS	(June 4, 20, July 3)	1+2.5	0	59	99
Ethofumesate (POST)	(June 4)	3.75	55	55	99
Etho+Glyt+AMS	(June 4)	3.75+1+2.5			
Glyt+AMS	(June 26)	1+2.5	38	63	99
Glyt+AMS	(June 4)	1+2.5			
Glyt+AMS+Dime	(June 20)	1+2.5+0.98	0	56	99
Glyt+AMS+Tfsu	(June 13, 26)	1+2.5+0.008	0	58	99
Glyt+AMS+Clpy	(June 13, 26)	1+2.5+0.06	96	89	99
Glyt+AMS	(June 13)	1+2.5			
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 26)	0.5+0.015+0.09+0.08+1.5%	96	81	99
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 13)	0.25+0.008+0.06+0.06+1.5%			
Glyt+AMS	(June 26)	1+2.5	93	81	99
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 4)	0.16+0.004+0.03+0.03+1.5%			
De&Ph&Et+Tfsu+Clpy+CletM+MSO	(June 20)	0.25+0.004+0.03+0.03+1.5%			
Glyt+AMS	(July 3)	1+2.5	93	71	99
Glyt+AMS	(June 4, 20)	1+2.5			
Glyt+AMS+Headline	(July 3)	1+2.5+0.1	0	60	99
Glyt+AMS	(June 4, 20)	1+2.5			
Glyt+AMS+SuperTin	(July 3)	1+2.5+0.25	0	65	99
EXP MEAN			45	72	99
C.V. %			19	8	1
LSD 5%			12	8	NS
LSD 1%			16	10	NS
# OF REPS			4	4	4

*Glyt=Roundup WeatherMAX formulation of glyphosate (1.0 lb ae/A = 28 fl oz/A of WeatherMAX); De&Ph&Et=Progress formulation of desmedipham & phenmedipham & ethofumesate; Tfsu=UpBeet formulation of triflusulfuron; Clpy=Stinger formulation of clopyralid; CletM=Select Max formulation of clethodim; Etho=Nortron formulation of ethofumesate; Dime=Outlook formulation of dimethenamid-P; AMS=Am-Stik liquid ammonium sulfate from West Central; MSO=methylated seed oil from Loveland; Cora=common ragweed; Colq=lambsquarters.

SMBSC – Evaluation of Glyphosate and Conventional Herbicides for Weed Control and Sugarbeet Production Using Growth Stage Variables to Determine Application Timing

The following weed control research is a screening of herbicide applied alone and in combinations for the control of various weeds.

Methods

Weed control trials were established at three locations; Milan, Sacred Heart and Hector, MN. Experiments were established in a randomized complete block design with 4 replications. Roundup Ready® sugarbeet variety Beta 95RR03 was planted at all locations to seed spacing of 4 inches. Treatments were applied to the center four rows of six rows, 35 foot long plots with 14 gallon of spray mix per acre using 8001 flat fan nozzles. The criteria for application timing were crop stage, weed stage and Growing Degrees Days (GDD). The GDD was calculated using SMBSC weather station data and applying 34^{o} as base for the calculation. Herbicide treatments were evaluated for sugarbeet injury and weed control efficacy at 14 and 30 days after the last treatment application. Sugarbeets were harvested to determine the treatment and weed control effect on sugarbeet production. Data was analyzed for homogeneity for combinability and was determined that the data could not be combined across locations. The data will be presented and results discussed separately for each location. The Amaranthus species are discussed in this report as a grouped. The Amaranthus species present at all locations researched in 2008 were redroot pigweed, smooth pigweed, tall waterhemp and palmer amaranth.

Table 1. Description of relative application timing

•Planting dates:

Sacred Heart	*5-May*
Milan	*5-May*
Hector	*8-May*

•Application timing by location and dates

	GDD 200 GDD	Weed size first 2 inch	GDD 400 GDD	Weed size second 2 inch	Weed size third 2 inch
S. Heart	22-May	*31-May*	*31-May*	*17-Jun*	*30-Jun*
Milan	*23-May*	*31-May*	*31-May*	*16-Jun*	*1-Jul*
Hector	*2-Jun*	11-Jun	*11-Jun*	*25-Jun*	*8-Jul*

Results and Discussion

Herbicide treatments will be discussed as conventional and Roundup treatments. Conventional treatments include non-glyphosate containing herbicides. The conventional treatments will be referred by their chemical name or as a conventional treatment. Roundup treatments were applied with Roundup PowerMax which is a 4.5 lb. a.e. glyphosate containing herbicide.

Milan, Mn location

1. Velvet leaf, water weed and Amaranthus species pressure was heavy in the testing area. Lambsquarter pressure was moderately heavy.
2. Sugarbeet injury tended to be greater with conventional herbicides versus Roundup treatments.
3. Upbeet herbicide was needed with the conventional herbicide treatment to achieve adequate velvetleaf control.
4. Roundup treatments which were initiated at the 2 inch height stage of velvet leaf and applied twice at this timing gave significantly less velvet leaf control than when treatments were applied at the 2 inch height stage and then repeated at the 4 inch height stage of velvet leaf. The application at the 4 inch height stage of the velvet leaf was important in the early control of velvet leaf.
5. Due to the early and rapid growth and continued emergence over time of velvet leaf an application at the 200 GDD and delaying the second application until an additional 400 GDD was achieved gave the best early season control.
6. An important factor in the control of the velvet leaf at the early stage of growth was the timing of the second application, the multiple applications made thereafter or the delay in velvet leaf growth after the initial application. The later was observed when Outlook was applied with Roundup or Nortron was applied preemergence with conventional herbicides.
7. Roundup treatment gave higher velvet leaf control in general or season long when an application was conducted at the canopy sugarbeet stage or multiple application of Roundup were conducted.

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8. Conventional herbicide control of smartweed was higher at 14 DAT compared to 30 DAT.
9. Smartweed control was greater when Roundup was applied at the 4 inch versus the 2 inch height of smartweed or 400 GDD versus 200 GDD. An application of Roundup at the 4 inch smartweed height whether as a single or as multiple applications.
10. An application at the sugarbeet canopy stage or multiple applications at timely smartweed heights solidified the season long control of smartweed.
11. Control of smartweed was significantly increased by Outlook when applied with Roundup at 200 GDD compared to roundup applied at 200 GDD without Outlook.

12. Conventional herbicide control of Amaranthus species was higher at 14 DAT compared to 30 DAT.
13. Amaranthus species control 14 DAT with Roundup applied two times at 200 GDD or two times at the 2 inch Amaranthus species height was significantly less than when 4 inch height stage of Amaranthus species or 400 GDD applications were made in the spray program.
14. Roundup applied at the sugarbeet canopy stage solidified long season control of Amaranthus species.
15. Multiple application of Roundup at various Amaranthus species heights gave good control at 14 DAT and 30 DAT.
16. Application of Roundup multiple times during sugarbeet growing season or at taller weeds heights up to 6 inches gave long season control.

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17. Conventional herbicides gave very good control of lambsquarter at 14 DAT but were significantly lower at 30 DAT.
18. All treatments containing Roundup gave very good control 14 DAT.
19. The only Roundup treatment that gave significantly lower lambsquarter control at 30 DAT compared to 14 DAT was a treatment that did not include an application at sugarbeet canopy stage.

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20. Sugarbeet production (table 7) was maximized when Roundup was applied at timings of 200 GDD and 400 GDD and sugarbeet canopy.
21. The greatest treatment advantage occurred with tons per acre. The change in extractable sugar per acre and revenue per acre was primarily due to the difference in tons per acre for each treatment
22. Treatment giving poor control early in the sugarbeet growth also gave lower sugarbeet growth and revenue per acre.

Table 2. Herbicide program influence on sugarbeet injury
Exp # 0831
Milan, Mn

Trt #	Herbicide treatments	Rate oz/acre	appl. Criteria	Sugarbeet injury 14 DAT	Sugarbeet injury 30 DAT	Sugarbeet injury average.
1	Progress+Upbeet+Stinger+MSO Progress+Upbeet+Stinger+MSO (2X)	8.5+0.125+1.3+1.5%: 11.5+0.125+1.3+1.5%:	cotyledon weed 200 GDD	20	0	10
2	Progress+Upbeet+Stinger+Nortron+MSO Progress+Upbeet+Stinger+Nortron+MSO (2X)	8.5+0.125+1.3+4+1.5%: 11.5+0.125+1.3+4+1.5%:	cotyledon weed 200 GDD	9	0	4
3	Nortron (pre) Progress+Upbeet+Stinger+Nortron+MSO (2X)	120 5.7+0.125+1.3+4+1.5%:	Sbeet emergence 200 GDD	25	0	13
4	Nortron (pre) Progress+Nortron Progress+Nortron+Outlook	120 16+4 22+4+21	Sbeet emergence 200 GDD 200 GDD	33	0	16
5	Roundup PowerMax+AMS (2X) Roundup PowerMax+AMS	22+2% 22+2%	2 inch weeds canopy	4	0	2
6	Roundup PowerMax+AMS (2X) Roundup PowerMax+AMS	22+2% 22+2%	200 GDD canopy	20	0	10
7	Roundup PowerMax+AMS+Outlook Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2%+18 22+2% 22+2%	2 inch weeds 2 inch weeds canopy	13	0	6
8	Roundup PowerMax+AMS+Outlook Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2%+18 22+2% 22+2%	200 GDD 200 GDD canopy	9	0	5
9	Roundup PowerMax+AMS Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2%+ 22+2% 22+2%	2 inch weeds 4 inch weeds canopy	4	0	2
10	Nortron (pre) Roundup PowerMax+AMS Roundup PowerMax+AMS	120 22+2% 22+2%	 4 inch weeds canopy	6	0	3
11	Roundup PowerMax+AMS Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2% 22+2% 22+2%	200 GDD 400 GDD canopy	4	0	2
12	Roundup PowerMax+AMS (2X) Roundup PowerMax+AMS	22+2% 22+2%	400 GDD canopy	0	0	0
13	Roundup PowerMax+AMS (2X) Roundup PowerMax+AMS	22+2% 22+2%	200 GDD canopy	8	0	4
14	Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2% 22+2%	200 GDD canopy	5	0	3
15	Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2% 22+2%	200 GDD 400 GDD	3	0	1
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	1	0	1
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds	4	0	2
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	4	0	2
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	6	0	3
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	9	0	4
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	8	0	4
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	13	0	6
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	5	0	3
			CV%	29	0	29
			LSD	5	0	3

Table 3. Herbicide program influence on velvetleaf control
Exp # 0831
Milan, Mn

Trt #	Herbicide treatments	Rate oz/acre	appl. Criteria	Velvet leaf control 14 DAT	30 DAT	average.
1	Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyledon weed	87	53	70
	Progress+Upbeet+Stinger+MSO (2X)	11.5+0.125+1.3+1.5%:	200 GDD			
2	Progress+Upbeet+Stinger+Nortron+MSO	8.5+0.125+1.3+4+1.5%:	cotyledon weed	87	60	74
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	11.5+0.125+1.3+4+1.5%:	200 GDD			
3	Nortron (pre)	120	Sbeet emergence	66	23	44
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	5.7+0.125+1.3+4+1.5%:	200 GDD			
4	Nortron (pre)	120	Sbeet emergence	59	10	34
	Progress+Nortron	16+4	200 GDD			
	Progress+Nortron+Outlook	22+4+21	200 GDD			
5	Roundup PowerMax+AMS (2X)	22+2%	2 inch weeds	50	99	75
	Roundup PowerMax+AMS	22+2%	canopy			
6	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	24	99	61
	Roundup PowerMax+AMS	22+2%	canopy			
7	Roundup PowerMax+AMS+Outlook	22+2%+18	2 inch weeds			
	Roundup PowerMax+AMS	22+2%	2 inch weeds	64	99	81
	Roundup PowerMax+AMS	22+2%	canopy			
8	Roundup PowerMax+AMS+Outlook	22+2%+18	200 GDD	66	99	83
	Roundup PowerMax+AMS	22+2%	200 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
9	Roundup PowerMax+AMS	22+2%+	2 inch weeds	49	99	74
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
10	Nortron (pre)	120		91	99	95
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
11	Roundup PowerMax+AMS	22+2%	200 GDD	90	99	94
	Roundup PowerMax+AMS	22+2%	400 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
12	Roundup PowerMax+AMS (2X)	22+2%	400 GDD	93	99	96
	Roundup PowerMax+AMS	22+2%	canopy			
13	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	49	99	74
	Roundup PowerMax+AMS	22+2%	canopy			
14	Roundup PowerMax+AMS	22+2%	200 GDD	26	99	63
	Roundup PowerMax+AMS	22+2%	canopy			
15	Roundup PowerMax+AMS	22+2%	200 GDD	88	54	71
	Roundup PowerMax+AMS	22+2%	400 GDD			
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	89	99	94
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds			
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	88	97	92
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	97	99	98
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	86	99	92
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	93	99	96
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	86	96	91
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	95	99	97
			CV%	8	6	5
			LSD	6	5	4

Table 4. Herbicide program influence on smartweed control

Exp # 0831

Milan, Mn

Trt #	Herbicide treatments	Rate oz/acre	appl. Criteria	Smart weed control 14 DAT	30 DAT	average.
1	Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyledon weed	95	51	73
	Progress+Upbeet+Stinger+MSO (2X)	11.5+0.125+1.3+1.5%:	200 GDD			
2	Progress+Upbeet+Stinger+Nortron+MSO	8.5+0.125+1.3+4+1.5%:	cotyledon weed	95	85	90
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	11.5+0.125+1.3+4+1.5%:	200 GDD			
3	Nortron (pre)	120	Sbeet emergence	94	80	87
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	5.7+0.125+1.3+4+1.5%:	200 GDD			
4	Nortron (pre)	120	Sbeet emergence	95	70	82
	Progress+Nortron	16+4	200 GDD			
	Progress+Nortron+Outlook	22+4+21	200 GDD			
5	Roundup PowerMax+AMS (2X)	22+2%	2 inch weeds	83	97	90
	Roundup PowerMax+AMS	22+2%	canopy			
6	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	45	98	72
	Roundup PowerMax+AMS	22+2%	canopy			
7	Roundup PowerMax+AMS+Outlook	22+2%+18	2 inch weeds	87	99	93
	Roundup PowerMax+AMS	22+2%	2 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
8	Roundup PowerMax+AMS+Outlook	22+2%+18	200 GDD	85	99	92
	Roundup PowerMax+AMS	22+2%	200 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
9	Roundup PowerMax+AMS	22+2%+	2 inch weeds	91	99	95
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
10	Roundup PowerMax+AMS	22+2%	4 inch weeds	97	99	98
	Roundup PowerMax+AMS	22+2%	canopy			
11	Roundup PowerMax+AMS	22+2%	200 GDD	93	99	96
	Roundup PowerMax+AMS	22+2%	400 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
12	Roundup PowerMax+AMS (2X)	22+2%	400 GDD	99	99	99
	Roundup PowerMax+AMS	22+2%	canopy			
13	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	65	98	82
	Roundup PowerMax+AMS	22+2%	canopy			
14	Roundup PowerMax+AMS	22+2%	200 GDD	30	98	64
	Roundup PowerMax+AMS	22+2%	canopy			
15	Roundup PowerMax+AMS	22+2%	200 GDD	94	69	81
	Roundup PowerMax+AMS	22+2%	400 GDD			
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	96	99	98
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds	97	99	98
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	91	91	91
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	95	99	97
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	91	99	95
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	94	99	96
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	93	94	93
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	97	97	97
			CV%	8	8	6
			LSD	7	7	6

Table 5. Herbicide program influence on amaranthus speciecis control

Exp # 0831

Milan, Mn

Trt #	Herbicide treatments	Rate oz/acre	appl. Criteria	Amaranrhus species control 14 DAT	30 DAT	average.
1	Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyledon weed	90	41	65
	Progress+Upbeet+Stinger+MSO (2X)	11.5+0.125+1.3+1.5%:	200 GDD			
2	Progress+Upbeet+Stinger+Nortron+MSO	8.5+0.125+1.3+4+1.5%:	cotyledon weed	93	75	84
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	11.5+0.125+1.3+4+1.5%:	200 GDD			
3	Nortron (pre)	120	Sbeet emergence	99	88	94
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	5.7+0.125+1.3+4+1.5%:	200 GDD			
4	Nortron (pre)	120	Sbeet emergence	99	73	86
	Progress+Nortron	16+4	200 GDD			
	Progress+Nortron+Outlook	22+4+21	200 GDD			
5	Roundup PowerMax+AMS (2X)	22+2%	2 inch weeds	67	99	83
	Roundup PowerMax+AMS	22+2%	canopy			
6	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	50	99	75
	Roundup PowerMax+AMS	22+2%	canopy			
7	Roundup PowerMax+AMS+Outlook	22+2%+18	2 inch weeds	98	99	98
	Roundup PowerMax+AMS	22+2%	2 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
8	Roundup PowerMax+AMS+Outlook	22+2%+18	200 GDD	96	99	97
	Roundup PowerMax+AMS	22+2%	200 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
9	Roundup PowerMax+AMS	22+2%+	2 inch weeds	56	99	78
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
10	Nortron (pre)	120		99	99	99
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
11	Roundup PowerMax+AMS	22+2%	200 GDD	92	99	96
	Roundup PowerMax+AMS	22+2%	400 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
12	Roundup PowerMax+AMS (2X)	22+2%	400 GDD	99	99	99
	Roundup PowerMax+AMS	22+2%	canopy			
13	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	56	99	78
	Roundup PowerMax+AMS	22+2%	canopy			
14	Roundup PowerMax+AMS	22+2%	200 GDD	36	99	68
	Roundup PowerMax+AMS	22+2%	canopy			
15	Roundup PowerMax+AMS	22+2%	200 GDD	92	69	81
	Roundup PowerMax+AMS	22+2%	400 GDD			
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	95	99	97
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds	99	99	99
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	91	99	95
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	99	99	99
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	92	99	96
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	99	99	99
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	93	99	96
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	98	99	99
			CV%	8	7	6
			LSD	7	7	5

Table 6. Herbicide program influence on lambsquarters control

Exp # 0831

Milan, Mn

Trt #	Herbicide treatments	Rate oz/acre	appl. Criteria	Lambsquarters control 14 DAT	30 DAT	average.
1	Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyledon weed	98	58	78
	Progress+Upbeet+Stinger+MSO (2X)	11.5+0.125+1.3+1.5%:	200 GDD			
2	Progress+Upbeet+Stinger+Nortron+MSO	8.5+0.125+1.3+4+1.5%:	cotyledon weed	98	79	88
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	11.5+0.125+1.3+4+1.5%:	200 GDD			
3	Nortron (pre)	120	Sbeet emergence	99	91	95
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	5.7+0.125+1.3+4+1.5%:	200 GDD			
4	Nortron (pre)	120	Sbeet emergence	99	87	93
	Progress+Nortron	16+4	200 GDD			
	Progress+Nortron+Outlook	22+4+21	200 GDD			
5	Roundup PowerMax+AMS (2X)	22+2%	2 inch weeds	96	99	98
	Roundup PowerMax+AMS	22+2%	canopy			
6	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	99	99	99
	Roundup PowerMax+AMS	22+2%	canopy			
7	Roundup PowerMax+AMS+Outlook	22+2%+18	2 inch weeds	99	99	99
	Roundup PowerMax+AMS	22+2%	2 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
8	Roundup PowerMax+AMS+Outlook	22+2%+18	200 GDD	99	99	99
	Roundup PowerMax+AMS	22+2%	200 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
9	Roundup PowerMax+AMS	22+2%+	2 inch weeds	99	99	99
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
10	Roundup PowerMax+AMS	22+2%	4 inch weeds	99	99	99
	Roundup PowerMax+AMS	22+2%	canopy			
11	Roundup PowerMax+AMS	22+2%	200 GDD	99	99	99
	Roundup PowerMax+AMS	22+2%	400 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
12	Roundup PowerMax+AMS (2X)	22+2%	400 GDD	99	99	99
	Roundup PowerMax+AMS	22+2%	canopy			
13	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	99	99	99
	Roundup PowerMax+AMS	22+2%	canopy			
14	Roundup PowerMax+AMS	22+2%	200 GDD	99	99	99
	Roundup PowerMax+AMS	22+2%	canopy			
15	Roundup PowerMax+AMS	22+2%	200 GDD	99	83	91
	Roundup PowerMax+AMS	22+2%	400 GDD			
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	99	99	99
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds	99	99	99
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	99	99	99
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	99	99	99
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	99	99	99
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	99	99	99
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	99	99	99
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	99	99	99
			CV%	5	9	6
			LSD	1	5	3

Table 7. Herbicide program influence on sugarbeet production

Exp # 0831

Milan, Mn

Trt #	Herbicide treatments	Rate oz/acre	appl. Criteria	Tons per acre	Ext. Suc. per ton	Ext. Suc. per acre	Revenue per acre
1	Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyledon weed	19.2	238	4570	482.24
	Progress+Upbeet+Stinger+MSO (2X)	11.5+0.125+1.3+1.5%:	200 GDD				
2	Progress+Upbeet+Stinger+Nortron+MSO	8.5+0.125+1.3+4+1.5%:	cotyledon weed	27.3	235	6413	664.73
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	11.5+0.125+1.3+4+1.5%:	200 GDD				
3	Nortron (pre)	120	Sbeet emergence	25.9	235	6089	632.44
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	5.7+0.125+1.3+4+1.5%:	200 GDD				
4	Nortron (pre)	120	Sbeet emergence	19.1	229	4362	439.16
	Progress+Nortron	16+4	200 GDD				
	Progress+Nortron+Outlook	22+4+21	200 GDD				
5	Roundup PowerMax+AMS (2X)	22+2%	2 inch weeds	28.5	242	6888	738.55
	Roundup PowerMax+AMS	22+2%	canopy				
6	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	28.1	245	6894	749.53
	Roundup PowerMax+AMS	22+2%	canopy				
7	Roundup PowerMax+AMS+Outlook	22+2%+18	2 inch weeds	25.6	240	6137	650.73
	Roundup PowerMax+AMS	22+2%	2 inch weeds				
	Roundup PowerMax+AMS	22+2%	canopy				
8	Roundup PowerMax+AMS+Outlook	22+2%+18	200 GDD	27.9	237	6605	691.60
	Roundup PowerMax+AMS	22+2%	200 GDD				
	Roundup PowerMax+AMS	22+2%	canopy				
9	Roundup PowerMax+AMS	22+2%+	2 inch weeds	24.9	248	6165	676.50
	Roundup PowerMax+AMS	22+2%	4 inch weeds				
	Roundup PowerMax+AMS	22+2%	canopy				
10	Nortron (pre)	120		23.5	237	5578	585.71
	Roundup PowerMax+AMS	22+2%	4 inch weeds				
	Roundup PowerMax+AMS	22+2%	canopy				
11	Roundup PowerMax+AMS	22+2%	200 GDD	31.6	250	7900	874.92
	Roundup PowerMax+AMS	22+2%	400 GDD				
	Roundup PowerMax+AMS	22+2%	canopy				
12	Roundup PowerMax+AMS (2X)	22+2%	400 GDD	24	248	5952	654.01
	Roundup PowerMax+AMS	22+2%	canopy				
13	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	23.8	247	5879	643.36
	Roundup PowerMax+AMS	22+2%	canopy				
14	Roundup PowerMax+AMS	22+2%	200 GDD	24.9	256	6374	722.29
	Roundup PowerMax+AMS	22+2%	canopy				
15	Roundup PowerMax+AMS	22+2%	200 GDD	24.6	251	6175	686.48
	Roundup PowerMax+AMS	22+2%	400 GDD				
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	25.9	245	6343	687.55
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds	25.0	246	6150	670.33
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	24.8	237	5864	613.60
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	25.0	240	6000	638.37
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	26.3	243	6390	686.57
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	25.4	293	7441	941.66
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	28.4	238	6766	712.89
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	26.6	247	6580	720.60
			CV%	14	5	14	16
			LSD	3.4	11	865	106.60

Sacred Heart, Mn Location

1. Sugarbeet injury was low regardless of the treatment at this location. Conventional herbicides either did or tended to give significantly higher sugarbeet injury than the Roundup treatments at 14 DAT. However, at 30 DAT the sugarbeet injury was statistically similar regardless of the herbicide treatment.
2. Multiple applications of Roundup at various heights of lambsquarter, gave the highest lambsquarter control at 14 DAT.
3. All Roundup treatments gave lambsquarter control of 90% percent or greater at 30 DAT, except when Roundup was applied two times when lambsquarter was 2 inches tall or at the 200 GDD timing and at the sugarbeet canopy stage. Outlook added to Roundup treatment applied two times when lambsquarter was 2 inches tall or at the 200 GDD timing significantly increased lambsquarter control.
4. Outlook applied with Roundup or Nortron applied preemergence gave significantly greater lambsquarter control compare to similar treatments without Outlook or Nortron in the spray program.

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5. Conventional herbicides gave 88% Amaranthus species control or greater at 14 DAT. Amaranthus species control lowered significantly when Nortron applied preemergence was not part of the spray program
6. Outlook applied postemergence with Roundup or Nortron applied preemergence to Roundup applications significantly increased control of Amaranthus species at 14 DAT.
7. Roundup applied multiple times to 4 or 6 inch tall Amaranthus species gave higher control than when Roundup was applied to Amaranthus species at 1 or 2 inch height. Later application increased control of Amaranthus species was probably due to emergence of Amaranthus species not emerged when the 1 and 2 inch height application were done.
8. Application of Roundup at the sugarbeet canopy stage gave significantly greater Amaranthus control than when there was no sugarbeet canopy application

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9. Sugarbeet production was relative to weed control at the various evaluation timings.
10. Outlook applied postemergence with Roundup increased weed control compared to similar treatments applied without Outlook.
11. All roundup treatments with applications at the sugarbeet canopy gave high weed control and there was a low variability at 30 DAT, but tons per acre was variable between treatments and the variability related into variable revenue per acre.

Table 8. Herbicide program influence on sugarbeet injury
Exp # 0833
Sacred Heart, Mn

				Sugarbeet injury		
Trt #	**Herbicide treatments**	**Rate oz/acre**	**appl. Criteria**	14 DAT	30 DAT	average.
1	Progress+Upbeet+Stinger+MSO Progress+Upbeet+Stinger+MSO (2X)	8.5+0.125+1.3+1.5%: 11.5+0.125+1.3+1.5%:	cotyledon weed 200 GDD	5	1	3.1
2	Progress+Upbeet+Stinger+Nortron+MSO Progress+Upbeet+Stinger+Nortron+MSO (2X)	8.5+0.125+1.3+4+1.5%: 11.5+0.125+1.3+4+1.5%:	cotyledon weed 200 GDD	8	0	3.8
3	Nortron (pre) Progress+Upbeet+Stinger+Nortron+MSO (2X)	120 5.7+0.125+1.3+4+1.5%:	Sbeet emergence 200 GDD	1	0	0.6
4	Nortron (pre) Progress+Nortron Progress+Nortron+Outlook	120 16+4 22+4+21	Sbeet emergence 200 GDD 200 GDD	0	1	0.6
5	Roundup PowerMax+AMS (2X) Roundup PowerMax+AMS	22+2% 22+2%	2 inch weeds canopy	0	1	0.6
6	Roundup PowerMax+AMS (2X) Roundup PowerMax+AMS	22+2% 22+2%	200 GDD canopy	0	0	0.0
7	Roundup PowerMax+AMS+Outlook Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2%+18 22+2% 22+2%	2 inch weeds 2 inch weeds canopy	0	1	0.6
8	Roundup PowerMax+AMS+Outlook Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2%+18 22+2% 22+2%	200 GDD 200 GDD canopy	0	3	1.3
9	Roundup PowerMax+AMS Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2%+ 22+2% 22+2%	2 inch weeds 4 inch weeds canopy	0	2	0.9
10	Nortron (pre) Roundup PowerMax+AMS Roundup PowerMax+AMS	120 22+2% 22+2%	 4 inch weeds canopy	0	0	0.0
11	Roundup PowerMax+AMS Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2% 22+2% 22+2%	200 GDD 400 GDD canopy	0	3	1.5
12	Roundup PowerMax+AMS (2X) Roundup PowerMax+AMS	22+2% 22+2%	400 GDD canopy	0	0	0.0
13	Roundup PowerMax+AMS (2X) Roundup PowerMax+AMS	22+2% 22+2%	200 GDD canopy	0	1	0.6
14	Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2% 22+2%	200 GDD canopy	0	3	1.3
15	Roundup PowerMax+AMS Roundup PowerMax+AMS	22+2% 22+2%	200 GDD 400 GDD	0	1	0.6
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	0	3	1.3
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds	0	0	0.0
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	0	2	0.9
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	0	1	0.6
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	0	3	1.3
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	0	3	1.3
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	0	0	0.0
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	0	3	1.3
			C.V. %	31	19	15
			LSD	3	4	2

Table 9. Herbicide program influence on lambsquarters control
Exp # 0833
Sacred Heart, Mn

Trt #	Herbicide treatments	Rate oz/acre	appl. Criteria	Lambsquarter control 14 DAT	30 DAT	average.
1	Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyledon weed	95	86	90
	Progress+Upbeet+Stinger+MSO (2X)	11.5+0.125+1.3+1.5%:	200 GDD			
2	Progress+Upbeet+Stinger+Nortron+MSO	8.5+0.125+1.3+4+1.5%:	cotyledon weed	98	69	84
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	11.5+0.125+1.3+4+1.5%:	200 GDD			
3	Nortron (pre)	120	Sbeet emergence	85	82	83
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	5.7+0.125+1.3+4+1.5%:	200 GDD			
4	Nortron (pre)	120	Sbeet emergence	89	84	87
	Progress+Nortron	16+4	200 GDD			
	Progress+Nortron+Outlook	22+4+21	200 GDD			
5	Roundup PowerMax+AMS (2X)	22+2%	2 inch weeds	92	79	86
	Roundup PowerMax+AMS	22+2%	canopy			
6	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	91	94	93
	Roundup PowerMax+AMS	22+2%	canopy			
7	Roundup PowerMax+AMS+Outlook	22+2%+18	2 inch weeds	95	99	97
	Roundup PowerMax+AMS	22+2%	2 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
8	Roundup PowerMax+AMS+Outlook	22+2%+18	200 GDD	98	98	98
	Roundup PowerMax+AMS	22+2%	200 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
9	Roundup PowerMax+AMS	22+2%+	2 inch weeds	94	99	96
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
10	Nortron (pre)	120		97	98	97
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
11	Roundup PowerMax+AMS	22+2%	200 GDD	87	98	92
	Roundup PowerMax+AMS	22+2%	400 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
12	Roundup PowerMax+AMS (2X)	22+2%	400 GDD	85	98	92
	Roundup PowerMax+AMS	22+2%	canopy			
13	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	88	98	93
	Roundup PowerMax+AMS	22+2%	canopy			
14	Roundup PowerMax+AMS	22+2%	200 GDD	83	98	90
	Roundup PowerMax+AMS	22+2%	canopy			
15	Roundup PowerMax+AMS	22+2%	200 GDD	98	91	94
	Roundup PowerMax+AMS	22+2%	400 GDD			
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	96	98	97
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds	88	98	93
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	99	95	97
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	97	98	97
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	99	98	98
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	91	98	94
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	99	97	98
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	99	96	98
			C.V. %	5	12	7
			LSD	7	16	9

Table 10. Herbicide program influence on amaranthus speciecis control
Exp # 0833
Sacred Heart, Mn

Trt #	Herbicide treatments	Rate oz/acre	appl. Criteria	amaranthus species control 14 DAT	30 DAT	average.
1	Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyledon weed	89	68	78
	Progress+Upbeet+Stinger+MSO (2X)	11.5+0.125+1.3+1.5%:	200 GDD			
2	Progress+Upbeet+Stinger+Nortron+MSO	8.5+0.125+1.3+4+1.5%:	cotyledon weed	95	62	78
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	11.5+0.125+1.3+4+1.5%:	200 GDD			
3	Nortron (pre)	120	Sbeet emergence	88	92	90
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	5.7+0.125+1.3+4+1.5%:	200 GDD			
4	Nortron (pre)	120	Sbeet emergence	96	95	95
	Progress+Nortron	16+4	200 GDD			
	Progress+Nortron+Outlook	22+4+21	200 GDD			
5	Roundup PowerMax+AMS (2X)	22+2%	2 inch weeds	80	95	87
	Roundup PowerMax+AMS	22+2%	canopy			
6	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	83	91	87
	Roundup PowerMax+AMS	22+2%	canopy			
7	Roundup PowerMax+AMS+Outlook	22+2%+18	2 inch weeds	93	99	96
	Roundup PowerMax+AMS	22+2%	2 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
8	Roundup PowerMax+AMS+Outlook	22+2%+18	200 GDD	98	99	99
	Roundup PowerMax+AMS	22+2%	200 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
9	Roundup PowerMax+AMS	22+2%+	2 inch weeds	79	98	89
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
10	Nortron (pre)	120		95	97	96
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
11	Roundup PowerMax+AMS	22+2%	200 GDD	83	99	91
	Roundup PowerMax+AMS	22+2%	400 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
12	Roundup PowerMax+AMS (2X)	22+2%	400 GDD	80	99	89
	Roundup PowerMax+AMS	22+2%	canopy			
13	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	76	98	87
	Roundup PowerMax+AMS	22+2%	canopy			
14	Roundup PowerMax+AMS	22+2%	200 GDD	59	98	78
	Roundup PowerMax+AMS	22+2%	canopy			
15	Roundup PowerMax+AMS	22+2%	200 GDD	87	77	82
	Roundup PowerMax+AMS	22+2%	400 GDD			
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	89	97	93
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds	74	95	85
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	93	95	94
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	99	99	99
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	90	97	94
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	78	99	88
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	91	99	95
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	99	93	96
			C.V. %	7	7	5
			LSD	9	9	7

Table 11. Herbicide program influence on sugarbeet production
Exp # 0833
Sacred Heart, Mn

Trt #	Herbicide treatments	Rate oz/acre	appl. Criteria	Tons per acre	Ext. Suc. per ton	Ext. Suc. per acre	Revenue per acre
1	Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyledon weed	33.5	245	8209	890.53
	Progress+Upbeet+Stinger+MSO	11.5+0.125+1.3+1.5%:	200 GDD				
	Progress+Upbeet+Stinger+MSO	11.5+0.125+1.3+1.5%:	200 GDD				
2	Progress+Upbeet+Stinger+Nortron+MSO	8.5+0.125+1.3+4+1.5%:	cotyledon weed	39.6	216	8561	804.71
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	11.5+0.125+1.3+4+1.5%:	200 GDD				
3	Nortron (pre)	120	Sbeet emergence	35.2	241	8491	907.41
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	5.7+0.125+1.3+4+1.5%:	200 GDD				
4	Nortron (pre)	120	Sbeet emergence	27.5	203	5581	480.07
	Progress+Nortron	16+4	200 GDD				
	Progress+Nortron+Outlook	22+4+21	200 GDD				
5	Roundup PowerMax+AMS (2X)	22+2%	2 inch weeds	37.9	252	9567	1069.90
	Roundup PowerMax+AMS	22+2%	canopy				
6	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	42.0	246	10305	1121.21
	Roundup PowerMax+AMS	22+2%	canopy				
7	Roundup PowerMax+AMS+Outlook	22+2%+18	2 inch weeds	47.1	245	11539	1253.43
	Roundup PowerMax+AMS	22+2%	2 inch weeds				
	Roundup PowerMax+AMS	22+2%	canopy				
8	Roundup PowerMax+AMS+Outlook	22+2%+18	200 GDD	46.1	246	11372	1242.15
	Roundup PowerMax+AMS	22+2%	200 GDD				
	Roundup PowerMax+AMS	22+2%	canopy				
9	Roundup PowerMax+AMS	22+2%+	2 inch weeds	39.0	243	9456	1015.84
	Roundup PowerMax+AMS	22+2%	4 inch weeds				
	Roundup PowerMax+AMS	22+2%	canopy				
10	Nortron (pre)	120		40.8	252	10264	1144.97
	Roundup PowerMax+AMS	22+2%	4 inch weeds				
	Roundup PowerMax+AMS	22+2%	canopy				
11	Roundup PowerMax+AMS	22+2%	200 GDD	39.4	243	9589	10.33.24
	Roundup PowerMax+AMS	22+2%	400 GDD				
	Roundup PowerMax+AMS	22+2%	canopy				
12	Roundup PowerMax+AMS (2X)	22+2%	400 GDD	41.0	240	9856	1047.00
	Roundup PowerMax+AMS	22+2%	canopy				
13	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	44.5	225	9984	983.59
	Roundup PowerMax+AMS	22+2%	canopy				
14	Roundup PowerMax+AMS	22+2%	200 GDD	46.6	248	11549	12.66.91
	Roundup PowerMax+AMS	22+2%	canopy				
15	Roundup PowerMax+AMS	22+2%	200 GDD	36.3	202	7330	625.27
	Roundup PowerMax+AMS	22+2%	400 GDD				
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	35.7	248	8861	974.49
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds	42.1	243	10242	1104.37
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	36.6	235	8605	891.76
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	41.8	242	10085	1078.89
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	32.5	251	8152	904.49
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	32.9	252	8287	923.74
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	42.3	246	10414	1135.28
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	37.8	241	9124	974.98
			C.V. %	7	9	12	14
			LSD	4.1	32	1525	206.71

Hector, Mn Location

1. Weed pressure at the Hector location was low to medium and weed control rating was reflective of that factor.
2. Weed control was high regardless of the treatment.
3. Most treatments gave very good revenue per acre.
4. Outlook in the Roundup spray program applied twice at 200 GDD and at sugarbeet canopy gave higher sugarbeet revenue per acre than a similar treatment without Outlook in the spray program.
5. The highest revenue was achieved with Roundup applied at 200 GDD, 400 GDD and sugarbeet canopy.

Table 12. Herbicide program influence on weed control in sugarbeet
Experiment 0835
Hector, Mn

Trt #	Herbicide treatments	Rate oz/acre	appl. Criteria	Lambs Quarters control	Amaranthus control	Yellow Foxtail control
1	Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyledon weed	71	62	27
	Progress+Upbeet+Stinger+MSO (2X)	11.5+0.125+1.3+1.5%:	200 GDD			
2	Progress+Upbeet+Stinger+Nortron+MSO	8.5+0.125+1.3+4+1.5%:	cotyledon weed	99	64	26
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	11.5+0.125+1.3+4+1.5%:	200 GDD			
3	Nortron (pre)	120	Sbeet emergence	99	95	85
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	5.7+0.125+1.3+4+1.5%:	200 GDD			
4	Nortron (pre)	120	Sbeet emergence	99	80	85
	Progress+Nortron	16+4	200 GDD			
	Progress+Nortron+Outlook	22+4+21	200 GDD			
5	Roundup PowerMax+AMS (2X)	22+2%	2 inch weeds	99	99	98
	Roundup PowerMax+AMS	22+2%	canopy			
6	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	99	99	96
	Roundup PowerMax+AMS	22+2%	canopy			
7	Roundup PowerMax+AMS+Outlook	22+2%+18	2 inch weeds	99	99	99
	Roundup PowerMax+AMS	22+2%	2 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
8	Roundup PowerMax+AMS+Outlook	22+2%+18	200 GDD	99	99	98
	Roundup PowerMax+AMS	22+2%	200 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
9	Roundup PowerMax+AMS	22+2%+	2 inch weeds	99	99	99
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
10	Nortron (pre)	120		99	99	99
	Roundup PowerMax+AMS	22+2%	4 inch weeds			
	Roundup PowerMax+AMS	22+2%	canopy			
11	Roundup PowerMax+AMS	22+2%	200 GDD	99	99	99
	Roundup PowerMax+AMS	22+2%	400 GDD			
	Roundup PowerMax+AMS	22+2%	canopy			
12	Roundup PowerMax+AMS (2X)	22+2%	400 GDD	99	99	99
	Roundup PowerMax+AMS	22+2%	canopy			
13	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	99	99	99
	Roundup PowerMax+AMS	22+2%	canopy			
14	Roundup PowerMax+AMS	22+2%	200 GDD	99	98	99
	Roundup PowerMax+AMS	22+2%	canopy			
15	Roundup PowerMax+AMS	22+2%	200 GDD	99	71	49
	Roundup PowerMax+AMS	22+2%	400 GDD			
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	99	99	99
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds	99	99	99
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	99	95	98
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	85	79	98
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	99	99	98
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	99	76	79
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	99	99	98
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	99	99	99
			C.V. %	2	10	5
			LSD	13	7	3

Table 13. Herbicide program influence on sugarbeet production
Experiment 0835
Hector, Mn

Trt #	Herbicide treatments	Rate oz/acre	appl. Criteria	TONS	Extractable Sucrose per ton	Extractable Sucrose per acre	Revenue per acre
1	Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyledon weed	27.9	255	7109	802.14
	Progress+Upbeet+Stinger+MSO (2X)	11.5+0.125+1.3+1.5%:	200 GDD				
2	Progress+Upbeet+Stinger+Nortron+MSO	8.5+0.125+1.3+4+1.5%:	cotyledon weed	27.0	263	7126	827.34
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	11.5+0.125+1.3+4+1.5%:	200 GDD				
3	Nortron (pre)	120	Sbeet emergence	29.8	255	7600	859.28
	Progress+Upbeet+Stinger+Nortron+MSO (2X)	5.7+0.125+1.3+4+1.5%:	200 GDD				
4	Nortron (pre)	120	Sbeet emergence	24.8	254	6315	708.09
	Progress+Nortron	16+4	200 GDD				
	Progress+Nortron+Outlook	22+4+21	200 GDD				
5	Roundup PowerMax+AMS (2X)	22+2%	2 inch weeds	29.7	259	7695	881.35
	Roundup PowerMax+AMS	22+2%	canopy				
6	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	29.3	259	7592	868.91
	Roundup PowerMax+AMS	22+2%	canopy				
7	Roundup PowerMax+AMS+Outlook	22+2%+18	2 inch weeds	27.2	265	7216	843.08
	Roundup PowerMax+AMS	22+2%	2 inch weeds				
	Roundup PowerMax+AMS	22+2%	canopy				
8	Roundup PowerMax+AMS+Outlook	22+2%+18	200 GDD	31.8	260	8282	952.42
	Roundup PowerMax+AMS	22+2%	200 GDD				
	Roundup PowerMax+AMS	22+2%	canopy				
9	Roundup PowerMax+AMS	22+2%+	2 inch weeds	31.0	262	8147	943.95
	Roundup PowerMax+AMS	22+2%	4 inch weeds				
	Roundup PowerMax+AMS	22+2%	canopy				
10	Nortron (pre)	120		30.8	255	7854	886.76
	Roundup PowerMax+AMS	22+2%	4 inch weeds				
	Roundup PowerMax+AMS	22+2%	canopy				
11	Roundup PowerMax+AMS	22+2%	200 GDD	30.4	270	8206	973.40
	Roundup PowerMax+AMS	22+2%	400 GDD				
	Roundup PowerMax+AMS	22+2%	canopy				
12	Roundup PowerMax+AMS (2X)	22+2%	400 GDD	30.3	258	7823	893.19
	Roundup PowerMax+AMS	22+2%	canopy				
13	Roundup PowerMax+AMS (2X)	22+2%	200 GDD	28.8	269	7734	914.67
	Roundup PowerMax+AMS	22+2%	canopy				
14	Roundup PowerMax+AMS	22+2%	200 GDD	30.7	269	8249	976.13
	Roundup PowerMax+AMS	22+2%	canopy				
15	Roundup PowerMax+AMS	22+2%	200 GDD	30.6	260	7944	911.62
	Roundup PowerMax+AMS	22+2%	400 GDD				
16	Roundup PowerMax+AMS (3X)	22+2%	1 inch weeds	31.1	262	8152	942.48
17	Roundup PowerMax+AMS (3X)	22+2%	2 inch weeds	31.4	259	8142	931.97
18	Roundup PowerMax+AMS (2X)	22+2%	4 inch weeds	31.3	229	7178	724.81
19	Roundup PowerMax+AMS (2X)	22+2%	6 inch weeds	30.4	261	7962	919.44
20	Roundup PowerMax+AMS (3X)	32+2%	1 inch weeds	29.8	253	7541	845.77
21	Roundup PowerMax+AMS (3X)	32+2%	2 inch weeds	29.6	262	7767	899.15
22	Roundup PowerMax+AMS (2X)	32+2%	4 inch weeds	32.2	261	8411	969.55
23	Roundup PowerMax+AMS (2X)	32+2%	6 inch weeds	30.5	266	8130	954.46
			C.V. %	7	5	8	10
			LSD	0.8	845	129	129.09

General Observation

1. Weed control and revenue per acre trended to be better when Roundup was applied at 200 GDD and 200 GDD and sugarbeet canopy or 200 GDD and 400 GDD and sugarbeet canopy.
2. The addition of Outlook with Roundup applied postemergence or Nortron applied preemergence followed by Roundup postemergence generally significantly increased weed control and sugarbeet production
3. Further research will be conducted to evaluate weed control efficacy and crop influence of treatments in reference to criteria for timing of application.