2015
RESEARCH REPORT

Southern Minnesota Beet Sugar Cooperative

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2015 ACKNOWLEDGEMENTS

SMBSC Research
Cooperators

Bob and Matt Condon
Anderson Farms
Rodeberg Partnership and Kris Rodeberg
Chris and Brian Schlegel
Nick and Dave Ludowese
Darrel Vick
Marlo Macik
Hultgren Farms
Phil Pieper
Phil Haen
Michael Anderson

Seed Furnished by:

Betaseed
ACH Seeds
Germains Technology Group
Hilleshog - Syngenta Seeds
Holly Seeds
SES/Vander Have
Maribo

Coded Variety
Cooperators

Brad Schmoll
Mike Schmoll
Jeff Schmoll
Keith Johnson
Kyle Petersen
Phil Haen
Chuck Haen

Variety Strip Trial
Cooperators

Anderson Farms
Dave Wertish
Kyle Petersen
Phil and Chuck Haen
Youngkrantz Farms
Rick and Jeff Broderius
Terry Noble
William Luschen
Lundberg Farms
Hultgren Farms

Technical Assistance:

Technical Assistance was provided by Mohamed Khan Jason Brantner, Ashok Chanda John Lamb, Tom Peters

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Authors

Mark Bloomquist
Nicole VanOs

Data Analysis

Mark Bloomquist
Nicole VanOs

Editors

Todd Geselius
Mark Bloomquist
Nicole VanOs

Agricultural Research Assistant

Gary Lindahl
Bowe Linde
Cody Groen

Agricultural Maintenance:

Jeremy Fischer
Bobby Halvorson
Brandon Malvin
Brent Fagen
Kirby Schmidt
Adam Sander
Matt Dunphy
Robert Rice

Agricultural Staff

Cody Bakker
Chris Dunsmore
Les Plumley
Mike Schjenken
Paul Wallert
Pete Caspers
Scott Thaden
Jared Kelm
Jody Steffel

2015 SMBSC Official Variety Trial Procedures

Mark Bloomquist

Gary Lindahl

Four Official Variety Trial locations were planted in 2015. These trials were located near Murdock, Renville, Lake Lillian, and Hector. Trials were planted with a modified 12 row John Deere 7300 vacuum planter. Plots were four 22"rows wide by forty feet long. Each variety was replicated six times across the trial. The experimental design of the trials was a partially balanced lattice design. Emergence counts were taken approximately 28 days after planting, and alleys were cut perpendicular to the rows. After the emergence counts were taken, plots were thinned to a uniform spacing of approximately 190-200 sugar beets per 100 foot of row, and all doubles were removed. Quadris was banded over the row at approximately the four to six leaf stage to suppress rhizoctonia root and crown rot.

Weed control was accomplished by applying Roundup Weathermax, Sequence, Dual Magnum, Stinger, Betamix, and Select Max at the appropriate rates and times. The weeds present at each site dictated the actual weed control products used at each site. All spraying operations were conducted by a tractor sprayer driving perpendicular to the rows down the tilled alleys. SMBSC Research Staff conducted all the spraying operations. Four or five *Cercospora* leafspot fungicide applications were made at each Official Variety Trial site.

In early September, approximately 2.5 feet is tilled under on each end of every plot to eliminate the border effect that develops on the outside of the plots near the tilled alleys. Row lengths are taken on each harvest row to calculate yield at harvest. All plots were defoliated using a 4-row defoliator. The center two rows of each plot were harvested using a 2-row research harvester. All beets harvested from the center two rows were weighed on a scale on the harvester and a sample of beets was taken for quality analysis.

All varieties were entered into various disease nurseries to evaluate the disease tolerance of the varieties. *Cercospora* leafspot nurseries were conducted in cooperation with the Beet Sugar Development Foundation at a location in Michigan and at a Betaseed location near Rosemount, MN. *Aphanomyces* root rot nurseries were conducted at Betaseed's facility in Shakopee, MN and in the SMBSC *Aphanomyces* nursery near Renville. *Rhizoctonia* tolerance was tested at a SMBSC location near Clara City as well as the BSDF *Rhizoctonia* nursery in Michigan.

All the data is summarized and merged with the 2013 and 2014 data to evaluate the varieties for approval. SMBSC Seed Policy sets out guidelines for minimum performance standards of the varieties. Varieties that meet all the approval criteria are approved for shareholders to plant their 2016 sugar beet crop.

SMBSC APPROVED VARIETIES
2016

FULLY APPROVED
UNLIMITED SALES VARIETIES

Beta 92RR30 (Aphanomyces)
Beta 92RR60
Crystal M375
Crystal M380 (Aphanomyces)
Crystal RR270

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

Beta 9475
Crystal M456
Hilleshog 9528RR

APHANOMYCES

SPECIALTY
APPROVED VARIETIES

Beta 92RR30 (fully approved)

Crystal M380 (fully approved)

RHIZOCTONIA

SPECIALTY
APPROVED VARIETIES

Beta 90RR54
Beta 91RR01
Crystal RR018
Hilleshog 9093RR
Hilleshog 9517 RR
Maribo MA109RR

CLS Specialty Approved Varieties

Beta 91RR01
Hilleshog 9517RR

2015 SMBSC Official Variety Trials Specifications

Trial Location	Cooperator	Entry Designation	Previous Crop	Starter Fertilizer	Planting Date	Disease	Harvest Date
Hector	G.E. Johnson Inc	Official Trial	Sweet corn	No	4/23/15	Light Rhizoctonia	9/29/15
Lake Lillian	Mike, Brad, and Jeff Schmoll	Official Trial	Sweet Corn	No	4/27/15	No disease issues	9/21/15
Renville	C&P Farms	Official Trial	Soybeans	Yes	4/29/15	Light Rhizoctonia	10/2/15
Murdock	Kyle Petersen	Official Trial	Sweet Corn	Yes	4/30/15	Light Rhizoctonia	10/5/15

All trials were sprayed with two applications of Sequence (glyphosate + Dual Magnum) Renville received a third glyphosate appliction. Trials were hand weeded for any escapes
Quadris was band applied to all trials at approximately the 4-8 leaf beet stage for rhizoctonia suppression.
Five CLS fungicide applications were applied to Murdock and Renville. Four CLS fungicides were applied to Lake Lillian and Hector.

2015 Disease Nursery Trial Specifications

Disease	Cooperator	Location	Ratings Performed By	Use of Ratings in 2015 Variety Approval
Cercospora	Betaseed	Rosemount	Betaseed	50% of 2015 CLS Rating
Cercospora	BSDF - USDA/ARS Linda Hanson Mitch McGrath	Michigan	USDA/ARS Personnel	50% of 2015 CLS Rating
Cercospora	SMBSC	Renville	SMBSC Research Staff	**Not Used for Approval in 2015**
Aphanomyces	Betaseed	Shakopee	Betaseed, Jason Brantner, Ashok Chanda, Mark Bloomquist	50% of 2015 Aphanomyces Rating
Aphanomyces	SMBSC	Renville	SMBSC Research Staff	50% of 2015 Aphanomyces Rating
Rhizoctonia	BSDF - USDA/ARS Linda Hanson	Michigan	USDA/ARS	2015 Rhizoctonia Specialty Approval Status
Rhizcotonia	SMBSC Bob Condon	Clara City	SMBSC Research Staff	2015 Rhizoctonia Specialty Approval Status

Table 1. Comparison of 2016 SMBSC Fully Approved Varieties and Specialty Varieties - 3 Year Data (2013 - 2015)

Entry	Rec/T (lbs) 3 yr avg	Rec/T (lbs) % of mean	Rec/A (lbs) 3 yr avg	Rec/A (lbs) % of mean	Sugar % 3 yr avg	Sugar % % of mean	Purity 3 yr avg	Purity % of mean	Yield (T/A) 3 yr avg	Yield (T/A) % of mean	Cercospora Leaf Spot 3 yr avg	Cercospora Leaf Spot % of mean	Rhizoct-onia 3 yr avg	Rhizoct-onia % of mean	Aphano-myces 3 yr avg	Aphano-myces % of mean	Emerge-ence (%) 3 yr avg	Emerge-ence (%) % of mean	Rev./* Ton % of mean	Rev./* Acre % of mean
2016 Approved Varieties																				
Beta 92RR30	285.9	99.6	8805.9	98.2	16.6	99.3	91.9	100.2	30.5	98.5	4.1	85.5	4.9	104.8	3.3	78.7	74.9	103.3	99.0	97.5
Beta 92RR60	286.9	100.0	9121.9	101.8	16.8	100.2	91.5	99.8	31.6	102.0	4.9	102.6	4.4	94.2	4.8	112.1	72.7	100.3	100.1	102.1
Crystal M375	289.1	100.7	9203.1	102.7	16.9	100.8	91.7	100.0	31.6	102.1	4.8	100.9	4.6	98.5	5.1	121.0	68.3	94.2	101.8	103.9
Crystal M380	286.5	99.8	8913.3	99.4	16.7	99.6	91.9	100.2	30.9	99.5	4.7	98.1	4.4	95.0	3.5	81.8	72.8	100.3	99.5	99.0
Crystal RR270	286.6	99.9	8779.5	97.9	16.8	100.1	91.5	99.8	30.4	97.9	5.4	112.9	5.0	107.5	4.5	106.5	73.9	101.9	99.7	97.6
Mean	**287.0**	**100.0**	**8964.8**	**100.0**	**16.7**	**100.0**	**91.7**	**100.0**	**31.0**	**100.0**	**4.8**	**100.0**	**4.7**	**100.0**	**4.2**	**100.0**	**72.5**	**100.0**	**100.0**	**100.0**
Test Market Varieties with 3 Years Data (% of mean is of approved mean)																				
Hilleshog 9528RR	272.3	94.9	8596.2	95.9	15.9	95.0	91.8	100.1	31.3	100.9	5.0	104.5	4.2	90.5	4.4	103.1	72.0	99.3	88.2	89.0
Specialty Approved Varieties with 3 Years of Data (% of mean is of approved mean)																				
Beta 90RR54	273.3	95.2	8873.9	99.0	16.0	95.7	91.5	99.8	32.3	104.2	4.1	85.6	3.7	78.4	4.0	93.4	74.2	102.3	88.9	92.6
Beta 91RR01	270.7	94.3	8675.1	96.8	16.0	95.4	91.1	99.3	31.9	102.9	3.8	78.8	3.8	81.1	3.9	91.2	74.4	102.6	86.8	89.4
Crystal RR018	276.4	96.3	8564.9	95.5	16.3	97.1	91.2	99.4	31.0	99.9	4.3	89.7	3.9	83.8	4.3	101.2	72.9	100.5	91.4	91.3
Hilleshog 9093RR	261.6	91.2	8084.7	90.2	15.5	92.6	90.8	99.1	30.7	99.0	4.4	92.0	3.5	74.0	5.1	120.2	72.0	99.2	79.4	78.6
Hilleshog 9517RR	274.6	95.7	7898.3	88.1	16.2	96.5	91.2	99.5	28.5	91.8	3.8	80.8	3.9	83.2	4.4	103.6	65.3	90.0	89.9	82.5
Maribo MA109RR	280.9	97.9	8320.5	92.8	16.4	97.9	91.8	100.1	29.4	94.9	4.3	89.3	3.1	65.8	4.5	105.9	73.2	100.9	95.1	90.2

* Revenue per Ton and Revenue per Acre figures were produced using the new SMBSC payment calculation for the 2016 crop.

Table 2. Comparison of 2016 Approved Varieties to Test Market Varieties and Specialty Varieties Based on 2 Year Data, 2014 - 2015

Entry	Rec/T (lbs) 2 yr avg	Rec/T (lbs) % of mean	Rec/A (lbs) 2 yr avg	Rec/A (lbs) % of mean	Sugar % 2 yr avg	Sugar % % of mean	Purity 2 yr avg	Purity % of mean	Yield (T/A) 2 yr avg	Yield (T/A) % of mean	Cercospora Leaf Spot 2 yr avg	Cercospora Leaf Spot % of mean	Rhizoctonia 2 yr avg	Rhizoctonia % of mean	Aphanomyces 2 yr avg	Aphanomyces % of mean	Emergence (%) 2 yr avg	Emergence (%) % of mean	Rev./* Ton % of mean	Rev./* Acre % of mean
2016 Approved Varieties																				
Beta 92RR30	285.0	99.4	8690.8	98.1	16.6	99.2	91.8	100.2	30.1	98.3	3.9	82.8	4.6	103.0	3.3	78.5	73.7	103.4	98.5	96.8
Beta 92RR60	286.8	100.0	9020.9	101.8	16.8	100.3	91.5	99.8	31.3	102.0	5.1	107.6	4.5	100.7	4.7	111.4	70.9	99.5	100.2	102.3
Crystal M375	289.0	100.8	9084.3	102.5	16.9	100.9	91.6	99.9	31.2	101.8	4.8	101.4	4.6	103.5	5.2	122.8	68.7	96.3	101.9	103.8
Crystal M380	286.2	99.8	8803.5	99.3	16.6	99.5	91.9	100.2	30.5	99.5	4.5	96.4	4.0	90.4	3.5	81.7	72.2	101.3	99.5	98.9
Crystal RR270	286.5	99.9	8717.4	98.4	16.8	100.1	91.5	99.9	30.1	98.4	5.3	111.8	4.5	102.3	4.5	105.6	70.9	99.5	99.9	98.2
Mean	**286.7**	**100.0**	**8863.4**	**100.0**	**16.7**	**100.0**	**91.7**	**100.0**	**30.6**	**100.0**	**4.7**	**100.0**	**4.4**	**100.0**	**4.3**	**100.0**	**71.3**	**100.0**	**100.0**	**100.0**
2016 Test Market Varieties for Limited Sales with 2 years data (% of mean is of approved mean)																				
Beta 9475	283.3	98.8	9142.5	103.1	16.5	98.6	91.9	100.2	32.1	104.6	4.0	84.2	4.5	101.3	4.9	114.2	67.1	94.1	97.2	101.8
Crystal M456	281.3	98.1	8612.1	97.2	16.4	97.7	92.0	100.4	30.4	99.2	4.5	96.4	4.7	107.2	4.9	116.1	74.6	104.7	95.5	94.7
Hilleshog 9528RR	271.8	94.8	8454.8	95.4	15.9	95.0	91.7	100.1	30.8	100.4	5.3	112.7	4.0	90.3	4.3	101.9	70.5	98.9	88.0	88.4
2016 Specialty Approved Varieties with 2 years data (% of mean is of approved mean)																				
Beta 90RR54	274.2	95.6	8836.1	99.7	16.1	96.1	91.4	99.8	32.0	104.5	4.1	87.6	3.7	84.6	3.9	92.7	73.7	103.3	89.8	93.8
Beta 91RR01	271.8	94.8	8662.5	97.7	16.0	95.7	91.1	99.4	31.7	103.4	3.6	75.9	3.8	86.6	3.9	90.5	73.5	103.1	87.9	90.9
Crystal RR018	277.7	96.9	8525.6	96.2	16.4	97.7	91.1	99.4	30.8	100.4	4.2	88.8	3.8	86.2	4.3	100.3	73.6	103.2	92.6	93.0
Hilleshog 9093RR	261.4	91.2	8074.1	91.1	15.5	92.8	90.7	99.0	30.6	99.9	4.4	93.3	3.3	73.6	5.1	119.2	72.1	101.1	79.4	79.3
Hilleshog 9517RR	274.2	95.6	7675.8	86.6	16.1	96.5	91.2	99.5	27.6	90.2	4.0	85.1	3.8	87.0	4.7	111.3	61.8	86.7	89.9	81.0
Maribo MA109RR	281.4	98.1	8252.2	93.1	16.4	98.2	91.7	100.1	29.1	94.9	4.5	95.8	2.9	64.9	4.4	102.9	70.6	99.0	95.7	90.8

* Revenue per Ton and Revenue per Acre figures were produced using the new SMBSC payment calculation for the 2016 crop.

Table 3. Comparison of 2016 Fully Approved Varieties to Test Market and Specialty Approved Varieties Based on 1 Year Data, 2015

Entry	Rec/T (lbs) 1 yr avg	Rec/T (lbs) % of mean	Rec/A (lbs) 1 yr avg	Rec/A (lbs) % of mean	Sugar % 1 yr avg	Sugar % % of mean	Purity 1 yr avg	Purity % of mean	Yield (T/A) 1 yr avg	Yield (T/A) % of mean	Cercospora Leaf Spot 1 yr avg	Cercospora Leaf Spot % of mean	Rhizoct-onia 1 yr avg	Rhizoct-onia % of mean	Aphano-myces 1 yr avg	Aphano-myces % of mean	Emerge-ence (%) 1 yr avg	Emerge-ence (%) % of mean	Rev./* Ton % of mean	Rev./* Acre % of mean
2016 Approved Varieties																				
Beta 92RR30	301.3	100.3	10649.5	100.9	17.3	99.8	92.6	100.4	35.4	98.3	3.9	83.2	4.8	104.1	3.1	75.8	75.3	101.4	100.7	101.2
Beta 92RR60	298.4	99.4	10605.6	100.5	17.4	100.0	91.7	99.5	35.5	102.0	5.1	107.2	4.6	100.0	4.7	113.3	73.4	98.8	98.7	99.4
Crystal M375	300.3	100.0	10532.4	99.8	17.4	100.2	92.1	99.9	35.1	101.8	4.7	98.1	4.8	104.8	4.9	119.5	73.2	98.5	100.1	99.8
Crystal M380	300.7	100.1	10615.4	100.6	17.3	99.8	92.4	100.3	35.4	99.5	4.4	93.1	4.1	88.8	3.3	80.4	75.3	101.3	100.2	100.7
Crystal RR270	300.8	100.2	10373.5	98.3	17.4	100.3	92.1	99.9	34.6	98.4	5.6	118.4	4.7	102.3	4.6	111.1	74.3	99.9	100.4	98.9
Mean	**300.3**	**100.0**	**10555.3**	**100.0**	**17.4**	**100.0**	**92.2**	**100.0**	**35.2**	**100.0**	**4.7**	**100.0**	**4.6**	**100.0**	**4.1**	**100.0**	**74.3**	**100.0**	**100.0**	**100.0**
2016 Test Market Varieties with 1 year data (% of mean is of approved mean)																				
Beta 9475	293.6	97.8	11000.3	104.2	17.0	97.6	92.4	100.2	37.5	106.7	3.9	81.5	4.6	100.2	4.5	109.6	69.4	93.4	95.2	101.6
Crystal M456	292.0	97.2	10360.3	98.2	16.8	96.6	92.7	100.6	35.5	101.0	4.7	99.3	5.0	100.6	5.2	125.5	76.3	102.6	93.8	94.8
Hilleshog 9528RR	285.3	95.0	10382.1	98.4	16.6	95.3	92.2	100.0	36.5	103.8	5.3	111.9	4.1	100.0	3.6	88.2	71.3	96.0	89.1	92.5
2016 Specialty Approved Varieties with 1 year data (% of mean is of approved mean)																				
Beta 90RR54	285.9	95.2	10783.8	102.2	16.6	95.5	92.2	100.0	37.8	107.3	4.1	85.6	4.1	100.0	4.1	100.4	76.7	103.2	89.6	96.1
Beta 91RR01	282.6	94.1	10320.5	97.8	16.5	95.2	91.6	99.3	36.6	104.0	3.5	73.5	3.8	99.3	4.2	100.8	75.4	101.5	87.0	90.5
Crystal RR018	290.0	96.6	10408.6	98.6	16.9	97.5	91.6	99.3	36.1	102.6	4.1	86.9	3.9	99.3	4.1	99.4	77.9	104.8	92.4	94.8
Hilleshog 9093RR	276.3	92.0	9935.1	94.1	16.2	93.4	91.4	99.1	36.0	102.3	4.4	91.8	3.3	99.1	4.8	116.8	74.6	100.4	82.4	84.3
Hilleshog 9517RR	290.0	96.6	9695.2	91.9	16.9	97.3	91.8	99.5	33.6	95.4	3.9	83.2	3.9	99.5	3.7	89.2	75.1	101.1	92.5	88.3
Maribo MA109RR	296.2	98.6	10217.7	96.8	17.2	98.7	92.2	100.0	34.6	98.4	4.5	94.8	2.9	100.0	4.0	96.1	74.6	100.4	97.1	95.5

* Revenue per Ton and Revenue per Acre figures were produced using the new SMBSC payment calculation for the 2016 crop.

2013 - 2015 Disease Nursery Data for Rhizoctonia, Aphanomyces, and Cercospora

** Lower Ratings mean more resistant to disease, and higher ratings mean more susceptible to the disease
This applies to all three disease nurseries

Variety Description	Rhizoctonia Root Ratings					Aphanomyces Root Ratings					Cercospora Leafspot Ratings				
	2015 Root Rating	2014 Root Rating	2013 Root Rating	2014-2015 2 Year Mean Baseline Adjusted Root Rating	2013-2015 3 Year Mean Baseline Adjusted Root Rating	2015 Root Rating	2014 Root Rating	2013 Root Rating	2014-2015 2 Year Mean Baseline Adjusted Root Rating	2013-2015 3 Year Mean Baseline Adjusted Root Rating	2015 CLS Rating	2014 CLS Rating	2013 CLS Rating	2014-2015 2 Year Mean Baseline Adjusted Root Rating	2013-2015 3 Year Mean Baseline Adjusted Root Rating
Fully Approved Varieties															
Beta 92RR30 (Aph)	4.8	4.3	5.6	4.6	4.9	3.1	3.6	3.3	3.3	3.3	3.9	3.9	4.4	3.9	4.1
Beta 92RR60	4.6	4.3	4.3	4.5	4.4	4.7	4.8	4.8	4.7	4.8	5.1	5.1	4.5	5.1	4.9
Crystal M375	4.8	4.3	4.6	4.6	4.6	4.9	5.5	4.9	5.2	5.1	4.7	4.9	4.9	4.8	4.8
Crystal M380 (Aph)	4.1	3.9	5.3	4.0	4.4	3.3	3.6	3.5	3.5	3.5	4.4	4.7	4.9	4.5	4.7
Crystal RR270	4.7	4.3	6.0	4.5	5.0	4.6	4.4	4.6	4.5	4.5	5.6	4.9	5.6	5.3	5.4
Test Market Varieties															
Beta 9475	4.6	4.4		4.5		4.5	5.2		4.9		3.9	4.1		4.0	
Crystal M456	5.0	4.5		4.7		5.2	4.7		4.9		4.7	4.4		4.5	
Hilleshog 9528RR	4.1	3.9	4.7	4.0	4.2	3.6	5.0	4.4	4.3	4.4	5.3	5.3	4.3	5.3	5.0
Specialty Approved															
Beta 91RR01 (RHC and CLS)	3.8	3.9	3.7	3.8	3.8	4.2	3.5	3.9	3.9	3.9	3.5	3.7	4.1	3.6	3.8
Beta 90RR54 (RCH)	4.1	3.3	3.5	3.7	3.7	4.1	3.8	4.0	3.9	4.0	4.1	4.2	4.0	4.1	4.1
Crystal RR018 (RHC)	3.9	3.7	4.1	3.8	3.9	4.1	4.4	4.3	4.3	4.3	4.1	4.3	4.4	4.2	4.3
Hilleshog 9093RR (RHC)	3.3	3.3	3.9	3.3	3.5	4.8	5.3	5.1	5.1	5.1	4.4	4.5	4.3	4.4	4.4
Hilleshog 9517 (RHC and CLS)	3.9	3.8	4.0	3.8	3.9	3.7	5.8	3.7	4.7	4.4	3.9	4.1	3.5	4.0	3.9
Maribo MA109RR (RHC)	2.9	2.8	3.5	2.9	3.1	4.0	4.8	4.7	4.4	4.5	4.5	4.5	3.7	4.5	4.3

Rhizoctonia Ratings from SMBSC Nursery at Clara City and BSDF Nursery in Michigan
Ratings are on scale of 1 - 7. (1 = Healthy, 7 = Dead)

Aphanomyces Ratings from SMBSC Nursery at Renville and Betaseed Nursery in Shakopee.
Ratings are on scale of 1 - 9. (1 = Healthy, 9 = Dead)

Cercospora Ratings from BSDF Nursery in Michigan and Betaseed Nursery near Randolph MN.
Ratings are on scale of 1-9. 1 = Clean leaves, 9 = Dead Leaves.

2015 SMBSC Variety Strip Trials - Summary of All Locations

Variety	Stand Count 28 DAP Beets/100' row	Sugar %	Purity %	Tons / Acre	Extractable Sugar per Acre	Percent of Mean Revenue per Acre
Beta 92RR30	207.9	17.2	91.8	28.7	8450.9	96.3
Beta 92RR60	208.3	17.4	91.4	30.0	8926.5	103.4
Crystal M375	194.7	17.5	91.9	30.3	9090.2	104.3
Crystal M380	216.0	17.2	91.9	29.4	8713.4	99.1
Crystal RR018	210.2	17.1	91.7	30.1	8841.4	100.1
Hilleshog 9528RR	193.9	16.6	91.9	31.7	8998.6	96.7
Mean	206.2	17.2	91.8	30.0	8836.8	100.0
%CV	6.7	1.5	0.5	6.9	7.2	9.0
Pr>F	0.0008	<0.0001	0.26	0.08	0.34	0.31
LSD (0.05)	13.2	0.2	NS	NS	NS	NS
Reps	9	9	9	9	9	9

Combined data of nine locations. Each location is considered a replicate.
Revenue calculated using new payment formula for 2016 crop.

2015 SMBSC Variety Strip Trial - Maynard

Variety	Stand Count 28 DAP Beets/100' row	Sugar %	Purity %	Tons / Acre	Extractable Sugar per Acre	Percent of Mean Revenue per Acre
Beta 92RR30	228	17.1	93.0	17.9	5349.6	90.0
Beta 92RR60	200	17.5	91.5	23.7	7093.9	119.5
Crystal M375	193	17.6	93.6	16.7	5192.4	90.7
Crystal M380	228	17.3	93.1	17.5	5280.7	89.9
Crystal RR018	213	17.2	92.9	25.3	7586.0	127.9
Hilleshog 9528RR	173	16.2	92.8	18.6	5202.9	81.9
Mean	206	17.1	92.8	19.9	5950.9	100.0

Planted: April 15
Harvested: September 22
Revenue calculated using new payment formula for 2016 crop.
Agriculturist - Cody Bakker

2015 SMBSC Variety Strip Trial - Raymond

Variety	Stand Count 28 DAP Beets/100' row	Sugar %	Purity %	Tons / Acre	Extractable Sugar per Acre	Percent of Mean Revenue per Acre
Beta 92RR30	200	19.2	93.1	24.9	8378.8	101.9
Beta 92RR60	205	19.2	92.5	27.7	9265.4	111.8
Crystal M375	205	19.1	92.7	25.8	8611.4	103.8
Crystal M380	228	18.7	92.1	26.9	8694.9	101.5
Crystal RR018	208	19.0	93.3	25.8	8637.6	104.2
Hilleshog 9528RR	205	17.6	92.7	26.9	8256.2	91.1
Hilleshog 9621	180	18.1	93.1	23.7	7503.8	85.7
Mean	204.4	18.7	92.8	26.0	8478.3	100.0

Planted: April 28
Harvested: October 15
Revenue calculated using new payment formula for 2016 crop.
Agriculturist - Jared Kelm

2015 SMBSC Variety Strip Trial - Renville

Variety	Stand Count 28 DAP Beets/100' row	Sugar %	Purity %	Tons / Acre	Extractable Sugar per Acre	Percent of Mean Revenue per Acre
Beta 92RR30	198	17.0	91.6	28.1	8163.5	107.5
Beta 92RR60	210	16.8	91.0	27.8	7914.3	101.3
Crystal M375	198	17.1	92.1	26.5	7811.6	104.7
Crystal M380	195	16.4	91.8	28.0	7844.6	98.7
Crystal RR018	195	16.6	91.6	27.0	7639.7	97.3
Hilleshog 9528RR	205	16.4	91.8	26.5	7421.9	93.3
Beta 90RR54		16.2	91.3	28.7	7922.5	97.3
Mean	200	16.6	91.6	27.5	7816.9	100.0

Planted: April 16
Harvested: September 10
Revenue calculated using new payment formula for 2016 crop.
Agriculturist - Mike Schjenken

2015 SMBSC Variety Strip Trial - Murdock

Variety	Stand Count 28 DAP Beets/100' row	Sugar %	Purity %	Tons / Acre	Extractable Sugar per Acre	Percent of Mean Revenue per Acre
Beta 92RR30	213	16.9	91.9	32.1	9346.4	104.7
Beta 92RR60	213	16.9	91.1	30.4	8709.9	95.9
Crystal M375	203	16.5	91.0	33.3	9338.1	99.6
Crystal M380	220	16.8	91.6	32.3	9272.7	102.1
Crystal RR018	203	16.4	91.3	32.3	9032.0	96.0
Hilleshog 9528	190	16.3	91.9	34.3	9573.1	101.7
Mean	207	16.6	91.5	32.5	9212.0	100.0

Planted: April 15
Harvested: September 4
Revenue calculated using new payment formula for 2016 crop.
Agriculturist - Jeff Keltgen

2015 SMBSC Variety Strip Trial - Hector

Variety	Stand Count 28 DAP Beets/100' row	Sugar %	Purity %	Tons / Acre	Extractable Sugar per Acre	Percent of Mean Revenue per Acre
Beta 92RR30+ZOC	178	18.6	91.8	27.5	8805.6	91.9
Beta 92RR60 + ZOC	200	18.6	91.9	27.8	8958.6	93.9
Crystal M375+ZOC	155	18.9	92.8	30.7	10144.6	109.3
Crystal M380 + ZOC	228	18.4	92.1	29.1	9274.6	96.3
Crystal RR018 + ZOC	228	18.6	92.3	28.4	9199.5	97.0
Hilleshog 9528RR + ZOC	198	18.5	92.1	33.4	10696.9	111.6
Mean	197.8	18.6	92.2	29.5	9513.3	100.0

Planted: April 14
Harvested: October 11
Revenue calculated using new payment formula for 2016 crop.
Agriculturist - Pete Caspers

2015 SMBSC Variety Strip Trial - Danube

Variety	Stand Count 28 DAP Beets/100' row	Sugar %	Purity %	Tons / Acre	Extractable Sugar per Acre	Percent of Mean Revenue per Acre
Beta 92RR30	209	16.0	90.1	31.0	8290.7	92.9
Beta 92RR60	201	16.6	90.0	32.2	8906.9	104.8
Crystal M375	174	16.2	89.6	34.3	9254.7	104.8
Crystal M380	199	16.3	90.5	30.2	8279.1	96.4
Crystal RR018	186	15.9	89.5	32.3	8518.9	93.2
Hilleshog 9528RR	191	15.5	89.7	39.5	10137.1	106.0
Hilleshog 9621RR	169	15.4	89.5	39.1	9932.5	101.9
Mean	189.9	16.0	89.8	34.1	9045.7	100.0

Planted: April 15
Harvested: Sept 18
Revenue calculated using new payment formula for 2016 crop.
Agriculturist - Chris Dunsmore

2015 SMBSC Variety Strip Trial - Belgrade

Variety	Stand Count 28 DAP Beets/100' row	Sugar %	Purity %	Tons / Acre	Extractable Sugar per Acre	Percent of Mean Revenue per Acre	Notes
Beta 92RR30	225	17.3	91.3	31.2	9219.1	84.2	wheel tracks
Beta 92RR60	223	18.0	92.6	32.9	10344.1	101.3	
Crystal M375	223	18.3	92.3	37.8	12012.4	119.1	
Crystal M380		18.2	92.9	32.3	10263.3	101.7	
Crystal RR018	228	18.0	92.7	34.2	10776.2	105.7	
Hilleshog 9528RR	223	17.3	93.0	32.7	9906.5	93.1	wheel tracks
Hilleshog 9621RR	223	16.9	92.6	36.6	10716.3	96.8	
Marbo MA109RR	210	17.5	91.7	35.2	10563.2	98.2	
Mean	222	17.7	92.4	34.1	10475.1	100	

Planted: April 16
Harvested: October 16
Revenue calculated using new payment formula for 2016 crop.
Agriculturist - Jared Kelm

2015 SMBSC Variety Strip Trial - Appleton

Variety	Stand Count 28 DAP Beets/100' row	Sugar %	Purity %	Tons / Acre	Extractable Sugar per Acre	Percent of Mean Revenue per Acre
Beta 92RR30	200	15.9	91.2	27.5	7422.5	100.6
Beta 92RR60	200	16.1	91.3	27.6	7553.2	105.0
Crystal M375	188	16.2	91.3	27.0	7439.2	104.4
Crystal M380	185	16.0	91.6	27.7	7581.8	105.0
Crystal RR018	198	15.6	90.3	25.7	6687.9	85.6
Hilleshog 9528RR	170	15.4	90.4	30.7	7882.2	98.9
Hilleshog 9621RR	188	15.8	91.2	28.2	7549.0	101.5
Maribo 109	180	16.3	91.1	25.6	7057.4	99.0
Mean	189	15.9	91.1	27.5	7396.7	100.0

Planted: April 16
Harvested: August 31
Trial was not machine harvested. Ten foot of row was harvested from 10 points across the strip trial for each variety.
Revenue calculated using new payment formula for 2016 crop.
Agriculturist - Scott Thaden

2015 SMBSC Variety Strip Trial - Lake Lillian

Variety	Stand Count 28 DAP Beets/100' row	Sugar %	Purity %	Tons / Acre	Extractable Sugar per Acre	Percent of Mean Revenue per Acre
Beta 92RR30	220	17.0	92.1	37.8	11081.7	96.7
Beta 92RR60	223	17.3	91.1	39.4	11591.8	101.6
Crystal M375	213	17.2	92.3	40.4	12007.4	106.8
Crystal M380	243	17.1	91.7	40.7	11936.5	104.4
Crystal RR018	233	16.9	91.5	39.9	11495.2	98.2
Hilleshog 9528RR	190	16.0	92.2	43.1	11910.6	96.1
Beta 90RR54		16.7	91.8	42.2	12089.7	102.5
Hilleshog 9621RR	203	15.6	91.9	45.5	12181.3	93.7
Mean	218	16.7	91.8	41.1	11786.8	100.0

Planted: April 16

Harvest: September 29

Revenue calculated using new payment formula for 2016 crop.

Agriculturist - Les Plumley

Evaluation of Fungicides Program for Control of *Cercospora* Leaf Spot, Raymond, MN - 2015

Introduction: *Cercospora* Leaf Spot is a disease that affects the SMBSC growing area every season. A well timed fungicide program is an important part of managing this disease. In recent years, additional concerns regarding potential *Cercospora* resistance to commonly used fungicides has increased the importance of including multiple modes of action in a *Cercospora* fungicide program.

Objectives: The objective of this trial was to evaluate several fungicide programs for control of *Cercospora* leaf spot. Each of these fungicide programs contained treatments that rotated the fungicide modes of action through the course of the program. Foliar ratings were conducted to measure treatment efficacy against CLS. The trial was harvested for yield and quality results.

Methods: The trial was set up in a randomized complete block design with four replications. Each individual plot was six (22”) rows wide by 35’ long. The trial was planted on April 15, 2015 with the variety Betaseed 90RR54. Two applications of Roundup Powermax were made for weed control, as well as a layby application of Outlook. Quadris was banded over the trial on June 10 to suppress *Rhizoctonia* root rot.

On July 9 and 16, the trial was inoculated with pulverized *Cercospora* leaf inoculum. The inoculation was conducted with a Gandy Air Unit. The first fungicide applications were made on July 30. The fungicide treatments were applied to the center four rows of each six row plot. In every plot, row one and six remained untreated. Additional fungicide treatments were applied on August 14, August 27, and September 10. Treatments were applied with a tractor sprayer at 4 mph using flat fan spray nozzles at 19 gallons per acre and a spray pressure of 90 psi.

Sugar beets were defoliated with a six row defoliator and harvested with a two row research harvester. The center two rows of each plot were harvested and weighed for yield determination. A sample was taken from every plot for analysis of sugar content and purity. The yield and rating data was compiled and an analysis of the data performed using SAS version 9.3. Table 1 lists the treatments as well as the Cercospora Leafspot ratings and yield information from the 2015 trial.

Results and discussion: The 2015 season was exceptionally favorable for *Cercospora* development. Foliar ratings were taken using the KWS 1-9 scale with 1 being disease free and 9 being completely brown. The untreated check plots had a CLS rating of 9 at the first rating period on September 8. There was a high level of *Cercospora* present throughout the trial and fungicide treated plots were also affected by the disease. At the second rating period, all treatments had CLS ratings greater that 5.9 which indicates some economic loss occurred in all treatments included in the trial. All the treatments resulted in CLS ratings statistically better than the untreated check at both rating periods. All treatments were statistically higher than the check for sugar percent, extractable sugar percent, and extractable sugar per ton. All treatments were also numerically higher than the check for extractable sugar per acre and all but three of the treatments were statistically higher than the untreated check for extractable sugar per acre. The data shows the importance of a *Cercospora* spray program to protect from losses in sugar content as well as recoverable sugar per acre.

2015 Cercospora Leafspot Fungicide Trial - Raymond

Treatment Number	Fungicide Treatment	Product Rate (oz./A)	Spray Interval	CLS Rating (1-9) 9/8/2015	CLS Rating (1-9) 9/23/2015	Sugar %	Extractable Sugar %	Extractable Sugar/Ton	Tons / Acre	Extractable Sugar Per Acre	Purity	Brei Nitrates
1	Untreated Check	N/A		9.0	9.0	13.9	11.5	229.8	28.0	6384.7	90.3	96.8
2	Proline + NIS	5	first appl.	5.6	6.4	15.9	13.4	268.3	30.2	8092.6	90.8	52.3
	Super Tin 4L	8	14 days									
	Headline	9.2	14 days									
3	Eminent	13	first appl.	5.0	6.4	15.7	13.3	266.0	32.5	8635.3	91.2	38.8
	Super Tin 4L	8	14 days									
	Headline	9.2	14 days									
4	Inspire XT	7	first appl.	5.1	6.3	15.7	13.3	266.0	30.8	7876.5	91.0	42.0
	Super Tin 4L	8	14 days									
	Headline	9.2	14 days									
5	Proline + NIS	5	first appl.	5.7	6.4	15.4	13.1	262.3	31.9	8369.5	91.4	43.8
	Super Tin 4L	8	14 days									
	Gem 500 SC	3.5	14 days									
6	Eminent	13	first appl.	5.1	6.5	15.5	13.0	259.7	31.4	8146.1	90.4	48.8
	Super Tin 4L	8	14 days									
	Gem 500 SC	3.5	14 days									
7	Inspire XT	7	first appl.	5.5	6.5	15.4	13.0	260.3	31.0	8056.1	91.0	56.8
	Super Tin 4L	8	14 days									
	Gem 500 SC	3.5	14 days									
8	Proline + NIS	5	first appl.	5.7	6.7	15.4	13.0	259.5	31.8	8252.4	90.9	51.3
	Super Tin 4L	8	14 days									
	Priaxor	6.7	14 days									
9	Eminent	13	first appl.	5.5	6.7	15.6	13.3	265.3	33.0	8749.0	91.5	47.8
	Super Tin 4L	8	14 days									
	Priaxor	6.7	14 days									
10	Inspire XT	7	first appl.	5.8	6.8	15.5	13.1	262.4	28.3	7424.2	91.0	38.5
	Super Tin 4L	8	14 days									
	Priaxor	6.7	14 days									
11	Proline + NIS	5	first appl.	5.3	6.5	15.7	13.3	266.1	30.8	8198.5	91.2	38.8
	Super Tin 4L	8	14 days									
	Headline	9.2	14 days									
	Super Tin 4L	8	14 days									
12	Eminent	13	first appl.	4.9	6.3	15.5	13.1	260.8	29.8	7731.6	90.8	48.8
	Super Tin 4L	8	14 days									
	Headline	9.2	14 days									
	Super Tin 4L	8	14 days									
13	Inspire XT	7	first appl.	5.6	6.8	15.1	12.7	254.9	28.3	7183.9	91.1	54.3
	Super Tin 4L	8	14 days									
	Headline	9.2	14 days									
	Super Tin 4L	8	14 days									
14	Proline + NIS + EBDC	5 + 48	first appl.	6.6	7.3	15.5	13.2	263.8	26.6	7014.2	91.5	47.3
	Super Tin 4L	8	14 days									
	Headline + EBDC	9.2 + 48	14 days									
15	Proline + NIS	5	first appl.	4.4	5.9	15.5	13.1	261.3	31.6	8197.5	90.9	44.3
	Super Tin 4L + Topsin	8 + 10	14 days									
	Headline	9.2	14 days									
16	Super Tin 4L	8	first appl.	4.6	6.1	15.2	12.8	255.4	28.7	7335.8	90.7	54.3
	Proline + NIS	5	14 days									
	Headline	9.2	14 days									
17	Super Tin 4L	8	first appl.	5.5	6.8	15.1	12.8	254.4	29.5	7495.7	90.9	56.8
	Eminent	13	14 days									
	Headline	9.2	14 days									
18	Super Tin 4L	8	first appl.	5.8	7.3	15.1	12.7	253.3	30.3	7665.7	90.6	49.0
	Inspire XT	7	14 days									
	Headline	9.2	14 days									
19	Eminent	13	first appl.	5.9	6.8	15.4	13.1	261.1	30.7	8006.3	91.4	48.8
	Super Tin 4L	8	14 days									
	Headline + Max-In Manganese	9.2 + 32	14 days									
20	Eminent	13	first appl.	5.6	6.5	15.2	12.7	253.5	30.6	7779.6	90.5	63.0
	Super Tin 4L	8	14 days									
	Headline + Max-in Boron	9.2 + 16	14 days									
Mean				5.6	6.7	15.4	13.0	259.1	30.3	7843.1	90.9	51.3
%CV				12.4	6.5	2.6	3.7	3.7	8.9	9.3	1.0	24.9
Pr>F				<0.0001	<0.0001	<0.0001	0.0007	0.0007	0.1500	0.0091	0.9079	<0.0001
LSD (0.05)				1.0	0.6	0.6	0.7	13.5	NS	1038.2	NS	18.1
Reps				4	4	4	4	4	4	4	4	4

SWINE MANURE APPLICATION MANAGEMENT IN A SUGAR BEET ROTATION

John A. Lamb[1], Mark W. Bredeheoft[2], Jim Radermacher[2], Nicole VanOs[2], Chris Dunsmore[2], and Mark Bloomquist[2]
[1]Department of Soil, Water, and Climate, University of Minnesota, St. Paul, Minnesota and [2] Agricultural Research Department, Southern Minnesota Beet Sugar Cooperative, Renville, Minnesota

Justification of Research: 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? Nitrogen from swine manure can be 80 % available in the year after application. 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 swine manure be applied 2) determine nitrogen fertilizer equivalent of swine manure applied one, two, and three years in advance of sugar beet production, and determine the affect of over fertilization with N on the quality, root yield, and summer petiole nitrate-N.

Summary of Literature Review: Little recent information is available on the effect of manure on sugar beet root yield and quality. Halvorson and Hartman (1974) reported that sucrose concentration and recoverable sugar per acre were reduced with the addition of beef manure while root yield was increased. Schmitt et al. (1996) reported that swine manure mineralization occurs several years after application in a legume-corn rotation. Swine manure was found to be 80 to 90 % available in the first year of application for corn production.

In a study conducted from 1999 to 2001, Lamb et. al 1999, 2000, and 2001 reported the effect of swine manure applied the prior fall on sugar beet production. The quality was reduced. Root yield was increased to the point that the increase compensated for the loss in quality. Results from applications made further ahead of sugar beet production were not reported because stand problems.

Objectives:

1. Determine when in a three year rotation, should swine manure be applied.
2. Determine nitrogen fertilizer equivalent of swine manure applied one, two and three years in advance of sugar beet production.
3. Determine the affect of over fertilization with N on the quality, and root yield.

Materials and Methods: An experiment was conducted at three locations in the Southern Minnesota Beet Sugar Cooperative growing area over a period of seven years to meet the stated objectives. The locations were near Prinsburg, Raymond, and Montevideo, Minnesota. The experiment included four replications of the treatments listed in Table 1. Swine manure treatments were applied at a rate of 3500 gallons per acre 1, 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 1 is the check treatment for the whole experiment while treatments 9, 17, and 25 are checks for the use of only manure. Treatments 2 through 7 are for N response to fertilizer in sugar beet following a soybean and corn crop fertilized according to University of Minnesota suggestions. Treatments 10 through 16 are for N response of sugar beet after manure application is made before the soybean crop, treatments 17 through 24 are for N response of sugar beet after manure application made before the corn crop, and treatments 25 through 32 are for N response of sugar beet after manure application made before sugar beet production. The N credit treatment was determined based on previous research for corn.

Table 1. Treatment List

Treatment number	Year 1 (soybean)	Year 2 (corn)	Year 3 (sugar beet)
1	No manure	0 N	0 N
2	No manure	120 N	0 N
3	No manure	120 N	30 N
4	No manure	120 N	60 N
5	No manure	120 N	120 N
6	No manure	120 N	150 N
7	No manure	120 N	180 N
8	No manure	0 N	90 N
9	Manure	0 N	0 N
10	Manure	N credit	0 N
11	Manure	N credit	30 N
12	Manure	N credit	60 N
13	Manure	N credit	90 N
14	Manure	N credit	120 N
15	Manure	N credit	150 N
16	Manure	N credit	180 N
17	0 N	Manure	0 N
18	0 N	Manure	30 N
19	0 N	Manure	60 N
20	0 N	Manure	90 N
21	0 N	Manure	120 N
22	0 N	Manure	150 N
23	0 N	Manure	180 N
24	0 N	Manure	N credit
25	0 N	0 N	Manure
26	0 N	120 N	Manure
27	0 N	30 N	Manure
28	0 N	60 N	Manure
29	0 N	90 N	Manure
30	0 N	150 N	Manure
31	0 N	180 N	Manure
32	0 N	210 N	Manure

The Raymond location was established in the fall of 2009. Soybean was grown in 2010, corn in 2011, and sugar beet in 2012. The Prinsburg location was established in the fall of 2010. Soybean, corn, and sugar beet were grown in 2011, 2012, and 2013, respectively. After the loss of a location established in the fall 2011, the final location was near Montevideo and established in the fall of 2012. Soybean, corn, and sugar beet were grown in 2013, 2014, and 2015.

Before the soybean production year, the manure treatments (YR 1) were applied. In the soybean production year, grain yield was determined with a small combine. The year 2 (Yr 2) manure and fertilizer treatments were applied in the late fall after soybean harvest. Corn grain was harvested either by hand or with a plot combine. The year 3 (Yr 3) manure treatments were applied late fall of year 2. Fertilizer treatments were applied in the spring before planting. Root yield and quality was determined in the fall. In each of the production years, optimum production practices for pest control and nutrient management besides nitrogen were used.

Results and Discussion:

Soybean: Soybean was grown as the first crop in the rotation. The only treatment that was applied before soybean production was manure. The application of manure did not affect soybean grain yield at 2 of the 3 sites, Table 2. At the Montevideo site, the use of manure increase grain yields 6 bushels per acre. This is very similar to what has been reported in other studies conducted in Minnesota. Predicting when the response will occur is difficult. Application of manure before soybean production is not recommended if the producer has corn acres to apply manure to first. The application has not caused a negative yield response in other research trials.

Table 2. The effect of manure application on soybean grain yield at Prinsburg, Raymond, and Montevideo.

	Prinsburg	Raymond	Montevideo
Treatment	Soybean grain yield (bu/A)		
Manure	42	53	38
No manure	41	52	44
Statistic (P>F)	0.62	0.23	0.0007

Corn: Corn was grown in the second year of the rotation. Table 3 reports the effect of N fertilizer application on corn grain yields. The grain yield response was not statistically strong at any of the sites.

Table 3. The effect of nitrogen fertilizer application on corn grain yield.

N rate	Prinsburg	Raymond	Montevideo
lb N/A	Corn grain yield (bu/A)		
0	215	191	182
30	227	184	184
60	237	192	190
90	237	193	214
120	232	189	209
150	235	200	194
180	235	178	210
210	246	198	202
Statistic (P>F)	0.13	0.16	0.09

Some comparisons between the different manure treatments and the 120 lb N/acre as fertilizer were made, Table 4. At Prinsburg, the application of manure before soybean had the poorest grain yields, while the application of manure just before the corn crop had the greatest grain yields. Application of manure before soybean production with the addition of fertilizer based on the nutrient credit from the manure before corn and the corn treated with 120 lb N/A as fertilizer had similar grain yields. These grain yields were between the corn grain yields for manure applied before soybean and the grain yields for corn with manure applied the fall before corn production. At Raymond and Montevideo, the manure applied before soybean production had smaller corn grain yield compared to the other N treatments. It appears that counting on the manure application before soybean production to supply enough N for corn production later in the rotation was not sufficient. Accounting for the N in the manure applied before the soybean production is important and if it is not enough for the needs of the corn plant then additional N fertilizer will be required.

Table 4. The effect of manure application and nutrient application on corn grain yield.

	Prinsburg	Raymond	Montevideo
Comparison	Corn grain yield (bu/A)		
*Yr 2	246	199	204
**120 lb N/A	232	196	210
***Yr 1 + NC	230	214	207
****Yr 1	206	180	176
Statistics			
Yr 2 vs 120 lb N/A	0.01	0.30	0.74
Yr 1 + NC vs Yr 2	0.004	0.85	0.60
Yr 1 vs Yr 1 + NC	0.04	0.002	0.003

*Yr 2 = manure applied the fall before corn production.
**120 lb N/A = 120 lb N/A applied and incorporated the fall before corn production.
***Yr 1 + NC = Manure applied the fall before previous soybean crop in the soybean, corn, sugar beet rotation plus N fertilizer applied before corn production based on the nutrient credit for the yr1 manure application.
****Yr 1 = Manure applied the fall before previous soybean crop in the soybean, corn, sugar beet rotation.

Sugar beet: *The effect of time of manure application before sugar beet production:* One of the questions that can be answered by this study is what is the effect of time of manure application before sugar beet production. At Prinsburg, the time of manure application significantly affected root yield, sucrose concentration, extractable sucrose per ton, and extractable sucrose per acre, Table 5. For root yield, the closer to sugar beet production the manure was applied, the greater the root yield. Extractable sucrose per acre was increased with the application of manure in the rotation but time of application was not important. The quality parameters were decreased by manure being applied the fall before sugar beet production. Applying manure at other times earlier in the rotation did not affect sucrose concentration or extractable sucrose per ton.

Table 5. The means and statistical analysis for the effect of manure application on sugar beet yield and quality at the Prinsburg site.

	Root yield	Sucrose	Extractable sucrose	
Manure treatment	ton/A	%	lb/ton	lb/A
*None	29.9	17.0	297	8893
**Yr 1	34.0	17.3	301	10242
***Yr 2	36.0	17.4	301	10850
****Yr 3	36.8	16.4	282	10366
Statistic (P>f)	0.04	0.001	0.0002	0.05

* None = No manure or fertilizer applied in rotation.
**Yr 1 = Manure applied fall before soybean production in a soybean, corn, and sugar beet rotation. No fertilizer application.
***Yr 2 = Manure applied fall before corn production in a soybean, corn, and sugar beet rotation. No fertilizer application.
****Yr 3 = Manure applied fall before sugar beet production in a soybean, corn, and sugar beet rotation. No fertilizer application.

At the Raymond site, the results were similar to the Prinsburg site, Table 6. The closer in the rotation that you applied manure, the greater the root yield and extractable sucrose per acre were. The quality parameters, sucrose concentration and extractable sucrose per ton were reduced by the application of manure in the fall before sugar beet production.

Table 6. The means and statistical analysis for the effect of manure application on sugar beet yield and quality at the Raymond site.

	Root yield	Sucrose	Extractable sucrose	
Manure treatment	ton/A	%	lb/ton	lb/A
*None	22.0	16.9	281	5637
**Yr 1	27.5	16.4	270	7390
***Yr 2	28.1	16.7	274	7727
****Yr 3	32.6	15.7	249	8182
Statistic (P>f)	0.06	0.08	0.04	0.09

* None = No manure or fertilizer applied in rotation.
**Yr 1 = Manure applied fall before soybean production in a soybean, corn, and sugar beet rotation. No fertilizer application.
***Yr 2 = Manure applied fall before corn production in a soybean, corn, and sugar beet rotation. No fertilizer application.
****Yr 3 = Manure applied fall before sugar beet production in a soybean, corn, and sugar beet rotation. No fertilizer application.

The results for the Montevideo site are presented in Table 7. Unlike the Prinsburg and Raymond sites, manure application did not affect any of the parameters measured.

Table 7. The means and statistical analysis for the effect of manure application on sugar beet yield and quality at the Montevideo site.

	Root yield	Sucrose	Extractable sucrose	
Manure treatment	ton/A	%	lb/ton	lb/A
*None	25.1	16.3	277	7048
**Yr 1	30.5	16.4	277	8601
***Yr 2	30.8	16.3	279	8592
****Yr 3	27.7	16.6	285	8002
Statistic (P>f)	0.23	0.29	0.20	0.56

* None = No manure or fertilizer applied in rotation.
**Yr 1 = Manure applied fall before soybean production in a soybean, corn, and sugar beet rotation. No fertilizer application.
***Yr 2 = Manure applied fall before corn production in a soybean, corn, and sugar beet rotation. No fertilizer application.
****Yr 3 = Manure applied fall before sugar beet production in a soybean, corn, and sugar beet rotation. No fertilizer application.

At two of the three locations in this study, the closer the application of manure was before sugar beet production, the greater the root yield and extractable sucrose per acre. At those same two sites, the application of manure in the fall before sugar beet production resulted in reduced quality. One last observation for this data is that without any N input for three year before sugar beet was grown, root yields were above 20 tons per acre at all locations. This means the N contribution from the organic matter in the soils is large.

The effect of N fertilization and manure application: Sugar beet was grown in the final year of the rotation. In this study, one objective was to determine if the timing of manure application in the rotation affected N response of sugar beet yield and quality. To meet this objective, we were looking for a manure application by N rate interaction. If there is none then the result would be that manure application has no effect on the response from N fertilizer application before sugar beet production. The statistical analysis for the Prinsburg site is presented in Table 8. At Prinsburg, we did not have an interaction between manure and N fertilizer application for sugar beet root yield, sucrose, extractable sucrose per ton, and extractable sucrose per acre. Manure application and N fertilizer did not affect sucrose concentration or extractable sucrose per ton, Table 8 and 9. Manure application and N fertilizer application did significantly affect root yield and quality. Root yield increased with increasing N fertilizer application rate up to the 150 lb N/A, Table 9. This was also true for extractable sucrose per acre. The closer that you apply manure to the production of sugar beet the greater the root yield and extractable sucrose per acre.

Table 8. The statistical analysis of manure and N fertilizer application on sugar beet root yield and quality at the Prinsburg site.

	Root yield	Sucrose	Extractable sucrose	
			lb/ton	lb/A
Source of variation	Probability of a greater F			
Manure	0.03	0.66	0.57	0.04
N rate	0.0001	0.98	0.95	0.0001
N rate X manure	0.22	0.55	0.92	0.18

Table 9. The effect of manure and N fertilizer application on sugar beet root yield and quality at the Prinsburg site.

N rate	Root yield	Sucrose	Extractable sucrose	
lb N/A	ton/A	%	lb/ton	lb/A
0	32.9	17.1	296	9749
30	33.8	17.2	299	10136
60	35.3	17.1	297	10459
90	36.7	17.2	298	10907
120	37.1	17.0	295	10899
150	38.6	17.1	297	11478
180	38.1	17.1	297	11318
*None	34.4	17.0	294	10088
**Yr 1 + NC	35.1	17.2	299	10489
***Yr 2	38.4	17.2	297	11424

*None = No manure applied in rotation, 120 lb N/A applied and incorporated the fall before corn production.
**Yr1 + NC = Manure applied the fall before previous soybean crop in the soybean, corn, sugar beet rotation plus N fertilizer applied before corn production based on the nutrient credit for the Yr 1 manure application.
***Yr 2 = manure applied the fall before corn production.

At the Raymond site, there was no interaction between manure and fertilizer N application for sugar beet root yield and quality, Table 10. Manure application did not affect any parameter measured while N fertilizer application affected root yield, extractable sucrose per ton, and extractable sucrose per acre, Table 10 and 11. Root yield was increased with fertilizer applications up to 120 lb N/acre. Extractable sucrose per ton was reduced as the N fertilizer rate increased. Extractable sucrose per acre increased with increasing N fertilizer application up to the 60 lb N/A application. The lack of response to manure was surprising. The yield and quality responses to N application were similar to what has occurred in the past.

Table 10. The statistical analysis of manure and N fertilizer application on sugar beet root yield and quality at the Raymond site.

	Root yield	Sucrose	Extractable sucrose	
			lb/ton	lb/A
Source of variation	Probability of a greater F			
Manure	0.88	0.68	0.72	0.66
N rate	0.01	0.14	0.02	0.04
N rate X manure	0.19	0.44	0.60	0.55

Table 11. The effect of manure and N fertilizer application on sugar beet root yield and quality at the Raymond site.

N rate	Root yield	Sucrose	Extractable sucrose	
lb N/A	ton/A	%	lb/ton	lb/A
0	28.7	16.5	272	7792
30	27.8	16.5	270	7537
60	31.3	16.6	272	8539
90	29.8	16.4	264	7836
120	31.8	16.1	259	8203
150	31.2	16.2	259	8104
180	28.7	16.3	263	7546
*None	30.1	16.4	267	8050
**Yr 1 + NC	30.1	16.3	265	7960
***Yr 2	29.6	16.4	265	7833

*None = No manure applied in rotation, 120 lb N/A applied and incorporated the fall before corn production.
**Yr1 + NC = Manure applied the fall before previous soybean crop in the soybean, corn, sugar beet rotation plus N fertilizer applied before corn production based on the nutrient credit for the Yr 1 manure application.
***Yr 2 = manure applied the fall before corn production.

The Montevideo site did have a significant interaction between manure application and fertilizer N application for root yield and extractable sucrose per acre, Table 12. The interesting aspect of this interaction is the lack of root yield and extractable sucrose per acre response to manure and N fertilizer application individually. There was no interaction between manure and fertilizer N application for sucrose concentration and extractable sucrose per ton, but the application of N fertilizer alone, did have a significant effect, Table 12.

To understand the interaction, the means of the effect of N fertilizer at with each manure application management treatment needs to be examined, Table 13. The interaction occurred because of the differing root yield and extractable sucrose per acre responses as the 30 lb N/acre treatment. The trend of the response of root yield and extractable sucrose per acre were not the same at that N rate. When examining the data, there is no good explanation for this situation and it is concluded that random variability caused the differences. Because of this, neither manure or N fertilizer affected root yield and extractable sucrose per acre at this site.

Manure did not significantly affect sucrose concentration or extractable sucrose per ton, Table 12 and 14. As fertilizer N application rate increased, the sucrose concentration and extractable sucrose decreased, Table 14. This result occurs frequently in sugar beet.

Table 12. The statistical analysis of manure and N fertilizer application on sugar beet root yield and quality at the Montevideo site.

	Root yield	Sucrose	Extractable sucrose	
			lb/ton	lb/A
Source of variation	Probability of a greater F			
Manure	0.23	0.54	0.75	0.55
N rate	0.14	0.0008	0.0003	0.17
N rate X manure	0.02	0.91	0.92	0.03

Table 13. The means for the interaction between N fertilizer application and manure application for root yield and extractable sucrose per acre at the Montevideo site.

	Manure			Manure		
	*None	**Yr1 + NC	***Yr 2	*None	**Yr1 + NC	***Yr 2
N rate	Root yield			Extractable sucrose		
lb/A	ton/A			lb/A		
0	22.8	30.9	30.8	6556	8549	8592
30	25.6	23.5	36.1	7235	6634	10032
60	32.2	33.8	33.3	8887	9439	9075
90		28.9	31.7		8293	8982
120	31.5	31.9	26.7	9160	9054	7253
150	33.4	27.7	30.8	9414	7246	7915
180	28.1	29.5	29.0	7636	7756	7613

*None = No manure applied in rotation, 120 lb N/A applied and incorporated the fall before corn production.
**Yr1 + NC = Manure applied the fall before previous soybean crop in the soybean, corn, sugar beet rotation plus N fertilizer applied before corn production based on the nutrient credit for the Yr 1 manure application.
***Yr 2 = manure applied the fall before corn production.

Table 14. The effect of manure and N fertilizer application on sugar beet root yield and quality at the Montevideo site.

N rate	Root yield	Sucrose	Extractable sucrose	
lb N/A	ton/A	%	lb/ton	lb/A
0	28.2	16.4	279	7899
30	28.4	16.4	280	7967
60	33.2	16.2	275	9155
90	30.3	16.5	280	8637
120	29.7	16.5	280	8355
150	30.3	15.8	266	8025
180	29.0	15.9	265	7669
*None	28.3	16.4	280	7969
**Yr 1 + NC	29.6	16.3	275	8162
***Yr 2	31.0	16.1	271	8379

*None = No manure applied in rotation, 120 lb N/A applied and incorporated the fall before corn production.
**Yr1 + NC = Manure applied the fall before previous soybean crop in the soybean, corn, sugar beet rotation plus N fertilizer applied before corn production based on the nutrient credit for the Yr 1 manure application.
***Yr 2 = manure applied the fall before corn production.

Summary:

The effect of timing of manure application in the soybean, corn, sugar beet rotation.

1. Manure significantly affected 2 of the 3 sites.
2. At the 2 sites, manure application increased root yield and extractable sucrose per acre. The closer to sugar beet production the application is the greater the root yield and extractable sucrose per acre response.
3. The application of swine manure in the fall before sugar beet production significantly decreased sugar beet sucrose concentration and extractable sucrose per ton. Depending on the quality payment system, this reduction can be economically significant.

The effect of time of manure application in the rotation and the application N fertilizer before sugar beet production.

1. No interaction occurred between N fertilizer application and manure management at 2 of the 3 sites.
2. N fertilizer rate increased root yield and extractable sucrose per acre at 2 of the 3 sites.
3. Manure management affected root yield and extractable sucrose at 1 site. The closer you apply manure to sugar beet production, the greater the yield. There was no effect at 2 sites.
4. N fertilizer application decreased extractable sucrose per ton at 2 of the 3 sites. This could affect the payment.

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A STRATEGY FOR MANAGING WATERHEMP IN SUGARBEET

Thomas J. Peters[1], Andrew B. Lueck[2] and James Radermacher[3]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist and [2]Research Specialist
North Dakota State University and the University of Minnesota, Fargo, ND and
[3]Research Agronomist, Southern Minnesota Beet Sugar Cooperative, Renville, MN

Summary

1. Making multiple applications of glyphosate in a single season is not a stand-alone strategy for waterhemp control in sugarbeet.
2. UpBeet, Betamix, or UpBeet plus Betamix applied with glyphosate plus ethofumesate improves waterhemp control compared to glyphosate plus ethofumesate, but does not provide season-long waterhemp control.
3. Soil-applied herbicides applied preplant incorporated (PPI) or preemergence (PRE) are effective at controlling waterhemp but may not provide season-long control.
4. Soil-applied herbicides applied postemergence to sugarbeet (lay-by) has provided the most efficacious and consistent waterhemp control across locations and years.

Introduction

Waterhemp continues to be a tough weed to control in fields planted to sugarbeet in Minnesota and eastern North Dakota. Fields with waterhemp as a problem are growing in number as waterhemp seeds are moving, presumably being carried in water, by Canada geese, and by humans who transport farm and service equipment. In 2014, waterhemp was found in sugarbeet fields in southern Cass and Clay Counties in North Dakota and Minnesota. Waterhemp was identified 130 miles north in 2015 or in Walsh County, North Dakota and Polk County, Minnesota.

Waterhemp is a summer annual weed in the pigweed family that can germinate in late May, June, and July in North Dakota and Minnesota which is much later than redroot pigweed or smooth pigweed. Waterhemp germinates and emerges from the soil surface to one-half inch deep in the soil and remains viable in soils from four to six years. A unique feature about waterhemp is male and female flowers are located on separate plants (dioecious). That is, male plants produces pollen and female plants make seed. This unique biology creates tremendous genetic diversity in populations and results in plants that are biologically and morphologically unique. It also has contributed to development of biotypes that are resistant to several herbicide families including ALS inhibitor (2), triazine (5), PPO inhibitor (14), and glyphosate (9) in Minnesota and North Dakota.

Sugarbeet fields in most growing regions received timely precipitation in 2015 that contributed to record sugarbeet yields. The precipitation also benefited waterhemp, especially in areas of fields with an open canopy. Frequent rains and open canopies allowed for multiple flushes of waterhemp in sugarbeet, soybean, and small grain stubble in July and August. Waterhemp was regarded by 46% of farmers who completed the annual survey of weed control and production practices in sugarbeet as their worst weed problem in 2015, well ahead of common ragweed (16%) and lambsquarters (10%).

Researchers and Agriculturalist have developed significant datasets and experiences dating back to waterhemp experiments conducted in sugarbeet near Hector, MN in 2010. Experiments designed to evaluate different approaches for waterhemp control have been conducted each year since 2010. The objectives of 2015 experiments were to: a) evaluate waterhemp control from S-metolachlor, ethofumesate, or S-metolachlor + ethofumesate applied PRE followed by multiple applications of glyphosate; b) evaluate waterhemp control from S-metolachlor, Warrant, or Outlook applied lay-by in sugarbeet; and; c) evaluate waterhemp control from multiple applications of glyphosate + POST herbicide combinations in sugarbeet. The purpose of this report is to summarize research from 2014 and 2015 on waterhemp control in sugarbeet and present our best recommendations for sugarbeet growers to use in their operations.

Materials and Methods

Experiments were conducted on natural populations of waterhemp near Herman and Moorhead, Minnesota in 2015. Plot area was worked by the cooperating farmer with a John Deere field cultivator equipped with rolling baskets on June 4, 2015 at Herman and with a Kongskilde s-tine field cultivator on April 30, 2015, at Moorhead. 'SesVanderhave 36271RR' sugarbeet treated with Tachigaren, Kabina, and Poncho Beta at 45 grams product, 12 grams a.i., and 5.07 fl oz of product, respectively, per 100,000 seeds was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on June 4 and April 30, 2015, respectively. Herbicide treatments were applied at Herman June 4, June 18, and July 7, 2015 and at Moorhead May 1, June 2, and June 19, 2015. All treatments were applied with a bicycle sprayer in 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 30 feet in length in fields with moderate to heavy infestations of glyphosate-resistant waterhemp. Ammonium sulfate (AMS) in all treatments was 'N-Pak' AMS, a liquid formulation from Winfield Solutions. Non-ionic surfactant (NIS) was 'Prefer 90', a product from West Central, Inc.

Sugarbeet injury was evaluated July 7, July 21, and July 31 at Herman, MN, and June 11 and July 1, 2015 at Moorhead, MN. Waterhemp control was evaluated July 7, July 21, and July 31, 2015 at Herman, MN, and June 11, July 1, and August 25, 2015 at Moorhead, MN. Lambsquarters control was evaluated July 21, 2015 at Herman, MN and August 25, 2015 at Moorhead, MN. All evaluations were a visual estimate of percent fresh weight reduction in the four treated rows compared to the adjacent untreated strip. Experimental design was randomized complete block with 4 replications. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package and with the ANOVA procedure as a split-plot analysis to determine interaction effects using SAS Data Management version SAS 9.3 software package.

Table 1. Application information for sugarbeet trials near Herman, MN in 2015.

Application code	A	B	C
Date	June 4	June 18	July 7
Time of Day	4:00 PM	6:00 PM	1:00 PM
Air Temperature (F)	72	71	74
Relative Humidity (%)	55	45	43
Wind Velocity (mph)	4	8	4
Wind Direction	SE	N	SE
Soil Temp. (F at 6")	63	68	66
Soil Moisture	Good	Good	Dry
Cloud Cover (%)	98	15	5
Sugarbeet stage (avg)	PRE	2 lf	8 lf

Table 2. Application information for sugarbeet trials near Moorhead, MN in 2015.

Application code	A	B	C
Date	May 1	June 2	June 19
Time of Day	12:00 PM	8:00 AM	3:00 PM
Air Temperature (F)	75	63	80
Relative Humidity (%)	28	62	45
Wind Velocity (mph)	3	7	7
Wind Direction	NW	SE	SE
Soil Temp. (F at 6")	60	58	66
Soil Moisture	Good	Wet	Good
Cloud Cover (%)	10	95	90
Sugarbeet stage (avg)	PRE	2-4 lf	4-6 lf

Results and Discussion

Sugarbeet experiments were conducted at multiple locations in 2014 and 2015 to evaluate waterhemp control. Waterhemp control ranged from 34% to 66% across experiments and years from either two or three POST applications of Roundup PowerMax (Table 3). In all experiments, Roundup PowerMax was applied with NIS and AMS. The data shown in Table 3 indicate the presence of glyphosate-resistant waterhemp biotypes that were not

Table 3. Waterhemp control from two or three applications of glyphosate[1] at four locations in 2014 and 2015.

	Herman, MN 2014	Herman, MN 2015	Moorhead, MN 2015	Lake Lillian, MN 2015
	----------------------------% waterhemp control[2]---------------------------			
Experiment 1	33	48	60	48
Experiment 2	35	56	34	-
Experiment 3	36	58	66	60
Experiment 4	-[3]	48	39	-

[1]Roundup PowerMax at 28 followed by (fb) 28 fb 22 fl oz/A or Roundup PowerMax at 28 fb 28 fl oz/A; + Prefer 90 NIS at 0.25% v/v + N-Pak AMS at 2.5% v/v

[2]Visual percent waterhemp control at preharvest evaluation

[3]- indicates experiment was not conducted at that location

controlled with multiple full-rate applications of glyphosate. These data are consistent with results from experiments conducted from 2010 through 2013 and conclude that making repeat applications of glyphosate alone is not an effective strategy to control waterhemp in sugarbeet fields.

To help manage weed resistance, university scientists from the Midwest recommend combining glyphosate with 'effective' waterhemp-control herbicides that represent different sites of action (SOA) than glyphosate. In sugarbeet, glyphosate can be applied in combination with Betamix (SOA 5), ethofumesate (SOA 8) and/or UpBeet (SOA 2) for improved waterhemp control. University scientists also recommend using high surfactant methylated oil concentrate (HSMOC) adjuvants when glyphosate is tank-mixed with other herbicides and to apply herbicides to small waterhemp, no more than 2 to 4 inches tall. HSMOC adjuvants were developed to enhance oil-based herbicides without antagonizing glyphosate.

Herbicide mixtures are commonly applied in crops to increase the spectrum of weed control. Waterhemp control from Roundup PowerMax plus ethofumesate at 4 fl oz/A was consistently greater than from Roundup PowerMax alone (Table 4). Numeric improvement in waterhemp control from the addition of ethofumesate to glyphosate was modest (5% to 20%). Improvement in control from addition of ethofumesate may be related to changes in the composition of the cell wall that enable more glyphosate to penetrate. Ethofumesate has been document to increase uptake of other foliar applied herbicides, thus improving season-long control (1,2).

Waterhemp control from Roundup PowerMax + ethofumesate and/or tank-mix herbicides was dependent on location and year (Table 4). For example, waterhemp control was much greater at Moorhead in 2015 compared to Herman in 2014 or 2015 and might be an anomaly. Improved waterhemp control was attributed to three factors observed at Moorhead: 1) herbicide applications were made when waterhemp was small (one to two inches tall); 2) sugarbeet were actively growing; and 3) optimum to excessive soil moisture conditions may have resulted in damping-off of waterhemp population as there was very little further growth and development in June and July.

Tank-mixing Roundup PowerMax + ethofumesate + either Betamix or UpBeet improved numeric waterhemp control 6% to 33% compared to PowerMax +ethofumesate alone but was statistically significant at only one of four locations. However, the three-way mixtures averaged only 72% to 78% waterhemp control across locations, which is insufficient. These data across multiple experiments and multiple years conclude that waterhemp cannot be consistently and effectively controlled by relying solely upon POST herbicides.

Table 4. Waterhemp control from glyphosate alone and glyphosate in combination with broadleaf herbicides in sugarbeet, across locations in 2014 and 2015.

Treatment[1]	Rate	Herman 2014	Herman 2015	Moorhead 2015	Lake Lillian 2015	Average[4]
	(fl oz or oz/A)	% waterhemp control[3]				
PMax[2] / PMax / PMax	**28 / 28 / 22**	36	20	66	61	46
PMax+Etho / PMax+Etho / PMax+Etho	**28+4 / 28+4 / 22+4**	58	40	81	66	61
PMax+Bmix / PMax+Bmix / PMax+Bmix	**28+12 / 28+16 / 22+24**	65	40	86	68	65
PMax+UpBeet / PMax+UpBeet / PMax+UpBeet	**28+0.75 / 28+0.75 / 22+0.75**	51	48	90	69	65
PMax+Etho+Bmix / PMax+Etho+Bmix / PMax+Etho+Bmix	**28+4+12 / 28+4+16 / 22+4+24**	69	73	88	78	78
PMax+Etho+UpBeet / PMax+Etho+UpBeet / PMax+Etho+UpBeet	**28+4+0.75 / 28+4+0.75 / 22+4+0.75**	64	68	93	64	72
PMax+Bmix+UpBeet / PMax+Bmix+UpBeet / PMax+Bmax+UpBeet	**28+4+12 / 28+4+16 / 22+4+24**	64	64	96	83	76
	LSD (0.05)	**20**	**18**	**12**	**NS**	**-**

[1]Treatments of Roundup PowerMax contained Prefer 90 NIS at 0.25% v/v + N-Pak AMS at 2.5% v/v. All other treatments contained Destiny HC at 1.5 pt/A + N-Pak AMS at 2.5% v/v.
[2]PMax=Roundup PowerMax; Etho=Ethofumesate 4SC; Bmix=Des&Phen 8+8; / indicates a different application timing
[3]Visual percent waterhemp control at preharvest evaluation
[4]Average across locations included for visual comparison and has not been analyzed statistically

University scientists from the Midwest also recommend using soil-applied herbicides for waterhemp control. Several soil-applied herbicide options exist in sugarbeet that represent different herbicide SOAs. Eptam and Ro-Neet (SOA 5) must be incorporated immediately after application to about four inches deep. Most sugarbeet growers are not willing to incorporate four inches deep due to soil moisture content in the spring and the detrimental effects this tillage may have on the seedbed and subsequent sugarbeet emergence. Soils following incorporation are also susceptible to losses from wind erosion. Ethofumesate is a good soil-applied herbicide that can be applied PRE but costs $94 per acre broadcast compared to $25 per acre for Dual Magnum (s-metolachlor).

Ro-Neet applied PPI, ethofumesate applied PPI, and ethofumesate applied PRE provided 91, 96, and 98% waterhemp control, respectively, at Lake Lillian, MN in 2015 (Table 5.) This location is characterized with high organic matter and fine textured soils. Ro-Neet and ethofumesate historically have provided good crop safety and weed control in soils in southern Minnesota.

Research has been conducted to evaluate sugarbeet safety and weed control from S-metolachlor since 1985. The research contributed to S-metolachlor being registered in sugarbeet in 2003. However, in its first season, S-metolachlor caused sugarbeet stand loss in fields, presumably due to cold and wet conditions after herbicide applications. In an effort to improve crop safety yet still provide acceptable weed control, recent experiments have evaluated S-metolachlor at low rates (0.5 to 0.75 pt/A) in a systems approach with other sugarbeet herbicides.

S-metolachlor applied PRE at 0.5 or 0.75 pt/A followed by three applications of Roundup PowerMax at 28 / 28 / 22 fl oz/A provided 89 and 94% waterhemp control, respectively, in 2014 at Herman, MN (Table 5). Sugarbeet injury was negligible from all treatments, presumably due to the excellent growing conditions associated with warmer weather. Experiments were planted in early June in 2014 due to wet and cold conditions in late April and for much of May.

The Moorhead and Lake Lillian locations were planted in early May, 2015. The Herman location was planted in early June and had an open canopy into late July due to a significant rhizoctonia rot root infestation. S-metolachlor at 0.5 or 0.75 pt/A followed by Roundup PowerMax at 28 /28 / 22 fl oz/A did not provide season-long waterhemp control at Moorhead or Herman in 2015 (Table 5). Ethofumesate at 1 or 2 pt/A + s-metolachlor tended to improve waterhemp control compared to S-metolachlor alone, but also caused greater sugarbeet injury at Moorhead.

Many factors contribute to the longevity of chloroacetamide herbicides, such as S-metolachlor, in soils with herbicide degradation beginning immediately following application. Research suggests chloroacetamide herbicides are able to control weeds for 35 to 50 days following application (3, 4). Waterhemp does not germinate and emerge until late May and, depending on environmental conditions, will continue to germinate and emerge though July and August. Thus, in a crop such as sugarbeet that has an open canopy for the first half of the growing season, herbicides applied in mid-April or early May will not provide season-long waterhemp control.

Table 5. Sugarbeet injury and waterhemp control from soil-applied herbicide treatments, across locations in 2014 and 2015.

Treatment[1]	Rate	App. Code[3]	Herman 2014	Moorhead 2015	Herman 2014	Herman 2015	Moorhead 2015	Lake Lillian 2015
	pt/A		---% sgbt injury---		---------------% waterhemp control[4]----------------			
Ro-Neet SB	**5.3**	A	8	19	91	76	65	91
Ethofumesate 4SC	**6 /7[2]**	A	8	11	74	74	79	98
Ethofumesate 4SC	**6 / 7[2]**	B	3	4	70	79	86	96
S-metolachlor	**0.5**	B	6	5	89	63	61	90
S-metolachlor	**0.75**	B	9	13	94	61	74	91
S-metolachlor	**1**	B	9	18	100	69	70	92
S-metolachlor	**2**	B	10	28	99	74	85	97
Etho+S-meto[5]	**1+0.5**	B	-	11	-	71	71	96
Etho+S-meto	**2+0.5**	B	-	11	-	73	56	81
Etho+S-meto	**1+1**	B	-	20	-	76	75	97
Etho+S-meto	**2+1**	B	-	15	-	74	83	99
Etho+S-meto	**1+2**	B	-	31	-	79	89	96
Etho+S-meto	**2+2**	B	-	36	-	88	90	97
No soil Herbicide			-	14	33	48	60	48
LSD (0.05)			**8**	**10**	**9**	**12**	**10**	**11**

[1]Treatments all included Roundup PowerMax at 28 fb 28 fb 22 fl oz/A + Prefer 90 NIS at 0.25% v/v + N-Pak AMS at 2.5% v/v
[2]Ethofumesate at 6 pt in 2014; 7 pt in 2015.
[3]Application codes are A = preplant incorporated (PPI) and B = preemergence (PRE)
[4]Visual percent waterhemp control at preharvest evaluation
[5]Etho+S-meto = Ethofumesate 4SC plus S-metolachlor

The concept of 'lay-by' is to use soil-applied herbicides after crop emergence but before weed emergence. In sugarbeet, S-metolachlor, Warrant, and Outlook can be applied POST to sugarbeet after sugarbeet have reached the two-leaf stage. Timely precipitation is required for activation since neither S-metolachlor, Warrant, nor Outlook control emerged weeds. Research conducted in 2015 suggests waterhemp emerges in Minnesota and North Dakota near the end of May. Thus, lay-by herbicide applications can be timed to waterhemp emergence rather than sugarbeet planting date. Six weeks of waterhemp control, beginning in mid-May, may extend the window for waterhemp control through June and early July or until sugarbeet canopy closure.

S-metolachlor, Warrant, and Outlook were applied lay-by at multiple locations in 2014 and 2015. Locations represented experiments with early sugarbeet planting (Moorhead, 2015) late sugarbeet planting (Herman, 2014 and Herman, 2015), and an open sugarbeet canopy (Herman, 2015). Glyphosate at 28 fl oz/A + ethofumesate at 4 fl oz/A was applied in combination with lay-by herbicides to control emerged weeds. Waterhemp control tended to be more consistent across locations and years from herbicides applied lay-by (Figure 1) compared to waterhemp control from herbicides applied PRE followed by POST (Table 5) or POST only (Table 3, Table 4). Outlook tended to provide more consistent waterhemp control than S-metolachlor or Warrant.

Waterhemp control may be related to herbicide solubility and resultant herbicide activation. Outlook is more water soluble than S-metolachlor or Warrant and thus, the more easily activated (4). Warrant is the least water soluble of the chloroacetamide herbicides and thus, most dependent on timely and significant precipitation for activation. Significant precipitation occurred four days after lay-by application and precipitation totals were 1.7 inches, two weeks after lay-by application at Moorhead, 2015. Similar precipitation totals occurred during the two week interval following lay-by application at Herman, 2015 but precipitation was more events and less total precipitation per event. Thus, activation of S-metolachlor and Warrant may not have occurred as quickly or as completely.

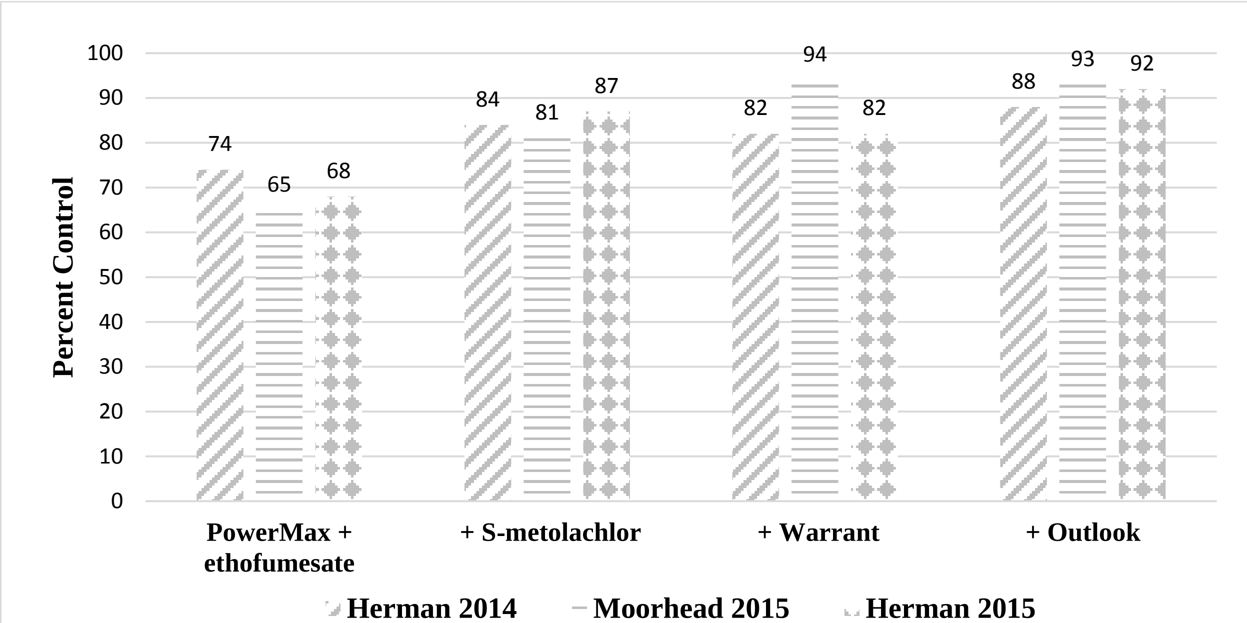

Figure 1. Waterhemp control from glyphosate plus ethofumesate and lay-by herbicides at different locations in 2014 and 2015.

There is a risk in relying on lay-by applications, that timely precipitation may not occur and thus, not activate herbicide. Preemergence herbicides followed by chloracetamide herbicides lay-by is a systems approach that may provide early-season broadleaf control including lambsquarters and redroot pigweed and available herbicide for waterhemp control until lay-by application is activated by precipitation. PRE fb lay-by may improve consistency of season-long control of waterhemp across environments.

S-metolachlor at 0.5 pt/A applied PRE followed by S-metolachlor, Outlook or Warrant provided near complete lambsquarters control and improved the consistency of waterhemp control at Herman and Moorhead in 2015 (Table 7, Table 8, Figure 2). Waterhemp control tended to be greater when S-metolachlor was applied PRE fb lay-by, compared to lay-by alone, Figure 3).

Sugarbeet stands at Herman were compromised by a severe rhizoctonia root rot infestation that compromised sugarbeet stand and confounded sugarbeet injury evaluation from herbicide treatments. Sugarbeet safety from glyphosate, lay-by or PRE fb lay-by was negligible at Moorhead.

These results are promising but are from two locations and one year’s data. Further research is needed to evaluate more environments and other variations on the PRE fb lay-by concept including ethofumesate fb lay-by, splitting lay-by applications, or ethofumesate or S-metolachlor fb split lay-by.

Table 7. Sugarbeet injury, waterhemp, and lambsquarters control from lay-by herbicide treatments at Herman, MN in 2015.

		App.	Sgbt		Waterhemp			Lambquarters
Treatment[1]	**Rate**	Code[2]	Jul 7	Jul 21	Jul 7	Jul 21	Jul 31	Jul 21
	fl oz or pt (p)/A		---% injury---		----------------% control----------------			
PMax[3]+Etho / PMax+Etho	**28+4 / 28+4**	B / C	10	28	68	74	61	100
PMax+Etho+Dual / PMax+Etho	**28+4+1.25p / 28+4**	B / C	10	21	86	93	83	100
PMax+Etho+War / PMax+Etho	**28+4+3.25p / 28+4**	B / C	13	26	85	83	73	100
PMax+Etho+Out / PMax+Etho	**28+4+18 / 28+4**	B / C	13	30	94	94	89	100
Dual / PMax+Etho+Dual / PMax+Etho	**0.5p / 28+4+1p / 28+4**	A / B / C	13	30	93	89	87	100
Dual / PMax+Etho+War / PMax+Etho	**0.5p / 28+4+3p / 28+4**	A / B / C	7	20	96	93	83	100
Dual / PMax+Etho+Out / PMax+Etho	**0.5p / 28+4+18 / 28+4**	A / B / C	10	25	96	99	96	100
LSD (0.10)			**13**	**12**	**6**	**10**	**13**	**NS**
CV			**98**	**43**	**7**	**10**	**14**	**0**

[1]Treatments of Roundup PowerMax contained Destiny HC at 1.5 pt/A + N-Pak AMS at 2.5% v/v
[2]Application codes refer to the information in Table 1
[3]PMax=Roundup PowerMax; Dual=Dual Magnum; War=Warrant; Out=Outlook; Etho=Ethofumesate 4SC

Table 8. Sugarbeet injury, waterhemp, and lambsquarters control from lay-by herbicide treatments at Moorhead, MN in 2015.

		App.	Sgbt		Waterhemp			Lambsquarter
Treatment[1]	**Rate**	Code[2]	Jun 11	Jul 1	Jun 11	Jul 1	Aug 25	Aug 25
	fl oz or pt (p)/A		---% injury---		-----------------% control----------------			
PMax+Etho / PMax+Etho	**28+4 / 28+4**	B / C	5	10	59	74	63	100
PMax+Etho+Dual / PMax+Etho	**28+4+1.25p / 28+4**	B / C	5	13	66	86	65	98
PMax+Etho+War / PMax+Etho	**28+4+3.25p / 28+4**	B / C	10	0	87	94	95	100
PMax+Etho+Out/ PMax+Etho	**28+4+18 / 28+4**	B / C	4	3	88	96	94	95
Dual / PMax+Etho+Dual / PMax+Etho	**0.5p / 28+4+1p / 28+4**	A / B / C	0	3	98	92	91	99
Dual / PMax+Etho+War / PMax+Etho	**0.5p / 28+4+3p / 28+4**	A / B / C	0	5	97	99	99	100
Dual / PMax+Etho+Out / PMax+Etho	**0.5p / 28+4+18 / 28+4**	A / B / C	5	8	98	98	91	100
LSD (0.10)			**7**	**11**	**17**	**14**	**17**	**7**
CV			**308**	**189**	**19**	**14**	**19**	**6**

[1]Treatments of Roundup PowerMax contained Destiny HC at 1.5 pt/A + N-Pak AMS at 2.5% v/v
[2]Application codes refer to the information in Table 1
[3]PMax=Roundup PowerMax; Dual=Dual II Magnum; War=Warrant; Out=Outlook; Etho=Ethofumesate 4SC

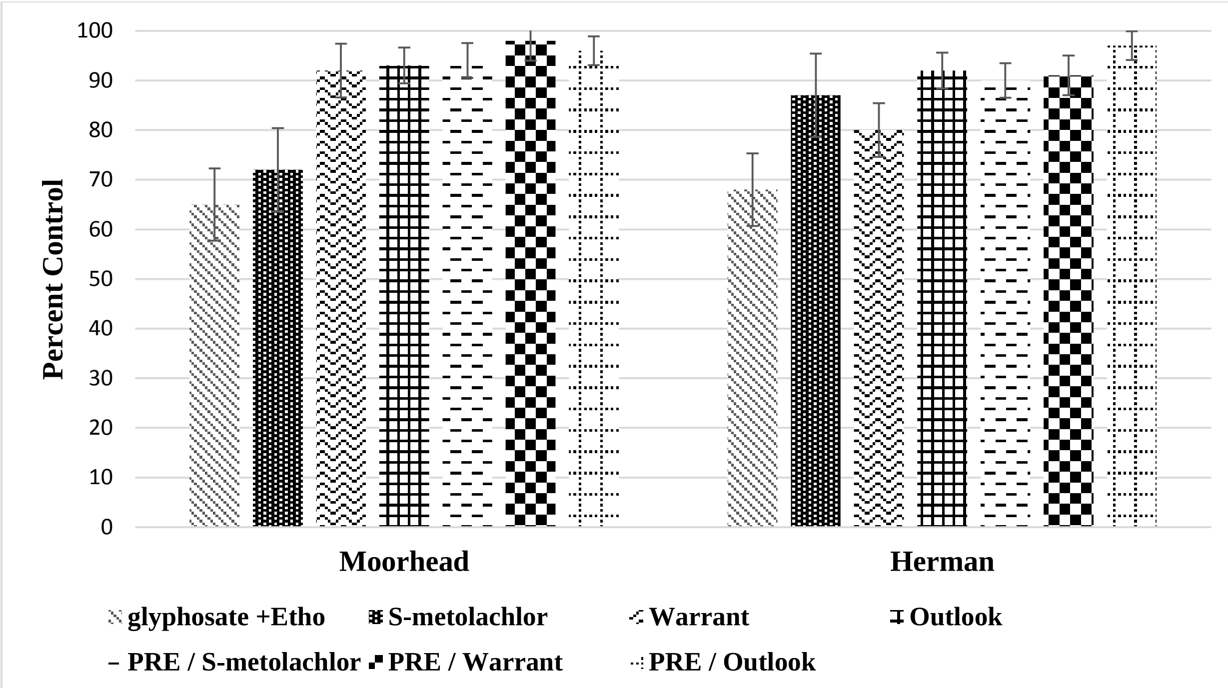

Figure 2. Waterhemp control[1] from lay-by herbicides[2] and PRE S-metolachlor followed by lay-by herbicides, at Herman, MN and Moorhead, MN in 2015.

[1]Standard deviation for herbicide comparisons by location

[2]Etho = ethofumesate

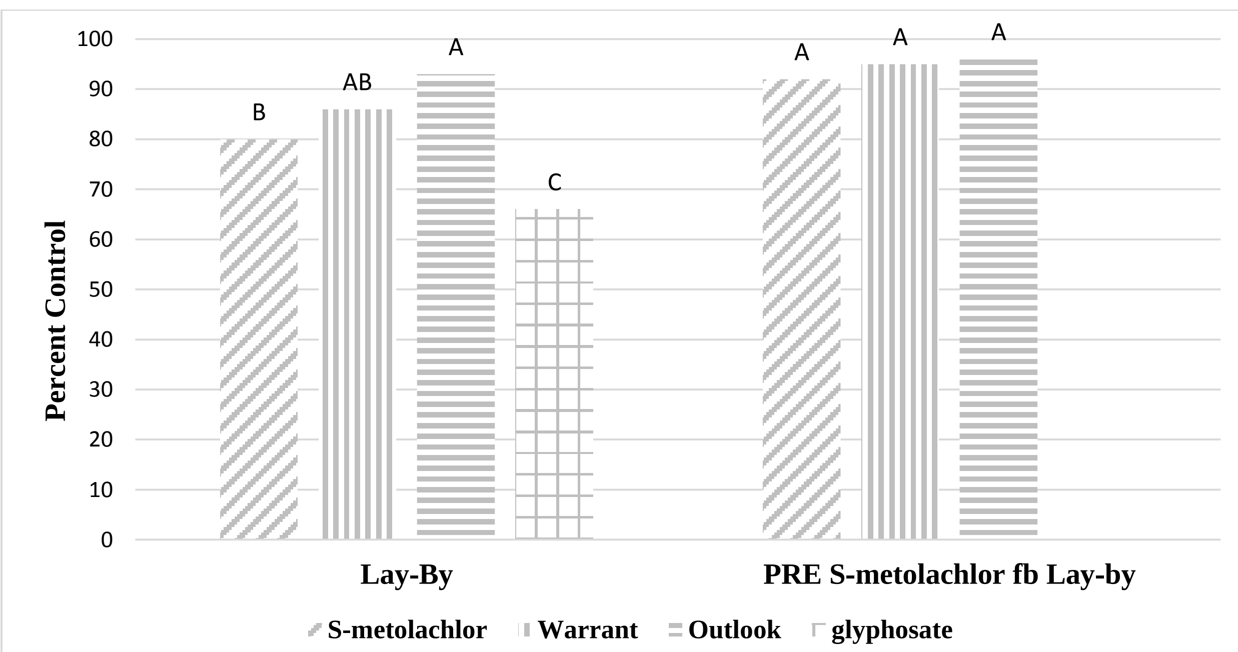

Figure 3. Waterhemp control from lay-by herbicides and PRE S-metolachlor followed by lay-by herbicides, averaged across Herman, MN and Moorhead, MN in 2015.

Sugarbeet planting date is the first consideration for waterhemp control recommendation (Table 9). Lay-by or split lay-by of chloroacetamide herbicides is the preferred approach for waterhemp control for early planted sugarbeet. Use PRE followed by a single lay-by application for fields with early germinating weeds or to manage the risk of uncertainty with activation of lay-by herbicide.

Late planted sugarbeet may not reach the sugarbeet 2-lf stage by May 15 or the date for lay-by application of chloroacetamide herbicides. Thus, S-metolachlor or ethofumesate should be applied PRE followed by lay-by. Timing of lay-by will be dependent on sugarbeet planting date, precipitation to activate PRE, and waterhemp pressure in the field.

Continue to scout sugarbeet fields for waterhemp in July and August. Tank-mixes of Betamix or UpBeet with Roundup plus ethofumesate are recommended for POST waterhemp control. Apply in combination with HSMOC at 1.5 pt/A and AMS at 8.5 to 17 lb/100 gallon water carrier.

Table 9. Recommendation for waterhemp control in sugarbeet, by planting date.

Planting Date	**Recommendation**
Plant Sugarbeet in April	Split application of chloroacteamide herbicides applied lay-by, 2-lf fb 4-6 lf
	Lay-by when sugarbeet is at the 2-lf stage or greater
	S-metolachlor or ethofumesate PRE followed by a single lay-by application
Plant Sugarbeet in May	S-metolachlor or ethofumesate PRE followed by a single lay-by at the full two leaf stage (4-lvs if PRE received good activating rainfall)
Mid July and August	Continue to scout fields for late germinating waterhemp
	Be prepared to rescue with Betamix + ethofumesate, UpBeet+ ethofumesate or Betamix + UpBeet

Future Research

2016 experiments will continue to explore a systems approach for waterhemp control that combines PRE and POST herbicides. The major focus will be on lay-by applications of soil-applied herbicides in sugarbeet. Waterhemp control and sugarbeet injury from lay-by applications will be compared to PRE followed by lay-by, split-layby, or PRE followed by split lay-by applications.

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SPRING-SEEDED CEREALS AS COVER CROPS IN SUGARBEET

Thomas J. Peters[1], Andrew B. Lueck[2], Mike Metzger[3] and James Radermacher[4]

[1]Extension Sugarbeet Agronomist and Weed Control Specialist and [2]Research Specialist
North Dakota State University and the University of Minnesota, Fargo, ND
[3]General Agronomist, Minn-Dak Farmers Cooperative, Wahpeton, ND
[4]Research Agronomist, Southern Minnesota Beet Sugar Cooperative, Renville, MN

Summary

1. Spring-seeded oat cover crop tolerates soil-applied S-metolachlor and ethofumesate better than barley and wheat.
2. S-metolachlor at 0.5 and 1 pt/A is safe on oat but S-metolachlor at 1 pt/A can greatly reduce barley and wheat ground cover. Ethofumesate at 1 pt/A may be applied only when oat is used as a spring-seeded cover crop.
3. Terminate wheat cover crop no later than the sugarbeet 6-leaf stage to maximize sugarbeet yield and extractable sucrose.
4. Wheat cover crop suppresses broadleaf weed emergence compared to no cover crop. Preliminary research suggests seeding rate from 0.75 to 1.5 bu/A would maximize the benefit.

Introduction

Farmers use spring-seed cover crops as a companion crop in sugarbeet for various reasons. Cover crops protect sugarbeet from high winds or damage from blowing soil. While the immediate benefit is to protect sugarbeet stands, cover crops reduce soil erosion which benefits soil health and is a best management practice that improves the sustainability of agriculture. There are other benefits. Farmers who produce sugarbeet for Southern Minnesota Beet Sugar Coop seed spring-seeded cereals as cover crops in exchange for phosphorus credits in cooperation with the Minnesota Pollution Control Agency, ultimately contributing to processing capacity.

The farmer has other management considerations when he/she elects to seed cover crops as a component in the sugarbeet production system. For example, soil-applied herbicides, used for waterhemp control, may injure certain cover species and negatively impact cover crop stand. Second, timing of cover crop termination is important since actively growing cover crops may reflect solar energy away from sugarbeet and negatively impact extractable sucrose (lb/A). Finally, there are indications that cover crops suppress germination and emergence of broadleaf weeds, at least early in the season.

Use of spring-seeded cover crops is important in eastern North Dakota and Minnesota. Farmers that participated in the annual growers survey reported spring-seeded cover crops usage on 49% of the sugarbeet acres in 2015 (Table 1) or a 5% increase from 2014 survey results. The goal of this article is to share information about cover crops so that farmers may realize a positive first experience from cover crop usage. The following report is a product of three years' experience with cover crops and is designed to address questions and technical challenges so that use of cover crops in sugarbeet maintains or increases its importance in 2016.

This report includes: a) a summary of three years' experience evaluating the impact of soil-applied herbicides on spring-seeded cereal cover crops; b) the effect of timing of cover crop removal on pounds per acre extractable sugar; and c) the effect of increasing cover crop density on suppression of broadleaf weeds in sugarbeet.

Table 1. Percent of sugarbeet acres seeded with various cover crops in 2015, by county.

County	No. of responses	Acres planted	Barley	Oat	Wheat	Rye	Other	No Cover Crops
			------------------------% of acres planted------------------------					
Cass	3	1,434	28	-	-	-	-	72
Chippewa[1]	14	7,976	6	59	15	-	-	20
Clay[2]	6	3,148	32	-	-	-	-	68
Grand Forks	4	5,143	40	-	-	-	-	60
Kittson	3	1,820	7	-	-	-	-	93
Marshall	2	1,425	-	-	-	-	-	100
Norman	3	3,404	75	-	-	-	-	25
Pembina	3	2,159	-	-	54	-	-	56
Polk[3]	14	6,486	24	-	-	-	-	76
Renville[4]	15	9,246	-	17	40	-	-	43
Richland	5	6,095	43	-	37	4	-	16
Traverse[5]	5	4,605	33	-	18	-	-	49
Walsh	4	1,985	-	-	20	-	-	80
Wilkin	9	3,850	53	-	3	-	-	44
Total	90	58,776	25	10	15	<1	-	51

[1]Includes Kandiyohi, Swift and Pope Counties
[2]Includes Becker County
[3]Includes Pennington County
[4]Includes Redwood and Yellow Medicine Counties
[5]Includes Grant County

Materials and Methods

<u>Impact of soil-applied herbicides on spring-seeded cereal cover crops</u>

Experiments were conducted near Foxhome, Minnesota in 2015. The experimental area was prepared using an Alloway Seedbetter equipped with rolling baskets on April 30, 2015. Experiment was a randomized complete block design (RCBD) with four replications in a split-plot arrangement with the whole plot being cover crop species and the subplot being herbicide. Each herbicide rate for a given herbicide was treated as a separate subplot. Barley, oat and wheat were broadcast applied at 1 bu/A utilizing an Earthway 3400 handheld spreader (Earthway Products Inc., Bristol, IN) before being incorporated using a Melroe spring-tooth drag. 'Crystal 981RR' sugarbeet treated with Tachigaren, Kabina, and Poncho Beta at 45 grams product, 12 grams a.i., and 5.07 fl oz of product, respectively, per 100,000 seeds was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre the same day.

Preemergence herbicides (sub-plot treatments) were applied with a bicycle sprayer at 15 gallons per acre (gpa) spray solution through 8002 flat fan nozzles pressurized with CO_2 at 40 pounds per square inch (psi). Herbicides were applied to the center four rows of six row plots 25 feet in length.
Glyphosate at 32 fl oz/A was applied on June 9th and June 30th for weed control. Each application of glyphosate included ammonium sulfate at 8.5 lb per 100 gal water. Fungicides were applied July 21, August 4, and August 18, 2015 to control Cercospora leaf spot.

Cover crop suppression was evaluated June 10, 2015. Evaluations were a visual estimate of percent biomass reduction in the four treated rows compared to the adjacent untreated strips. Leaf Area Index (leaf area/ground area) was calculated via imagery acquired on July 7, 2015 utilizing a DJI Phantom 3 Professional UAV (DJI - Shenzhen, China) and Easy Leaf Area Software (Plant Sciences Dept. – Univ of CA) for each individual sub-plot. Data were analyzed with the ANOVA procedure of Agricultural Research Manager (ARM), version 2015.6 software package and with the ANOVA procedure as a split-plot analysis to determine interaction effects using SAS Data Management version SAS 9.3 software package.

Timing of cover crop removal in sugarbeet

Experiments were conducted near Prosper, North Dakota in 2015. Urea fertilizer was applied at 80 lb/A and incorporated using a Kongskilde s-tine field cultivator equipped with rolling baskets on April 16, 2015. Wheat was spread perpendicular to plots across the experimental area with a 3-point mounted rotary spreader at 1 bushel per acre and incorporated with tillage prior to planting sugarbeet. Hilleshog 'HM4022RR' sugarbeet treated with Cruiser 5FS at 60 gm ai, Apron XL at 15 gm ai, and Maxim 4FS at 2.5 gm a.i., respectively, per 100,000 seeds was planted 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on April 16, 2015. Counter 20G insecticide at 9 lb/A was applied in a 5-inch band and drag-chain incorporated at planting. Wheat cover crop was terminated by applying glyphosate on various dates that corresponded to wheat growth height. All treatments were applied with a bicycle sprayer at 17 gpa spray solution through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots 30 feet in length. Glyphosate was applied in combination with 'Prefer 90' NIS at 0.25% v/v and 'N-Pak' ammonium sulfate (AMS) at 2.5% v/v.

Table 2. Application information for timing of cover crop removal in sugarbeet, Prosper, ND in 2015.

Application code	A	B	C	D	E
Date	May 20	May 22	May 27	June 2	June 7
Time of Day	6:00 PM	6:00 PM	12:00 PM	3:00 PM	12:30 PM
Air Temperature (F)	67	74	75	78	80
Relative Humidity (%)	23	24	46	51	32
Wind Velocity (mph)	5	3	3.5	15	5
Wind Direction	NW	SE	N	S	NW
Soil Temp. (F at 6")	58	62	58	62	62
Soil Moisture	Good	Good	Good	Wet	Good
Cloud Cover (%)	40	20	5	70	5
Sugarbeet stage (avg)	2 lf	2-4 lf	4 lf	4-6 lf	6 lf
Cover Crop (untreated avg)	2-4"	4"	6"	8"	10-12"

Cercospora leaf spot was controlled with Agri Tin + Topsin at 6 + 7.6 fl oz/A, Proline + Induce at 5 fl oz/A + 0.125% v/v and Headline SC 9 fl oz broadcast on July 16, August 4, and August 27, respectively. Sugarbeet was harvested September 17, 2015 from the center two rows of each plot and weighed. Twenty to thirty pounds of sugarbeet were collected from each plot and analyzed for quality at American Crystal Sugar Quality Lab, East Grand Forks, MN. Experiments were RCBD with eight replications. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package.

Weed suppression with cover crops in sugarbeet

Experiments were conducted on natural populations of waterhemp, lambsquarters, and redroot pigweed near Moorhead, Minnesota in 2015. The experimental area was tilled using a Kongskilde s-tine field cultivator equipped with rolling baskets on April 30, 2015. Hilleshog 'HM4022RR' sugarbeet treated with Cruiser 5FS at 60 gm ai, Apron XL at 15 gm ai, and Maxim 4FS at 2.5 gm ai, respectively, per 100,000 seeds was seeded 1.25 inches deep in 22 inch rows at 60,825 seeds per acre on April 30, 2015. Wheat at the appropriate weight per area was premeasured and hand-spread across plots to simulate various cover crop density. Assure II at 6 fl oz/A was applied with a bicycle sprayer at 17 gpa through 8002 XR flat fan nozzles pressurized with CO_2 at 40 psi to the center four rows of six row plots on June 2, 2015 to terminate cover crop and improve ease of data collection.

Visual percent broadleaf weed control, weed counts per meter square, and cover crop counts per meter square were collected on June 11, 2015. Data were analyzed with the ANOVA procedure of ARM, version 2015.6 software package.

Results and Discussion

Impact of soil-applied herbicides on spring-seeded cereal cover crops

Similar experiments were conducted in 2013 and 2014. Oat response to soil-applied herbicides varied by herbicide. Oat was more tolerant of S-metolachor than ethofumesate in experiments conducted near Herman, MN, and Prosper, ND, in 2013 (1, 2). Stand counts, plant height, and visual ground cover from S-metolachlor applied preemergence (PRE) at 0.5 or 1.0 pt/A was similar to the untreated check. Ethofumesate applied PRE at 3 pt/A significantly shortened oat and reduced stand per unit area at Prosper and Herman, but did not affect ground cover at Lake Lillian in 2014 (3).

A barley cover-crop experiment was planted near Foxhome, MN, and wheat cover-crop experiments were planted near Crookston, MN, and Herman, MN, in 2014 (3). As with oat, barley and wheat response to soil-applied herbicides was dependent on herbicide and herbicide rate. S-metolachlor was safer to barley and wheat than ethofumesate. S-metolachlor at 0.5 pt/A tended to be safer to barley and wheat than S-metolachlor at 1 pt/A. Despite the difference in crop response to s-metolachlor rates, there was satisfactory barley and wheat ground cover to protect sugarbeet seedlings from wind or blowing soil, even following application of S-metolachlor at 1 pt/A. In general, oat was more tolerant of S-metolachlor and ethofumesate than barley or wheat and barley was affected less by soil-applied herbicides than wheat.

Water solubility and absorption may partially explain differential herbicide response. S-metolachlor is more water soluble than ethofumesate and is taken up by cereals through the shoot, just above the seed (4). Thus, precipitation moves S-metolachlor past the shoots of developing cereals. Ethofumesate requires more precipitation to move it from the seeding zone and is taken up by both cereal roots and shoots, thus, increasing the potential for injury. Since barley, oat and wheat were planted at different locations and experienced different environmental conditions, comparisons of impact of herbicide and herbicide rate on cover crop injury across cereal species was not possible.

Impact of soil-applied herbicides on spring-seeded barley, oat and wheat cover crops was evaluated at Foxhome, MN, Lake Lillian, MN, and Prosper, ND, in 2015. Barley, oat, and wheat tolerated S-metolachlor or ethofumesate at Prosper, ND, in 2015, presumably because precipitation to activate the herbicides did not occur until four weeks after seeding date or until cereals had germinated and emerged. This outcome demonstrates the importance of the interaction among soil-applied herbicides, spring-seeded cereal cover crops, and precipitation. At Lake Lillian, neither S-metolachlor nor ethofumesate affected barley, oat, or wheat stand. Ethofumesate at 2 pt/A tended to reduce barley, oat, and wheat visual ground cover compared to ethofumesate at 1 pt/A, S-metolachlor at 0.5 or 1 pt/A, and the untreated check. Similarly to the results from Prosper, the results from Lake Lillian presumably are attributed to lack of significant precipitation the first two weeks after planting.

Barley, oat, and wheat response to soil-applied herbicides varied by herbicide and rate at Foxhome (Table 3, Figure 1). S-metolachlor or ethofumesate, soil-applied, damaged oat the least and wheat the most. S-metolachlor at 0.5 pt/A was safest of all herbicide treatments evaluated, but reduced barley, oat, and wheat ground cover compared to the untreated check. Increasing the S-metolachlor rate from 0.5 to 1 pt/A decreased oat, barley and, wheat ground cover. Ethofumesate injured cover crops more than S-metolachlor. Oat tolerated ethofumesate at 1 pt/A, but oat ground cover was reduced from ethofumesate at 2 pt/A. Ethofumesate at either 1 or 2 pt/A significantly reduced barley and wheat ground cover compared to S-metolachlor at 0.5 pt/A.

Table 3. Impact of soil-applied herbicide on barley, oat, and wheat ground cover 35 days after planting near Foxhome, MN 2015

Herbicide Treatment	Rate	Barley[2]	Oat	Wheat	Treatment Average[4]
	pt/A	------------------% visual ground cover------------------			
No Soil-Applied[1]		100	96	100	99
s-Metolachlor	0.5	63	81	29	58
s-Metolachlor	1.0	15	49	10	25
Ethofumesate	1.0	15	46	8	23
Ethofumesate	2.0	15	18	13	22
Cover crop Average[3]		46	58	32	

[1]LSD (0.10) for cover crops within a treatment = 14
[2]LSD (0.10) treatments within a cover crop = 16
[3]LSD (0.10) between cover crop averages = 9
[4]LSD (0.10) between treatment averages = 9

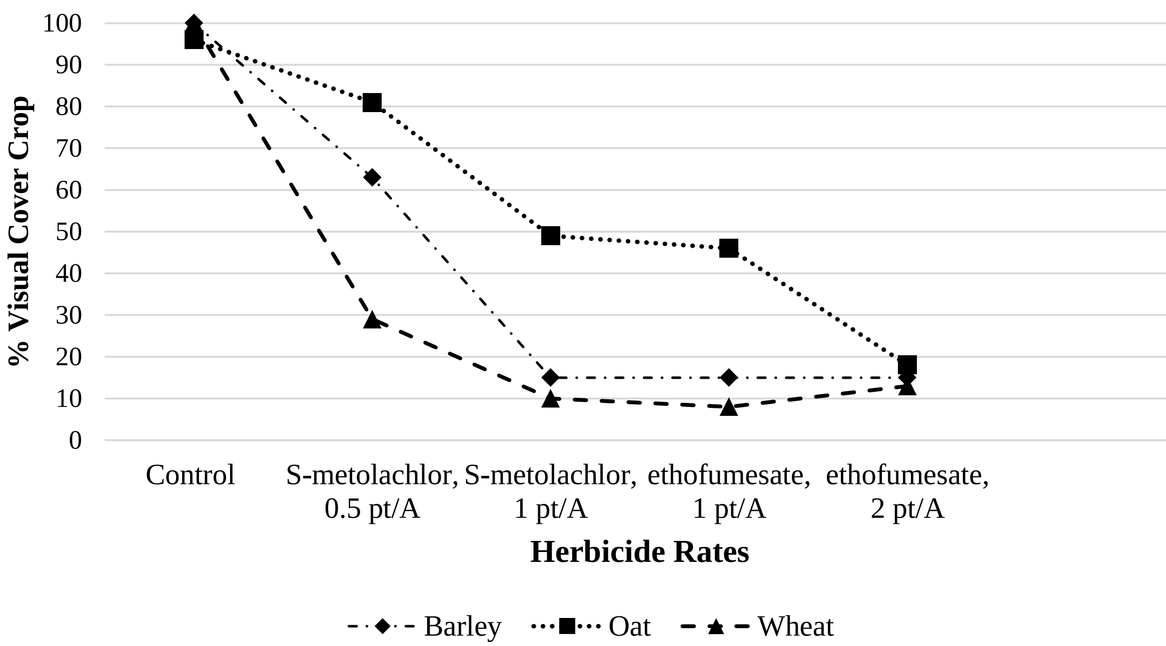

Figure 1. Impact of soil-applied herbicides and herbicide rate on Barley, oat and wheat visual ground cover, 35 days after planting, Foxhome, MN, 2015

Soils at Foxhome are a sandy loam. S-metolachlor and ethofumesate are less readily adsorbed to course textured soils and, thus, are activated more easily into soils at the Foxhome location by precipitation. The experiment was scheduled for planting when rainfall was in the forecast to increase the potential impact of soil-applied herbicides on cover crops. Sufficient precipitation to incorporate S-metolachlor or ethofumesate occurred within 48 hours after herbicide application (communication with Mr. Mike Metzger.

Three years' experience evaluating the effect of soil-applied herbicides on spring seed cereals as cover crops indicates:: a) oat tolerates soil-applied herbicides the best followed by barley and then wheat; b) S-metolachlor is safer to barley and wheat than ethofumensate; c) apply S-metolachlor at 0.5 to 1 pt/A and/or ethofumesate at 1 pt/A with oat and S-metolachlor at 0.5 pt/A with barley and wheat ; d) soil-applied herbicides are more injurious to cover crops on course textured soils than fine or medium textured soils; and e) rainfall within 48 to 72 hours after planting may influence herbicide response to cover crops, regardless of soil texture.

Timing of cover crop removal in sugarbeet

At the 90% confidence level, sugarbeet yield (Pr>F 0.0305) and extractable sugar (Pr>F 0.0764) were influenced by the timing of wheat cover crop removal whereas percent sugar (Pr>F 0.3526) was not (Table 4). Sugarbeet yield (tons/A and lb/A extractable sucrose) was greatest when wheat, seeded as a companion crop just prior to sugarbeet, was terminated no later than the 4-leaf sugarbeet stage. The experiment tended to demonstrate a sugarbeet yield and extractable sugar advantage from sugarbeet seeded with a wheat cover crop compared to sugarbeet seeded without a cover crop.

Cover crops need to be carefully managed after emergence. Sugarbeet cooperative agriculturalist recommend terminating cover crops when sugarbeet are at the 2 to 4-leaf stage. Results of this experiment tend to support the recommendation, especially if the time required before herbicide kills the cover crop is considered. Cover crop species are actively growing during spring weather conditions and create a mat of high albedo reflection that rob heat units from slower growing sugarbeet seedlings. Cover crops also create a very heavy below ground root mass, analogous to an 'iceberg' in ocean waters, that is competing with the sugarbeet plant for moisture and nutrients. Finally, cover crops will continue to protect sugarbeet seedlings from wind or blowing soil even after they have been terminated with herbicide. That is, the carcasses from dead cereal grasses will protect the sugarbeet seedling several weeks or until the sugarbeet plant is able to withstand wind and blowing soil.

Table 4. Effect of timing of wheat cover crop removal on sugarbeet yield, percent sugar, and extractable sucrose at Prosper, ND in 2015.

Sugarbeet stage at wheat termination	Wheat height at termination	Yield	Sugar	Extractable sucrose
no. of leaves	inches	ton/A	%	lb/A
No Cover Crop	n/a	35.3 ab	17.0	11,051 ab
2	2	36.0 a	16.9	11,253 a
3	4	36.6 a	16.5	11,173 ab
4	6	35.5 ab	16.8	10,929 abc
5	8	33.8 b	16.7	10,373 c
6	10-12	34.0 b	16.9	10,644 bc
LSD (0.10)		1.6	NS	542
CV		5	3	6

Weed suppression with cover crops in sugarbeet

There were on average 221 broadleaf weeds per meter square in plots not seeded with wheat cover crop in the experiment at Moorhead, MN (Table 5). Weeds observed were lambsquarters, redroot pigweed, common cocklebur, common ragweed, and biennial wormwood. Seeding wheat cover crop with sugarbeet provided weed suppression. Numerically, there was a 52% reduction in broadleaf weeds when wheat was seeded as a companion crop with sugarbeet at 45 lb/A (approximately ¾ bushel). Increasing the seeding rate from 45 pound to 90 increased visual broadleaf control. There was no significant benefit from increasing the wheat seeding rate from 90 to 180 lb/A.

Farmers seed cover crops with sugarbeet for several reasons. Seeding rate usually is between half and three-quarter bushel depending on cereal species according to farmers and agriculturalists. This experiment indicated that in addition to the other benefits, cover crops suppressed broadleaf weed emergence. Results suggest the maximum weed suppression benefit was at approximately 1.5 bu/A or 2 to 3 times the seeding density currently used by farmers.

Table 5. Broadleaf weed suppression from wheat cover crop seeded at various density at Moorhead, MN in 2015.

Wheat Seeding Rate	Cover Crop Density	Visual Broadleaf Weed Control	Weed Density
lb/A	plants/m^2	%	plants/m^2
0	34	15	221
45	143	55	105
90	150	75	81
180	358	85	30
LSD(0.10)	56	19	83
CV	24	25	59

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ESTIMATING TIME OF WATERHEMP EMERGENCE USING A GROWING DEGREE DAY CALCULATOR

Thomas J. Peters

Extension Sugarbeet Agronomist and Weed Control Specialist
North Dakota State University and the University of Minnesota, Fargo, ND

Summary

1. Waterhemp germination and emergence occurs the end of May in sugarbeet growing regions in eastern North Dakota and Minnesota.
2. Positive verification and reporting of waterhemp germination and emergence in 2016 will enable adjustment of the 'Tbase' component of the model and improve accuracy of the forecast model

Introduction

Waterhemp is different from redroot pigweed in that it germinates and emerges later in the spring. It also emerges over a prolonged period of time (8 to 10 weeks) as compared to redroot pigweed. Thus, lay-by application of residual herbicides (herbicide application after sugarbeet have emerged but before waterhemp emergence) is a good weed management strategy for providing season-long control. Metolachlor, (Dual Magnum, Cinch and generics), Warrant and Outlook are labeled for waterhemp control lay-by when sugarbeet growth stage ranges from 2 to 8 leaves.

Sugarbeet rarely germinate and emerge uniformly. Thus, farmers must delay lay-by herbicide application to ensure sugarbeet stand is complete and sugarbeet across the field are at minimum in the 2-leaf stage before application. To achieve maximum control, lay-by herbicides must be rainfall activated prior to weed emergence since these herbicides do not control emerged weeds. This means farmers need to be concerned about germinating and emerging weeds, especially waterhemp. In many respects, lay-by application is a compromise between sugarbeet growth stage, activation of residual herbicide, and the germination and emergence of weeds. The idea for waterhemp control with lay-by herbicides is to position the application to maximize the longevity of the soil-applied herbicide in order to combat waterhemp throughout the duration of the growing season.

Growing degree days (GDD) have many applications in crop management. Accumulated GDD, calculated by summing GDDs for each day during a period, are useful in tracking the development of several important crops and insect pests. One of the original uses of GDD was characterization of corn development and classifying corn hybrid maturities. Corn has a base temperature of 50°F and each corn hybrid has a certain GDD requirement to reach maturity. Those grown in the central Corn Belt require anywhere from 2100 to 3200 GDD depending on the hybrid and critical time points such as tasseling, silk emergence and kernel blistering. Relative maturity can be measured by GGD.

GDDs have been used to classify weeds to simplify scouting (Iowa State University IPM-64). Annual weeds were clustered into five groups based on GDD accumulation ranging from less than150 (winter annuals) to grasses and broadleaves that germinated and emerged at greater than 350 accumulated GDD (base 48). By tracking GDDs, it may be possible to estimate waterhemp germination and emergence in order to time application of lay-by residual herbicides in sugarbeet. The objective of this probe experiment was to determine if waterhemp GDD accumulation could forecast waterhemp germination and emergence and be used as a tool to time residual herbicide application in sugarbeet.

Materials and Methods

Daily maximum and minimum temperatures were collected from NDAWN (North Dakota Agricultural Weather Network) or NOAA (National Oceanic and Atmospheric Administration) weather stations located near Prosper and Wahpeton, North Dakota and Moorhead, Sabin, Morris, Montevideo and Litchfield, Minnesota. GDDs were calculated by determining the mean daily temperature and subtracting this value from the base temperature needed for germination and emergence of waterhemp. Based upon the information developed by researchers at Iowa State University (1), the base temperature selected was '48°F' and accumulated GDDs was 350.

The GDD accumulation for one day for waterhemp was represented by the equation:

GDD = (Tmax +Tmin)/2 - Tbase

where:
Tmax is maximum daily air temperature
Tmin is the minimum daily air temperature
Tbase is the base temperature for waterhemp, '48' based on research conducted at Iowa State University.

Calendar date when accumulated GDDs, calculated by summing GDDs for each day from January 1, 2015, totaled 350 would be first date for waterhemp emergence. Farmers would need to anticipate precipitation events and apply lay-by herbicides at least five to seven days in advance of calendar date to ensure herbicide was activated before the calendar date for waterhemp emergence.

Results

Waterhemp growing degree day accumulation (calculated using NDAWN and NOAA stations maximum and minimum daily temperature data) and resultant calendar date to accumulate approximately 350 GDDs are presented in Table. Data indicated only a six day difference in calendar day to accumulate 350 GDDs from stations/cities 200 miles apart. Data also indicates 350 GDD accumulation generally occurred by late May.

"The second half of June" was the common reply during winter grower meetings when asked when waterhemp would germinate and emerge in sugarbeet in central and west central Minnesota in 2015. This calendar date was based on estimates of waterhemp emergence from studies conducted in Iowa fields and 2014 experiments near Herman and Moorhead, MN. **The predicted date of waterhemp germination and emergence was clearly inaccurate!**

The first telephone calls in 2015 about possible waterhemp emergence occurred in early May. However, the 'callers' often were not comfortable with positive waterhemp identification since waterhemp is very similar to redroot pigweed, powell pigweed or smooth pigweed during the early vegetative stage. The data in Table suggest there is a possibility those early observations in southern Minnesota were indeed waterhemp.

Table. Growing Degree Days (GDDs) accumulated to predict the calendar date of waterhemp emergence at 7 locations in 2015.

Location	Calendar Date	Accumulated GDDs
Prosper, ND	June 2	358
Moorhead, MN	May 28	353
Sabin, MN	May 28	354
Wahpeton, ND	May 31	349
Morris, MN	May 29	359
Litchfield, MN	June 3	348
Montevideo, MN	May 29	357

Discussion

2014 was a late spring for sugarbeet growers and researchers alike. The majority of our research locations were planted after May 15th and into freshly tilled fields. In retrospect, there may have been very small waterhemp germinating and emerging in experimental locations at planting at the Moorhead and Herman, MN locations. We typically till the experimental area prior to planting to ensure emerged or emerging weeds do not confound results. Thus, waterhemp would reinitiate the germination and emergence process at planting, partially explaining a predicted waterhemp emergence date of 'after June 15.'

Record keeping on waterhemp GDD accumulation in 2015 combined with greater knowledge of the biology of waterhemp supports the revised hypothesis, that waterhemp germinates and emerges end of May in sugarbeet growing regions in Minnesota and North Dakota. This working hypothesis will be tested for confirmation in 2016. Positive identification of waterhemp at the cotyledon to two leaf stage is critical to complete and verify the model. Second, the observation much occur in fields near climate collection instrumentation.

Future Research

Waterhemp germination and emergence will be tracked at several locations in 2016 to improve waterhemp forecast tracking and model development. Several agriculturalists and consultants shall assist in positive waterhemp identification and documentation of the first calendar date associated with the sighting. Observations shall occur at multiple locations in sugarbeet growing regions to verify the model.

Leadership at sugarbeet cooperatives have committed to utilizing resources to develop an electronic application to track GDD accumulation. The idea is for these estimates to be tracked and available for access on a smart phone application. We believe a forecast of waterhemp germination and emergence using a model is an obtainable goal and will assist farmers with management decisions for waterhemp control in sugarbeet.

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