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2006 Southern Minnesota Beet Sugar Cooperative Official Variety Trial Research

Five Official Coded Variety Trials were conducted in the SMBSC growing area in 2006. Each location consisted of one trial that tested the performance of the Commercial and Semi-Commercial variety lines and another trial to test Round-Up Ready variety lines. Trial sites were chosen based upon a known or probable occurrence of Rhizomania infection. Sites were located near Hector, Lake Lillian, Renville, Clara City, and Gluek. Trial areas were fertilized using University of Minnesota recommendations for nitrogen, phosphorus, and potassium. Total soil test plus applied nitrogen in the zero to four foot soil profile across the five sites averaged 114 lbs. per acre and ranged from 100 to 138 lbs. per acre. Ethofumesate was used on the Commercial/Semi-Commercial trials as a pre-emergence weed control product at three of the five locations. Two locations utilized an oat cover crop that was maintained through the use of post-emergence weed control products. The transgenic entries within the Roundup-Ready trials did not receive a pre-emergence weed control product at any site and were sprayed exclusively with a glyphosate product either two or three times depending upon weed pressure. The Renville, Lake Lillian, and Hector locations were planted between April 25th and April 27th. Planting was delayed at the Gluek and Clara City locations due to wet soil conditions. The Gluek and Clara City locations were planted May 19th, and May 22nd, respectively. Seed bed conditions were generally good and seed spacing was four inches at all locations.

Seedling emergence was variable across the locations and was generally related to the time of planting. The later planted locations received very hot and windy conditions after planting but prior to emergence, which dried out the seed bed and made emergence variable. The Clara City site was ultimately abandoned but the Gluek location was later thinned in a manner that removed the seedlings that emerged late and made the location uniform based upon the earliest emerged beets. Stand counts used in calculating variety emergence data were taken between 27 and 29 days after planting at each of the sites. Upon completion of stand counts, trials were thinned to a final stand count ranging from 150 to 160 plants per 100 feet of row or approximately 35,000 to 38,000 plants per acre. Thinning of the plot area at each location was completed by June 23rd.

Rhizomania severity across the five locations ranged from slight to severe. Based upon observation of susceptible checks, the Hector location had a uniformly severe infection of *Aphanomyces cochlioides.* Due to the uniformity of diseases when present, all locations except the Clara City location were harvested and combined for analysis to use in creating the three-year variety mean. These data were used for approving or disapproving candidate varieties.

The SMBSC Beet Seed Policy requires that candidate variety performance be compared to the performance of previously approved varieties in order to obtain full approval for sale at SMBSC. To obtain unlimited sales at SMBSC, a candidate variety must meet or exceed 100% and 195% of the mean of the currently approved varieties for extractable sucrose per ton and extractable sucrose per ton + extractable sucrose per acre, respectively. In addition, the Aphanomyces and Cercospora Leafspot (CLS) ratings of candidate varieties must not exceed 5.0. Upon application of the Beet Seed Policy criteria, there were no additional varieties approved for full approval for 2007. Further, two varieties approved for sales in 2006 were voluntarily withdrawn from sales and testing. The result is that five varieties are approved for unlimited sales for the 2007 crop year. There are two varieties approved as specialty varieties; one for Aphanomyces tolerance and the other for Rhizoctonia tolerance. Five varieties were allowed for Test Market sales in 2007. One that first received Test Market in 2005 will remain a Test Market in 2006 due to a concern over susceptibility to CLS, which will require further observation. The other four Test Market varieties have two years of data and possess qualities that merit a closer look in the field in 2007. The 2006 list of Approved, Test Market, and Specialty varieties in addition to trial specifications and the three, two and one-year variety performance data are provided in the following pages.

SMBSC APPROVED VARIETIES – 2007

UNLIMITED VARIETIES

Beta 4930R
Beta 4901R

Hilleshog 2467Rz
Hilleshog 2411Rz

Holly Hybrid 255

SPECIALTY VARIETIES

Beta 4811R (APH)

Hilleshog 3035Rz (RZC)

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

Beta 1322

Beta BM 1591

Hilleshog 3031Rz

Hilleshog 3036Rz

Hilleshog 3028Rz

2006 SMBSC Official Variety Trials Specifications

Trial #	Trial Location	Cooperator	Entry Designation	Previous Crop	Total Nitrogen	Planting Date	Stand Counts	Disease	Harvest Date
0656-05	Gluek	Luschen/Noble	Comm./SemiComm	Field Corn	101	5/19/06	6/16/06	Severe Rzm; (Susc chk 36% of site mean).	9/25/06
0656-35	Gluek	Luschen/Noble	Transgenic	Field Corn	101	5/19/06	6/16/06	Slight Aph; (Susc chk 82% of site mean).	9/20/06
0656-04	Clara City	B&L Schwitters	Comm./SemiComm	Soybeans	117	5/22/06	N/A		N/A
0656-34	Clara City	B&L Schwitters	Transgenic	Soybeans	117	5/22/06	N/A		N/A
0656-03	Renville	C&P Haen	Comm./SemiComm	Field Corn	115	4/26/06	5/23/06	Slight Rzm (75%) and Slight Aph (85%).	9/15/06
0656-33	Renville	C&P Haen	Transgenic	Field Corn	115	4/25/06	5/23/06		9/14/06
0656-02	Lake Lillian	Schmoll Bros.	Comm./SemiComm	Sw Corn	97	4/26/06	5/24/06	Slight Rzm (72%) & Slight Aph (88%)	9/27/06
0556-34	Lake Lillian	Schmoll Bros.	Transgenic	Sw Corn	97	4/26/06	5/24/06		9/26/06
0656-01	Hector	Rich Wehking	Comm./SemiComm	Field Corn	138	4/27/06	5/25/06	Mod./Severe Rzm (53%) & Severe Aph (31%)	9/28/06
0656-31	Hector	Rich Wehking	Transgenic	Field Corn	138	4/27/06	5/25/06		9/29/06

Table 1. Mean of the Three Year 2007 SMBSC Varieties Approved for Unlimited Sales - Based Upon Approval Criteria

CONVERTED

Entry - Converted			*Rec/T (lbs)* 3 yr avg	*Rec/T (lbs)* % of mean	*Rec/A (lbs)* 3 yr avg	*Rec/A (lbs)* % of mean	*%ES* 3 yr avg	*%ES* % of mean	*Yield (T/A)* 3 yr avg	*Yield (T/A)* % of mean	*Sugar %* 3 yr avg	*Sugar %* % of mean	*Cercospora Leaf Spot* 3 yr avg	*Cercospora Leaf Spot* % of mean	*Emerg-ence (%)* 3 yr avg	*Emerg-ence (%)* % of mean	*Aphano-myces* 3 yr avg	*Aphano-myces* % of mean	*Purity (%)* 3 yr avg	*Purity (%)* % of mean
2007 APPROVED VARIETIES																				
Beta 4901R	RZM	202.97	240.74	97.81	6189.37	104.68	12.04	97.83	25.66	106.70	14.56	98.35	4.67	105.17	69.57	100.52	4.80	96.62	89.64	99.50
Beta 4930R	RZM	197.46	244.69	99.42	5768.18	97.55	12.24	99.43	23.76	98.79	14.77	99.75	4.05	91.25	72.34	104.53	4.58	92.29	89.97	99.87
Hilleshog 2411Rz	RZM	196.94	249.31	101.30	5625.73	95.14	12.47	101.29	22.61	94.04	14.91	100.72	4.23	95.20	68.95	99.63	5.44	109.42	90.36	100.31
Hilleshog 2467Rz	RZM	205.35	248.36	100.91	6146.04	103.94	12.42	100.89	24.61	102.36	15.00	101.28	4.89	110.16	68.15	98.46	5.10	102.62	90.12	100.04
HOLLY 255	APH & RZM	199.75	247.51	100.57	5835.19	98.69	12.38	100.56	23.59	98.11	14.79	99.91	4.36	98.23	67.04	96.86	4.92	99.04	90.33	100.28
			246.12	**100.00**	**5912.90**	**100.00**	**12.31**	**100.00**	**24.05**	**100.00**	**14.81**	**100.00**	**4.44**	**100.00**	**69.21**	**100.00**	**4.97**	**100.00**	**90.08**	**100.00**
2007 SPECIALTY VARIETIES (% of Mean is of Approved Mean)																				
Beta 4811R	APH & RZM	197.58	238.88	97.06	5943.54	100.52	11.94	97.04	24.94	103.71	14.45	97.59	4.38	98.57	69.43	100.32	4.11	82.65	89.79	99.67
2007 PREVIOUSLY APPROVED VARIETIES NOT MEETING CRITERIA - FINAL YEAR OF SALES (% of Mean is of Approved Mean)																				
Candidate Varieties	**Specialty**	**RST+ RSA**																		
TEST MARKET VARIETIES FOR LIMITED SALES WITH 3 YEARS OF DATA (% of Mean is of Approved Mean)																				
Beta 1322		209.70	245.33	99.68	6505.65	110.02	12.27	99.67	26.36	109.63	14.81	100.02	5.10	114.89			4.34	87.31	89.90	99.80

Table 2. Comparison of 2007 Approved Varieties to Candidate Test Market Varieties Based on 2 Year Data, 2005 - 2006

CONVERTED

Entry - Converted			Rec/T (lbs) 2 yr avg	Rec/T (lbs) % of mean	Rec/A (lbs) 2 yr avg	Rec/A (lbs) % of mean	%ES 2 yr avg	%ES % of mean	Yield (T/A) 2 yr avg	Yield (T/A) % of mean	Sugar % 2 yr avg	Sugar % % of mean	Cercospora Leaf Spot 2 yr avg	Cercospora Leaf Spot % of mean	Emergence (%) 2 yr avg	Emergence (%) % of mean	Aphanomyces 2 yr avg	Aphanomyces % of mean	Purity (%) 2 yr avg	Purity (%) % of mean
2007 APPROVED VARIETIES																				
Beta 4901R	RZM	200.47	238.12	96.76	6443.07	103.70	11.91	96.79	26.94	106.74	14.50	97.57	4.76	107.33	69.51	100.31	4.61	93.42	89.23	99.46
Beta 4930R	RZM	198.46	246.50	100.17	6106.76	98.29	12.33	100.16	24.73	98.00	14.87	100.06	3.96	89.24	71.38	103.00	4.60	93.16	89.75	100.04
Hilleshog 2411Rz	RZM	197.46	250.83	101.93	5935.15	95.53	12.54	101.91	23.83	94.41	15.09	101.51	4.17	94.06	69.20	99.87	5.43	110.11	89.95	100.26
Hilleshog 2467Rz	RZM	204.36	248.92	101.15	6412.55	103.21	12.45	101.14	25.52	101.13	15.07	101.41	4.96	111.89	69.65	100.52	5.20	105.42	89.51	99.77
HOLLY 255	APH & RZM	199.25	246.06	99.99	6167.21	99.26	12.31	100.00	25.17	99.72	14.78	99.45	4.32	97.47	66.74	96.31	4.83	97.89	90.13	100.46
			246.08	**100.00**	**6212.95**	**100.00**	**12.31**	**100.00**	**25.24**	**100.00**	**14.86**	**100.00**	**4.43**	**100.00**	**69.29**	**100.00**	**4.93**	**100.00**	**89.71**	**100.00**
2007 SPECIALTY VARIETIES (% of Mean is of Approved Mean)																				
Beta 4811R	APH & RZM	198.90	239.85	97.47	6301.78	101.43	11.99	97.44	26.37	104.48	14.53	97.74	4.32	97.42	66.60	96.11	4.01	81.24	89.60	99.87
Hilleshog 3035Rz	RZC	209.27	246.76	100.27	6771.82	109.00	12.34	100.28	27.20	107.77	14.88	100.09	4.66	105.04			4.85	98.24	89.84	100.14
2007 PREVIOUSLY APPROVED VARIETIES NOT MEETING CRITERIA - FINAL YEAR OF SALES (% of Mean is of Approved Mean)																				
TEST MARKET VARIETIES FOR LIMITED SALES WITH 2 YEARS OF DATA (% of Mean is of Approved Mean)																				
Candidate Varieties	**Specialty**	**RST+ RSA**																		
Beta 1322		214.85	248.39	100.94	7077.01	113.91	12.42	100.93	28.35	112.34	15.01	101.00	5.29	119.35	71.58	103.30	4.04	81.79	89.65	99.92
Beta BM 1591		211.11	247.18	100.45	6875.65	110.67	12.36	100.45	27.79	110.12	14.91	100.33	4.84	109.08			4.55	92.18	89.76	100.05
Hilleshog 3028Rz		209.03	245.80	99.88	6780.93	109.14	12.29	99.88	27.48	108.88	14.84	99.83	5.04	113.63			4.53	91.71	89.67	99.95
Hilleshog 3031Rz		203.16	252.90	102.77	6236.96	100.39	12.65	102.76	24.42	96.75	15.16	101.98	4.25	95.89			4.94	100.04	90.18	100.51
Hilleshog 3036Rz		209.67	255.35	103.77	6579.81	105.90	12.77	103.78	25.60	101.43	15.25	102.58	5.13	115.71			4.70	95.34	90.41	100.78

Table 3. Mean of the One Year Performance of 2007 SMBSC Approved and Test Market Varieties, 2006 Data.

CONVERTED

Entry - Converted			Rec/T (lbs) 2006	Rec/T % of mean	Rec/A (lbs) 2006	Rec/A % of mean	%ES 2006	%ES % of mean	Yield (T/A) 2006	Yield % of mean	Sugar % 2006	Sugar % of mean	Cercospora Leaf Spot 2006	Cercospora % of mean	Emerg-ence (%) 2006	Emerg. % of mean	Aphano-myces 2006	Aphano. % of mean	Purity (%) 2006	Purity % of mean
2007 APPROVED VARIETIES																				
Beta 4901R	RZM	204.14	258.22	97.56	7225.74	106.58	12.92	97.61	27.73	108.53	15.38	97.81	4.65	104.69	65.59	101.07	4.78	93.44	90.52	99.85
Beta 4930R	RZM	199.48	267.61	101.11	6669.31	98.37	13.38	101.09	24.81	97.10	15.84	100.74	4.09	91.98	70.70	108.95	5.01	98.03	90.87	100.23
Hilleshog 2411Rz	RZM	193.04	267.17	100.95	6243.70	92.09	13.36	100.94	23.49	91.94	15.89	101.06	4.55	102.50	63.11	97.25	5.94	116.07	90.57	99.90
Hilleshog 2467Rz	RZM	207.19	267.18	100.95	7202.90	106.24	13.36	100.94	26.62	104.19	15.90	101.12	4.83	108.85	66.33	102.21	5.43	106.23	90.52	99.85
HOLLY 255	APH & RZM	196.14	263.16	99.43	6556.81	96.71	13.16	99.43	25.10	98.24	15.61	99.27	4.09	91.98	58.74	90.52	4.41	86.23	90.82	100.18
			264.67	**100.00**	**6779.69**	**100.00**	**13.24**	**100.00**	**25.55**	**100.00**	**15.72**	**100.00**	**4.44**	**100.00**	**64.89**	**100.00**	**5.12**	**100.00**	**90.66**	**100.00**
2007 SPECIALTY VARIETIES (% of Mean is of Approved Mean)																				
Beta 4811R	APH & RZM	203.34	261.44	98.78	7088.56	104.56	13.07	98.75	27.33	106.97	15.51	98.64	4.26	95.93	62.90	96.93	4.53	88.52	90.82	100.18
Hilleshog 3035Rz	RZC	207.60	262.17	99.06	7359.24	108.55	13.11	99.05	27.65	108.22	15.56	98.96	4.77	107.31			5.17	100.98	90.78	100.13
2007 VARIETIES WITH ONE MORE YEAR OF SALES (% of Mean is of Approved Mean)																				
2007 TEST MARKET VARIETIES FOR LIMITED SALES (% of Mean is of Approved Mean)																				
Beta 1322		217.48	266.25	100.60	7924.22	116.88	13.31	100.56	29.63	115.97	15.79	100.42	5.16	116.08	68.88	106.14	4.66	91.15	90.82	100.18
Beta BM 1591		216.63	266.57	100.72	7858.29	115.91	13.33	100.71	29.54	115.62	15.82	100.61	4.83	108.85			4.48	87.54	90.76	100.11
Hilleshog 3028Rz		213.96	264.32	99.87	7734.85	114.09	13.22	99.88	29.22	114.36	15.69	99.78	5.04	113.45			4.46	87.21	90.67	100.01
Hilleshog 3031Rz		204.20	271.43	102.55	6891.52	101.65	13.57	102.52	25.14	98.40	15.98	101.63	4.45	100.31			5.38	105.25	91.30	100.71
Hilleshog 3036Rz		209.34	272.15	102.83	7221.22	106.51	13.61	102.83	26.34	103.09	16.00	101.76	5.23	117.83			4.78	93.44	91.30	100.71

Table 9. Comparison of 2007 Approved to Transgenic Varieties Based on 2 Year Data, 2005 - 2006

CONVERTED

Entry - Converted			*Rec/T (lbs)*		*Rec/A (lbs)*		*%ES*		*Yield (T/A)*		*Sugar %*		*Cercospora Leaf Spot*		*Emerg-ence (%)*		*Aphano-myces*		*Purity (%)*	
			2 yr Avg	**% of mean**	**2 yr avg**	**% of mean**	**2 yr avg**	**% of mean**	**2 yr avg**	**% of mean**	**2 yr avg**	**% of mean**	**2 yr avg**	**% of mean**	**2 yr avg**	**% of mean**	**2 yr avg**	**% of mean**	**2 yr avg**	**% of mean**
Beta 4811R	APH & RZM	199.07	239.85	97.88	6301.78	101.19	11.99	97.86	26.37	103.70	14.53	98.11	4.32	97.84	66.60	96.74	4.01	83.87	89.60	99.89
Beta 4901R	RZM	200.63	238.12	97.17	6443.07	103.46	11.91	97.20	26.94	105.95	14.50	97.94	4.76	107.79	69.51	100.96	4.61	96.43	89.23	99.48
Beta 4930R	RZM	198.65	246.50	100.59	6106.76	98.06	12.33	100.59	24.73	97.27	14.87	100.44	3.96	89.63	71.38	103.68	4.60	96.17	89.75	100.06
Hilleshog 2411Rz	RZM	197.66	250.83	102.36	5935.15	95.30	12.54	102.35	23.83	93.71	15.09	101.89	4.17	94.46	69.20	100.52	5.43	113.66	89.95	100.28
Hilleshog 2467Rz	RZM	204.55	248.92	101.58	6412.55	102.97	12.45	101.57	25.52	100.38	15.07	101.79	4.96	112.38	69.65	101.17	5.20	108.82	89.51	99.79
HOLLY 255	APH & RZM	199.44	246.06	100.41	6167.21	99.03	12.31	100.43	25.17	98.98	14.78	99.83	4.32	97.90	66.74	96.94	4.83	101.05	90.13	100.48
			245.04	100.00	6227.75	100.00	12.25	100.00	25.42	100.00	14.81	100.00	4.42	100.00	68.84	100.00	4.78	100.00	89.70	100.00

TRANSGENIC VARIETIES - 2 YEAR DATA

Beta B5601RR		175.71	231.97	94.66	5047.09	81.04	11.61	94.72	21.50	84.57	14.13	95.41	4.97	112.51	52.44	76.16	5.58	116.83	89.46	99.73
Beta B5603RR		218.12	254.11	103.70	7126.09	114.42	12.70	103.61	27.95	109.94	15.00	101.32	5.21	118.10	60.76	88.25	4.82	100.92	91.29	101.78
VDH H36501 RR		215.98	248.95	101.59	7123.48	114.38	12.44	101.53	28.71	112.93	14.66	98.99	5.48	124.01	70.55	102.48	6.38	133.43	91.54	102.05

Table 10. Comparison of 2007 Approved Varieties To Candidate Transgenic Varieties Based on 1 Year Data, 2006

CONVERTED

Entry - Converted		Rec/T (lbs) 2006	Rec/T % of mean	Rec/A (lbs) 2006	Rec/A % of mean	%ES 2006	%ES % of mean	Yield (T/A) 2006	Yield % of mean	Sugar % 2006	Sugar % of mean	Cercospora Leaf Spot 2006	Cercospora % of mean	Emergence (%) 2006	Emergence % of mean	Aphanomyces 2006	Aphanomyces % of mean	Purity (%) 2006	Purity % of mean
Beta 4811R		261.44	98.98	7088.56	103.77	13.07	98.95	27.33	105.74	15.51	98.86	4.26	96.58	62.90	97.43	4.53	90.25	90.82	100.15
Beta 4901R		258.22	97.76	7225.74	105.78	12.92	97.82	27.73	107.29	15.38	98.03	4.65	105.40	65.59	101.59	4.78	95.26	90.52	99.82
Beta 4930R		267.61	101.32	6669.31	97.63	13.38	101.30	24.81	95.99	15.84	100.97	4.09	92.61	70.70	109.51	5.01	99.94	90.87	100.20
Hilleshog 2411Rz		267.17	101.15	6243.70	91.40	13.36	101.15	23.49	90.88	15.89	101.29	4.55	103.20	63.11	97.75	5.94	118.33	90.57	99.87
Hilleshog 2467Rz		267.18	101.15	7202.90	105.44	13.36	101.15	26.62	102.99	15.90	101.35	4.83	109.59	66.33	102.74	5.43	108.30	90.52	99.82
HOLLY 255		263.16	99.63	6556.81	95.98	13.16	99.63	25.10	97.11	15.61	99.50	4.09	92.61	58.74	90.98	4.41	87.91	90.82	100.15
		264.13	**100.00**	**6831.17**	**100.00**	**13.21**	**100.00**	**25.85**	**100.00**	**15.69**	**100.00**	**4.41**	**100.00**	**64.56**	**100.00**	**5.02**	**100.00**	**90.69**	**100.00**

TRANSGENIC VARIETIES - 1 YEAR DATA

Beta B5601RR	146.92	226.00	85.56	4191.00	61.35	11.31	85.63	18.27	70.69	13.94	88.86	4.77	108.05	36.50	56.54	6.86	136.71	88.71	97.82
Beta B5603RR	212.21	259.00	98.06	7798.00	114.15	12.93	97.89	30.08	116.38	15.33	97.72	5.01	113.56	54.57	84.52	5.10	101.62	90.92	100.26
Beta B6604RR	151.03	232.00	87.84	4317.00	63.20	11.62	87.97	18.41	71.23	14.09	89.81	4.89	110.92	38.51	59.65	7.88	157.10	89.77	98.99
Beta B6605RR	174.83	256.00	96.92	5322.00	77.91	12.83	97.14	20.43	79.04	15.32	97.65	4.67	105.84	43.62	67.56	7.31	145.74	90.45	99.74
Beta B6606RR	145.50	222.00	84.05	4198.00	61.45	11.08	83.89	18.80	72.74	13.73	87.52	4.74	107.39	40.74	63.10	7.90	157.44	88.47	97.56
Crystal C9601RR	206.82	278.00	105.25	6938.00	101.56	13.89	105.16	24.78	95.87	16.10	102.62	5.09	115.33	58.87	91.18	5.35	106.63	92.41	101.90
Crystal C9602RR	199.26	248.00	93.89	7198.00	105.37	12.42	94.03	28.81	111.47	14.65	93.38	4.74	107.39	52.18	80.82	5.50	109.64	91.49	100.89
Crystal C9603RR	198.50	250.00	94.65	7094.00	103.85	12.49	94.56	28.30	109.49	14.92	95.10	5.09	115.33	46.10	71.40	6.09	121.34	90.55	99.85
Hilleshog 9016RR	204.77	249.00	94.27	7548.00	110.49	12.46	94.33	30.03	116.19	14.76	94.08	5.16	116.87	56.92	88.16	6.44	128.36	91.11	100.47
Hilleshog 9017RR	215.18	269.00	101.84	7742.00	113.33	13.45	101.83	28.70	111.04	15.79	100.65	5.38	121.94	54.54	84.48	6.19	123.34	91.51	100.91
Hilleshog 9018RR	203.88	251.00	95.03	7436.00	108.85	12.56	95.09	29.47	114.02	14.86	94.72	5.59	126.79	54.28	84.07	6.21	123.68	91.19	100.56
Hilleshog 9019RR	211.45	268.00	101.47	7513.00	109.98	13.42	101.60	27.92	108.02	15.79	100.65	5.04	114.22	58.74	90.98	7.30	145.40	91.35	100.73
VDH 36624RR	220.32	269.00	101.84	8093.00	118.47	13.43	101.68	29.92	115.76	15.68	99.95	5.43	123.04	64.18	99.41	5.77	114.99	91.94	101.38
VDH H36501 RR	213.17	261.00	98.81	7812.00	114.36	13.03	98.65	29.77	115.18	15.17	96.70	5.64	127.89	61.29	94.93	7.55	150.42	92.29	101.77

2006 Southern Minnesota Beet Sugar Cooperative Variety Strip Trial Research

There were ten variety strip trials conducted in the SMBSC growing area in 2006. Eight variety strip trials were established in shareholders fields within the area of the cooperative that is heavily populated with beet production. Two additional variety strip trials were conducted in the north and northwest areas. The objective of the eight strip trials located in the core of the cooperative area was to provide an opportunity to observe variety performance in actual field conditions. The purpose of the strip trials in the northern region was the same but an additional purpose was to provide insight into variety performance in the soil types and cropping systems that predominate in this area in the absence of nearby Official Variety Trials.

Six varieties were common at all locations. However, the Belgrade strip trial included an additional variety known to possess some Rhizoctonia tolerance. All variety strip trials were planted with shareholder planters. The eight trials placed in the core growing region of the cooperative were harvested with shareholder harvesters. Harvest of these sites consisted of delivery of harvested loads from a measured strip of land. Each variety had five samples taken for quality analysis. Data from the eight core growing area strip trials can be found on page 10.

The harvest of the two northern locations consisted of hand harvesting fifteen to twenty samples per variety at each location. Each sample contained 10 feet of row that was used for quality analysis. Yield was estimated by using the sample weight over the 10 feet of harvested row for each sample and converting to tons per acre. The northern strip trials are hand harvested due to the distance of the field from sugar beet receiving stations and the likelihood needing to haul partial loads a long distance if harvested in strips. Data from the two northern area strip trials can be found on pages 11 and 12. All strip trials were harvested in mid to late September.

The Shareholder/Ag-Staff strip trial data table represents an average of the variety performance from all eight of the strip trials conducted in the core growing area. The strip trials conducted in the north and northwest growing areas are not combined and are presented separately due to the differences in soil and environmental conditions at each of the sites.

2006 Shareholder/Ag-Staff Variety Strip Trial Data: Combined Across Eight Locations.

Variety	28d 100' Std Ct	% of Mean	Sucrose (%)	% of Mean	Purity (%)	% of Mean	Yield (Ton/A)	% of Mean	ES (%)	% of Mean	ESA (lbs)	% of Mean	$/Ton ($)	% of Mean	$/Acre ($)	% of Mean
Beta 1322	168	108.5	15.50	101.3	89.89	99.9	27.17	109.3	12.88	101.3	7001.51	110.7	$35.77	102.4	$971.75	112.0
HM 2467	164	105.9	15.45	101.0	89.86	99.9	24.42	98.2	12.83	100.9	6268.55	99.1	$35.51	101.7	$867.14	99.9
Beta 4811	157	101.4	15.31	100.1	90.04	100.1	24.70	99.3	12.75	100.2	6296.10	99.6	$35.05	100.4	$865.69	99.8
VDH 46527	144	93.0	14.86	97.1	89.59	99.6	26.36	106.0	12.27	96.4	6466.41	102.3	$32.58	93.3	$858.88	99.0
HM 2423	141	91.1	15.36	100.4	90.49	100.6	21.69	87.2	12.87	101.2	5584.41	88.3	$35.71	102.2	$774.48	89.3
Average:	**154.8**		**15.3**		**90.0**		**24.9**		**12.7**		**6323.4**		**$34.92**		**867.6**	

2006 Belgrade SMBSC Northern Variety Strip Trial Data.

Variety	Visual Rzc Grade	Sugar (%)	% of Mean	Purity (%)	% of Mean	Yield (Ton/A)	% of Mean	ES (%)	% of Mean	ESA (lbs/A)	% of Mean	$/Ton ($)	% of Mean	$/Acre ($)	% of Mean
Beta 4901	B+	14.65	102.4	87.26	99.8	35.08	107.0	11.65	102.3	8174.05	109.5	$29.42	104.8	$1,032.08	112.1
Beta 1322	B+	14.25	99.6	87.63	100.2	36.12	110.2	11.38	99.9	8220.76	110.1	$28.03	99.8	$1,012.38	110.0
HM 3035	A-	14.62	102.2	88.35	101.0	32.09	97.9	11.83	103.9	7591.86	101.7	$30.34	108.0	$973.55	105.8
HM 2467	C+	14.89	104.1	87.55	100.1	30.82	94.0	11.91	104.6	7341.07	98.3	$30.75	109.5	$947.79	103.0
Beta 4811	B	13.90	97.2	87.26	99.8	33.15	101.1	11.02	96.7	7303.32	97.8	$26.16	93.1	$867.06	94.2
VDH 46527	D+	13.75	96.1	86.77	99.2	32.39	98.8	10.80	94.8	6997.00	93.7	$25.05	89.2	$811.48	88.2
HM 2423	D	14.05	98.2	87.26	99.8	29.77	90.8	11.14	97.8	6634.28	88.9	$26.81	95.5	$798.09	86.7
Average:		**14.30**		**87.44**		**32.77**		**11.39**		**7466.05**		**$28.08**		**$920.35**	

2006 Hancock SMBSC Northern Variety Strip Trial Data.

Variety	Sugar (%)	% of Mean	Purity (%)	% of Mean	Yield (Tons/A)	% of Mean	ES (%)	% of Mean	ESA (lbs/A)	% of Mean	$/Ton ($)	% of Mean	$/Acre ($)	% of Mean
Beta 1322	16.63	99.8	89.99	100.4	34.74	108.7	13.90	100.3	9658.85	109.3	$40.99	100.6	$1,424.14	109.7
VDH 46527	15.99	95.9	89.33	99.7	36.85	115.3	13.21	95.3	9732.97	110.1	$37.42	91.8	$1,378.88	106.2
HM 2423	17.05	102.3	90.86	101.4	29.54	92.4	14.45	104.3	8538.90	96.6	$43.83	107.6	$1,294.73	99.7
Beta 4901	16.73	100.4	88.96	99.3	31.00	97.0	13.78	99.4	8541.09	96.6	$40.35	99.0	$1,250.79	96.4
HM 2467	17.21	103.3	89.03	99.4	28.72	89.8	14.21	102.6	8161.39	92.3	$42.57	104.5	$1,222.68	94.2
Beta 4811	16.39	98.3	89.43	99.8	30.97	96.9	13.58	98.0	8409.23	95.1	$39.32	96.5	$1,217.81	93.8
Average:	**16.67**		**89.60**		**31.97**		**13.85**		**8840.41**		**$40.75**		**$1,298.17**	

Previous Crop Effects on Sugarbeet Response to Nitrogen Fertilizer

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

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

In 2005, a site near the Hector piler was established to accomplish the objective. The initial set up year, four large replicated blocks (35 X 66 ft.) of corn, genetically modified corn (round up ready and Bt), sweet corn, soybean, and spring wheat were grown. Each crop was fertilized according to U of MN guidelines in the initial set up year.

Deep soil samples for nitrate-N will be taken late fall of the initial year to characterize the sites. The large crop blocks were subdivided into 11 X 35 ft. subplots to accommodate six N rates (0, 30, 60, 90, 120, and 150 lb N per acre) that were applied late fall before the sugar beet crop was grown. In the 2006, sugar beet was grown with root yield and quality measured.

In 2006, there was no previous crop by nitrogen rate interaction for any reported parameter, Table 1. The lack of an interaction means that nitrogen rate guidelines are not affected by the previous crop at this location. Root yield and extractable sucrose per acre were significantly affected by previous crop and nitrogen application rate, Table 2. Sugarbeet grown after genetically modified corn for Bt and RR had the lowest root yield extractable sucrose per acre, followed by non-genetically modified corn. Sugarbeets grown after soybean and sweet corn had similar root yield and extractable sucrose per acre while sugarbeet grown after spring wheat had to largest. At this site the optimum root yield and extractable sucrose per acre were obtained at the 90 lb per acre nitrogen application, Table 3.

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

Table 1. Statistical analysis for root yield, purity, extractable sucrose per ton, and extractable sucrose per acre.

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

Table 2. The means for the effect of previous crop on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2006.

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

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

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

This is the first year of this study and the results reported are only for one site. At this time, there is no evidence to adjust nitrogen application rates for sugarbeet because of previous crop.

SEED-SAFE APPLICATIONS OF FLUIDS AT PLANTING[1]]

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SUMMARY

The information provided in this report is a summary of research conducted in 2006, the third year of a 3 year project. The conclusions from data collected are in general agreement with conclusions from research conducted in 2004 and 2005. For soils with a non-sandy texture, the three fluid fertilizers (10-34-0, 3-18-18, 4-10-10) can be applied in a band close to corn seed at reasonable rates (5 to 10 gallons per acre) without having a serious effect on yield. The use of 10-34-0 at high rates had a negative effect on germination. Although there were fewer plants, the corn crop was able to compensate by growing larger ears on each plants. The data collected for three years provide a strong base for the positive impact for the use of seed placed fertilizer on yield if the soil texture is not sandy.

Management suggestions change for corn production on sandy soils. Data collected for the three years show that there is a risk for reduction in emergence if banded fertilizer is placed too close to the seed. Although there was no objective to define an ideal distance between seed and fertilizer, there was some reduction in emergence when this distance was 0.75 inches. A distance of at least 1.0 inches between seed and fertilizer should reduce the risk of damage to emergence when soils are sandy.

The soybean crop is more sensitive than corn to fertilizer placed close to the seed. All fluid materials, even though applied at lower rates, reduced emergence. This was most noticeable when 10-34-0 was used. Soybeans, however, compensated for the stand reduction and the yields were not affected.

Previous guidelines suggest that the sum of N and K_2O should be considered when rate of fertilizer placed close to the seed is in question. The results from this study indicate, however, that nitrogen is the component most responsible for reduced emergence.

INTRODUCTION

Because of grower interest in use of fertilizer placed in a band close to the seed at time of planting, this study was conducted to meet several objectives.

These objectives were:

- to measure effect of rate and placement of three fluid fertilizers on crop emergence
- to measure effect of rate and placement of these fluid fertilizer on crop yield

[1]] Prepared for Fluid Form, Phoenix, AZ, February 19-20, 2007

- to monitor impact of rate and placement of these fluid fertilizers on uptake of phosphorus and potassium by young corn, soybean, and sugarbeet plants

Research funded by the Fluid Fertilizer Foundation in the mid 1990's showed that relatively high rates of fluids (10-34-0, 4-10-10, 7-21-7) could be applied in direct contact with corn seed at planting with no negative impact on either emergence or yield if soils were not sandy or dry. The soybean crop was less tolerant of fertilizer placed with the seed. Recent research in Iowa has documented the positive benefits of several fluid fertilizers placed near, but not in contact with, or very close to corn and soybean seed at planting.

More recent research in northwestern Minnesota has shown that 10-34-0 applied at low rates in contact with the seed has a very positive effect on both the yield and quality of the sugarbeet crop. Because of the ease of handling and accuracy in calibration, placement near the seed is an ideal fit for the use of fluid fertilizers. Therefore, this study was conducted to meet the previously stated objectives.

EXPERIMENTAL PROCEDURE

This study was conducted in fields of three cooperating crop producers and the Southwest Research and Outreach Center at Lamberton. Corn was the test crop at two sites with contrasting soil textures (loamy fine sand, silty clay loam). The soil in the soybean field had a silty clay loam texture. The soil texture in the sugarbeet field was a silty clay loam.

Soil samples (0 to 6 inches) were collected from the experimental sites prior to planting. Results of the analysis of these samples are summarized in Table 1. Because of the sandy texture and medium soil test for potassium, adequate amounts of S (supplied as 12-0-0-24) and K (supplied as 0-0-60) were applied to all treatments at the corn (S) site. No phosphate and/or potash were broadcast at the other three sites.

Table 1. Relevant properties of soils at the experimental sites.

	Experimental Site			
Property	Corn (S)	Corn (SWROC)	Soybean	Sugarbeet
pH	6.4	5.4	6.3	7.5
phosphorus, ppm	55.8 (Bray)	4.5 (Bray)	37.7 (Bray)	5 (Olsen)
potassium, ppm	112	119	178	248
soil texture	loamy fine sand	silty clay loam	silty clay loam	silty clay loam

Adequate N was applied to all treatments at the corn (S), corn (SWROC) and sugarbeet sites. At the corn (S) site, the N was supplied in the combination of 21-0-0-24 (preplant), 46-0-0 (sidedress), and 28-0-0 with the irrigation water. The needed N was supplied as 46-0-0 at the corn (SWROC) and sugarbeet site.

All combinations of three fluid fertilizers (10-34-0, 4-10-10, 3-18-18) were applied at three positions near the seed (with seed, above the seed, below the seed).

When applied in a band either above or below the seed, there was approximately ½ to ¾ inch of soil between seed and fertilizer. The rates of application varied with crop and fluid fertilizer. These rates are listed in Table 2. The application of 3-18-18 was reduced so that equal rates of K_2O would be used when the 4-10-10 and 3-18-18 were compared.

Table 2. Rates of fluid fertilizers used for corn, soybean, and sugarbeet production.

Fluid	Corn		Soybean		Sugarbeet	
Grade	high rate	low rate	high rate	low rate	high rate	low rate
	- - - - - - - - -		gallons/acre	- - - - - - - - -		
10-34-0	10	5	6	3	4	2
4-10-10	10	5	6	3	4	2
3-18-18	6.8	3.4	4	2	2.6	1.3

Stand counts for the three crops were taken approximately 3 weeks after emergence. Yields were measured at times appropriate for each crop. Soybean yields are reported at 13.5% moisture. Corn yields are reported at 14.5% emergence. Sugarbeet yield is expressed as lb. sugar per acre rather than tons of sugarbeets/acre.

Whole plant samples were collected at the time when emerged stand was measured. These samples were dried, weighed, ground, and analyzed for P and K. Uptake of P and K was computed from dry weight and plant analysis information. The uptake information is not included in this report.

RESULTS AND DISCUSSION

Corn Emergence:

The effect of treatment on corn emergence varied with soil texture (Table 3). At the SWROC site, emergence was not significantly affected by grade, rate of application or placement. There was, however, a significant fluid grade X rate of application interaction.

A significant fluid grade X rate of application was also measured at the corn (S) site where the soil texture was a loamy fine sand (Table 3). When averaged over the fluid grade, emergence was reduced when the high rates were applied either below or above the seed. Averaging over fluid grade, emergence was reduced when the materials were placed with the seed at the low rate. These observations explain the significant interaction.

When averaged over rate and placement, emergence was reduced significantly when the 10-34-0 was used (93.7% of control). Similar averaging shows that emergence was nearly equal when the 4-10-10 and 3-18-18 are compared (99.6% of control and 102.2% of control respectively). These measurements of emergence indicate that the amount of nitrogen applied in the fluid fertilizer affects the emergence more that the combination of N and K_2O.

The results from 2006 are consistent with results recorded in 2005. Emergence from a soil with a loamy fine sand texture was reduced when 10-34-0 was placed close to the seed. No reduction in emergence was measured when corn is grown in a soil with a

Table 3. Corn emergence as affected by fluid material, rate, and placement in soils with two contrasting soil textures. 2006.

	Soil, Texture, Placement, and Rate											
	silty clay loam						loamy fine sand					
	with seed		top of seed		below seed		with seed		top of seed		below seed	
Grade	high	low	high	low	high	low	high	low	high	low	high	low
	% of control											
10-34-0	92.8	98.0	100.7	100.0	102.0	99.4	98.5	91.6	88.6	93.9	87.0	103.1
4-10-10	97.4	96.1	98.7	96.7	100.7	93.5	96.9	103.8	96.2	100.0	100.0	100.8
3-18-18	92.2	98.7	95.4	98.0	102.6	93.5	104.6	95.4	104.6	104.6	100.8	103.1
Control:	33,323 plants per acre						28,532 plants per acre					

Table 4. Corn yield as affected by fluid material, rate, and placement in soils with two contrasting soil textures.

	Soil, Texture, Placement, and Rate											
	silty clay loam						loamy fine sand					
	with seed		top of seed		below seed		with seed		top of seed		below seed	
Grade	high	low	high	low	high	low	high	low	high	low	high	low
	bu./acre											
10-34-0	182.3	184.8	172.7	182.7	185.1	185.1	209.0	204.5	196.4	205.5	203.7	200.1
4-10-10	183.3	180.0	177.9	190.2	177.7	184.3	209.8	212.9	216.8	206.4	211.8	220.5
3-18-18	179.3	176.2	184.6	174.5	182.9	178.1	215.1	211.3	220.1	224.7	218.6	204.2
Control:	180.7 bu. per acre						217.9 bu. per acre					

silty clay loam texture. Therefore, corn producers should plan to place fluid fertilizer at least 1 inch from the seed when the soil texture is a sandy loam, sand, or loamy fine sand.

Corn Yield:

Measured yields are listed in Table 4. None of the factors studied (fluid grade, placement, rate) affected yields where the soil texture was a silty clay loam. However, when averaged over rate and placement, grain yield was significantly reduced when 10-34-0 rather than 3-18-18 and 4-10-10 was placed close to the seed (203.2 vs. 215.7 and 213.0 bu. per acre respectively). This yield reduction can best be attributed to the reduction in emerged stand. As was the case with emerged stand, these results are consistent with those measured in 2005.

The yield reduction attributed to placement of 10-34-0 too close to the seed was approximately 6%. In contrast to past years, yield reduction attributed to the use of 10-34-0 was greatest when this fluid was not applied in direct contact with the seed. Yields were nearly equal when the 10-34-0 was placed either above (200.9 bu. per acre) or below (201.0 bu. per acre) the seed if the two rates are averaged. The average yield was 206.7 bu. per acre when this material was placed in contact with the seed. There is no apparent explanation for this difference between 2005 and 2006.

Soybean Emergence:

In past trials, soybean emergence was negatively affected by placement of fertilizer near the seed. Results of emergence measurements taken in 2006 were consistent with results from previous studies. Emergence was significantly affected by the grade used as well as rate and placement. There was also a significant rate X placement interaction. The effect of these factors on emergence is summarized in Table 5. When averaged over placement and rate emergence was 91.0%, 95.2% and 97.3% of the control when 3-18-18, 10-34-0, and 4-10-10 respectively were applied. Considering placement, greatest emergence was achieved when all fertilizers at both rates were applied above the seed (97.8% of the control).

In 2006, the reduction in emergence was not as large as in past years when reductions of approximately 35% were measured. This difference is attributed to the fact that there was approximately 0.5 in. of rain within 2 hours of planting in 2006.

Soybean Yield:

The main effects of fertilizer grade, placement, and rate had no significant effect on soybean yield in 2006. The interaction between fertilizer grade and placement, however, was significant. Even though there were differences in emergence, these differences were not reflected in yield.   This is not unusual for soybeans. Frequently, there is compensation for fewer plants from more pods per plant.

The interaction between fertilizer grade and placement is explained by examining yields when the fertilizer was placed above the seed. With the use of 10-34-0 and 3-18-18, this placement produced the highest yield. However, placement with the seed produced the highest yield when the 4-10-10 was used.

Sugarbeet Emergence:

The effect of three factors studied on sugarbeet emergence is summarized in Table 7. The fluid grade, rate of application, and placement had no significant effect on this measurement. This conclusion can be explained by the fact that low rates were used and the fact that sugarbeet seed is coated. This coating may help to prevent damage to the seed.

Table 5. The effect of rate and placement of three fluid grades on emergence of soybeans in 2006.

	Placement and Rate					
	with seed		top of seed		below seed	
Grade	high	low	high	low	high	low
	% of control					
10-34-0	89.2	99.4	99.0	101.7	89.5	92.6
4-10-10	97.2	96.3	99.7	96.0	95.5	98.9
3-18-18	81.1	95.8	93.8	96.9	85.8	92.9

control = 153,767 plants per acre

Table 6. The effect of rate and placement of three fluid grades on yield of soybeans. 2006.

	Placement and Rate					
	with seed		top of seed		below seed	
Grade	high	low	high	low	high	low
	bu./acre					
10-34-0	68.4	65.3	69.2	69.2	68.3	69.0
4-10-10	70.6	69.6	66.4	66.9	66.7	66.0
3-18-18	65.0	67.1	71.1	74.3	67.0	67.8

control = 64.5 bu. per acre

Table 7. The effect of rate and placement of three fluid grades on sugarbeet emergence.

	Placement and Rate					
	with seed		top of seed		below seed	
Grade	high	low	high	low	high	low
	% of control					
10-34-0	102.9	96.7	104.9	100.0	100.4	104.4
4-10-10	104.4	96.4	99.3	102.2	101.5	97.1
3-18-18	105.4	98.6	97.5	100.4	100.7	99.6

control = 65,578 plants per acre

Recoverable Sucrose:

Sugarbeet producers are paid on the basis of pounds of recoverable sucrose per acre. Therefore, the effect of the factors studied on this measurement is summarized in Table 8. At this site, the rate and placement of the three fluid materials had no significant effect on recoverable sucrose. This conclusion is the same as the conclusion reached from similar trials conducted in 2005.

Table 8. The effect of rate and placement of three fluid grades on sugar yield.

	Placement and Rate					
	with seed		top of seed		below seed	
Grade	high	low	high	low	high	low
	- - - - - - - lb. extractable sucrose per acre - - - - - - -					
10-34-0	8,796	8,088	8,166	8,100	7,869	7,714
4-10-10	8,258	7,475	7,722	7,434	8,051	8,221
3-18-18	8,282	7,878	7,809	8,604	7,677	8,092

control = 8,626 lb. per acre

SMBSC Preliminary testing to evaluate nitrogen and phosphorus credit
in Precipitated Calcium Carbonate (PCC or Factory spent lime)

The benefits of Precipitated Calcium Carbonate (PCC or Factory spent lime) has been investigated and proven over the past two decades. However, the specific reason for the benefits realized in crop production has not been determined as of present. Many researchers are trying to dissect the benefits of the PCC and have not been able to not been able to determine the details of the benefit. The research described in this report investigates the nitrogen and phosphorus credits obtainable in SMBSC PCC. SMBSC PCC varies in the analysis, depending on the sample taken from the approximate 100,000 tons of lime used by the SMBSC sugar beet factory on an annual basis. The PCC used in this test contained 7 lbs of nitrogen and 15 lbs of phosphorus per ton.

Methods

Four tests were established to investigate the nitrogen and phosphorus credit in SMBSC PCC as considered with sugar beet production. Two tests were conducted considering nitrogen credit in SMBSC PCC and two tests were conducted considering phosphorus credit in SMBSC PCC. All four experiments were conducted in a randomized complete block design. The individual experimental units were 11 ft wide (6 rows) and 40 feet long. The producer left a strip within the field with no PCC applied. Experiments were then conducted within the unapplied strip and the applied area in side by side comparisons. Since the presence or absence of PCC was not an effect on the individual experiments one can not make direct comparisons of PCC credits. The only comparisons one can assume are nitrogen and phosphorus rate effects within each experiment and not comparison across PCC applications. Stand counts at the 4 leaf sugar beet stage and at harvest were collected for comparisons among nitrogen rates and phosphorus rates. Light band reflectance measurements were collected with a Green Seeker light reflectance instrument which measures Normalized Differential Vegetative Index (NDVI) and Red Band Near infra Red (RNIR). Plant tissue analysis was conducted at the time reflectance data was collected. Leaf samples were taken from the sugar beets 8 and 12 leaf pairs. The sugar beets in all experiments were taken for yield and quality on September 28, 2006 from the third row of the six row experimental unit. The complete row was harvested and two sub samples collected for weight and quality analysis in the SMBSC quality tare lab.

Nitrogen testing methods

Nitrogen was applied according to the treatment with in the experimental unit and randomization. A blanket 45 lb per acre phosphorus treatment was applied to all experimental units to eliminate the phosphorus variable in sugar beet production. Potassium levels in the soil were high enough, so that no phosphorus needed to be applied.

Phosphorus testing methods

Nitrogen was applied according to the treatment within the experimental unit and randomization. Nitrogen was added to each experimental unit to bring total nitrogen (soil test nitrogen plus applied nitrogen) to 110 lbs nitrogen per acre level. Treatments were applied using “burned” turkey manure. The burned turkey manure is turkey manure burned for energy as proposed in the Benson Minnesota facility. The process eliminates the nitrogen from the turkey manure. The burned turkey manure was applied at 300 and 600 lbs per acre, which would coincide with equivalent amounts applied in Europe. The treatments are designated in the tables under phosphorus applied per acre as 300BM and 600BM.

Results and Discussion

All results will be discussed as separate experiments due to the limitations of the experiments explained above. A comparison of relative differences was conducted by graphing treatment average data points and applying a best line fir the data using simple regression analysis. This is the only comparison that will be made across experiments with the same nutrient (nitrogen or phosphorus), but only using tendencies due to the experiment limitations.

Nitrogen without PCC testing results

(Tables 1 and 2)
Tons per acre were not statistically different between nitrogen rates. Sugar percent, purity and sugar per ton significantly decreased as nitrogen rate increased. Sugar beet brie nitrate (Nppm) increased significantly as nitrogen rate increased. Extractable sugar per acre was significantly different with varied nitrogen treatments. The highest extractable sugar per acre and revenue per acre was achieved at the 90 lbs per acre treatment with total nitrogen of 126 lbs per acre.

Stand count did not change with nitrogen rate. NDVI declined as nitrogen rate increased and Red/Nir changed significantly as nitrogen rate changed. Plant tissue phosphorus and nitrate increased as nitrogen rate increased.

Table 1. Evaluation considering nitrogen influence on sugar beet yield and revenue in the absence of PCC
Exp # 0619A

Nitrogen Rate	0-4 ft. nitrogen	Total nitrogen	Factory lime (PCC) tons/acre	Tons per acre	Sugar percent	PURITY	PPM Nitrate	Ext. Suc. per ton	Ext. Suc. per acre	revenue per acre
0	36	36	0	28.79	17.20	92.20	12	297	8549	1175
30	36	66	0	28.95	17.18	91.21	12	293	8499	1158
60	36	96	0	30.12	16.98	90.78	14	287	8656	1159
90	36	126	0	31.28	16.94	90.76	16	287	9002	1207
120	36	156	0	32.21	15.96	89.71	49	265	8549	1067
			C.V%	**18.66**	**2.44**	**0.94**	**23.66**	**3.52**	**19.77**	**21.07**
			LSD (0.05)	**NS**	**0.55**	**1.15**	**6.49**	**13.49**	**2293.5**	**NS**

Table 2. Evaluation considering nitrogen influence on plant analysis and reflectance measurements in the absence of PCC
Exp # 0619A

Nitrogen Rate	0-4 ft. nitrogen	Total nitrogen	Factory lime (PCC) tons/acre	4 lf stand count	Harvest count	NDVI	Red/Nir	Plant Tissue NO3-N	Plant Tissue P2O5
0	36	36	0	17.8	15.1	0.591	0.271	17116	2677
30	36	66	0	17.7	16.3	0.657	0.217	18565	2527
60	36	96	0	17.9	19.3	0.636	0.236	19879	2375
90	36	126	0	17.6	15.3	0.633	0.237	21131	2254
120	36	156	0	17.5	19.6	0.601	0.262	22907	2302
			C.V%	**9.52**	**28.83**	**7.39**	**15.06**	**14.40**	**10.19**
			LSD (0.05)	**NS**	**NS**	**0.060**	**0.040**	**3848**	**332**

<u>*Nitrogen with PCC testing results*</u>
(Tables 2 and 4)
All yield and quality variables were non-significant in relation to nitrogen applied in the absence of PCC. However, when total nitrogen was increased to 156 lbs per acre, an increase in revenue per acre tended to occur with sugar percent, purity, and extractable sugar per acre. Contradictory, sugar beet brie nitrate tended to increase when total nitrogen was increased to 156 lbs. per acre. These results indicate a nitrogen credit, in that the variables were not significantly different as nitrogen rate increased to 126 lbs total nitrogen. Sugar beet production was negatively effected when total nitrogen was increased to 156 lbs. total nitrogen

Stand count on 5/31/06 and at harvest was not influenced by nitrogen rate. NDVI increased and Red/NIR tended to decline as nitrogen rate increased. Plant tissue nitrate increased as nitrogen rate increased. Plant tissue phosphorus tended to decline as nitrogen rate increased.

Table 3. Evaluation considering nitrogen influence on sugar beet yield and revenue in the presence of PCC
Exp # <u>0619B</u>

Nitrogen Rate	0-4 ft. nitrogen	Total nitrogen	Factory lime (PCC) tons/acre	Ton per acre	Sugar percent	Purity	PPM Nitrate	Ext. Suc. per ton	Ext. Suc. per acre	revenue per acre
0	36	36	4	32.42	16.87	91.14	11	287	9305	1244.87
30	36	66	4	31.28	16.89	91.15	16	288	8993	1204.82
60	36	96	4	30.90	16.84	91.31	11	287	8873	1187.55
90	36	126	4	31.83	16.85	91.75	17	289	9203	1238.59
120	36	156	4	32.94	16.19	91.14	22	275	9050	1166.41
			C.V%	**6.76**	**3.08**	**1.16**	**50.46**	**4.55**	**7.51**	**9.83**
			LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 4. Evaluation considering nitrogen influence on plant analysis and reflectance measurements in the presence of PCC
Exp # <u>0619B</u>

Nitrogen Rate	0-4 ft. nitrogen	Total nitrogen	Factory lime (PCC) tons/acre	4 lf stand count	Harvest count	NDVI	Red/Nir	Plant Tissue NO3-N	Plant Tissue P2O5
0	36	36	4	17.0	19.7	0.572	0.282	16885	2418
30	36	66	4	16.8	16.6	0.642	0.227	18837	2286
60	36	96	4	16.7	16.5	0.627	0.240	19299	2160
90	36	126	4	17.0	18.4	0.593	0.268	20564	2092
120	36	156	4	17.4	18.9	0.609	0.256	21315	2118
			C.V%	**9.94**	**22.52**	**6.17**	**12.19**	**10.49**	**15.11**
			LSD (0.05)	**NS**	**NS**	**0.050**	**0.040**	**2727.5**	**NS**

<u>*Phosphorus without PCC testing results*</u>
*(*Tables 5 and 6*)*
Tons per acre and extractable sugar per ton were not consistently influenced by phosphorus rate. Sugar percent tended to decrease as phosphorus rate increased. Purity and brie nitrate (NPPM) were not significantly influenced by phosphorus rate. Revenue per acre was highest at 30 and 0 lbs phosphorus per acre, respectively. Burned turkey manure gave higher sugar percent, but lower tons per acre which resulted in lower extractable sugar per acre and revenue per acre compared to the phosphorus treatments.

Stand count on 5/31/06 and at harvest were not significantly influenced by phosphorus rate. NDVI was not significantly influenced by phosphorus rate or burned manure rate. Red/NIR and plant nitrate and phosphorus was not consistently influenced by phosphorus rate and was not significantly influence by burned manure.

Table 5. Evaluation considering phosphorus influence on sugar beet yield and revenue in the absence of PCC
0620A

Phosphorus. Lbs/Acre	Factory Lime (PCC) tons/acre	Tons per acre	Sugar percent	Purity	Nppm	Ext. Suc. per ton	Ext. Suc. per acre	revenue per acre
0	0	30.27	17.22	91.67	12	295	8942	1224.18
15	0	30.27	16.90	91.02	12	287	8687	1161.86
30	0	31.16	16.97	91.70	10	291	9082	1230.06
45	0	26.77	16.86	91.93	23	290	7749	1043.84
60	0	29.05	16.77	91.01	14	285	8275	1100.27
300 BM	0	25.30	17.20	91.62	15	295	7466	1021.39
600 BM	0	27.80	17.30	91.73	9	297	8257	1135.18
	C.V%	**6.52**	**1.85**	**0.74**	**77.00**	**7.53**	**6.36**	**6.9**
	LSD (0.05)	**2.45**	**0.41**	**NS**	**NS**	**NS**	**699**	**103**

Table 6. Evaluation considering phosphorus influence on plant analysis and reflectance measrements in the absence of PCC
0620A

Phosphorus. Lbs/Acre	Factory Lime (PCC) tons/acre	4 lf stand count	Harvest stand count	NDVI	Red/Nir	Plant Tissue NO3-N	Plant Tissue P2O5
0	0	17.31	19.25	0.38	0.29	22319	2045
15	0	17.57	17.29	0.38	0.25	20240	2039
30	0	18.19	21.13	0.39	0.23	23206	2227
45	0	18.63	17.00	0.38	0.27	21552	2242
60	0	18.31	17.25	0.41	0.23	23741	2250
300 BM	0	18.81	16.63	0.37	0.32	16872	2175
600 BM	0	18.07	20.43	0.43	0.32	18023	2326
	C.V%	**8.87**	**24.32**	**21.31**	**10.35**	**12.37**	**8.18**
	LSD (0.05)	**NS**	**NS**	**NS**	**0.038**	**3300**	**230**

Phosphorus with PCC testing results
(Tables 7 and 8)

Phosphorus rate in the presence of lime did not influence tons per acre, sugar percent, purity, Brie nitrate (NPPM), extractable sugar per acre or revenue per acre. Extractable sugar per acre was different in relation to phosphorus rate but was not directly related to the rate of phosphorus. Tons per acre were significantly lower when burned turkey manure was applied. Sugar percent, purity, Brie nitrate and extractable sugar per ton were not different when considering burned turkey manure rates compared to phosphorus rates. Extractable sugar per acre and revenue per acre were significantly lower with burned turkey manure compared to phosphorus rates due to the reduction in tons per acre with the burned turkey manure treatments. Phosphorus rates and burned turkey manure did not influence stand count at 4 leaf or harvest.

NDVI, RedNIR, plant issue nitrate and phosphorus were not influenced by phosphorus rate. Burned turkey manure decreased NDVI and plant tissue nitrate while increasing Red/NIR and plant tissue phosphorus.

Table 7. Evaluation considering phosphorus influence on sugar beet yield and revenue in the presence of of PCC

<u>0620B</u>

Phosphorus. Lbs/Acre	Factory lime (PCC) tons/acre	Tons per acre	Sugar percent	Purity	Nppm	Ext. Suc. per ton	Ext. Suc. per acre	revenue per acre
0	4	32.42	17.24	91.15	8	294	9522	1297.64
15	4	30.08	17.20	91.48	8	294	7081	1207.89
30	4	32.94	17.41	91.49	11	298	7856	1354.13
45	4	32.42	17.29	91.52	12	296	7681	1316.85
60	4	33.35	17.11	91.63	15	293	7824	1331.16
300 BM	4	26.22	17.36	91.50	9	297	6235	1071.97
600 BM	4	25.76	17.50	91.42	9	299	6170	1066.91
	C.V%	**18.05**	**2.50**	**0.64**	**58.53**	**3.05**	**17.34**	**17.21**
	LSD (0.05)	**5.8**	**NS**	**NS**	**NS**	**NS**	**1659**	**226**

Table 8. Evaluation considering phosphorus influence on plant analysis and reflectance measremnts in the presence of PCC

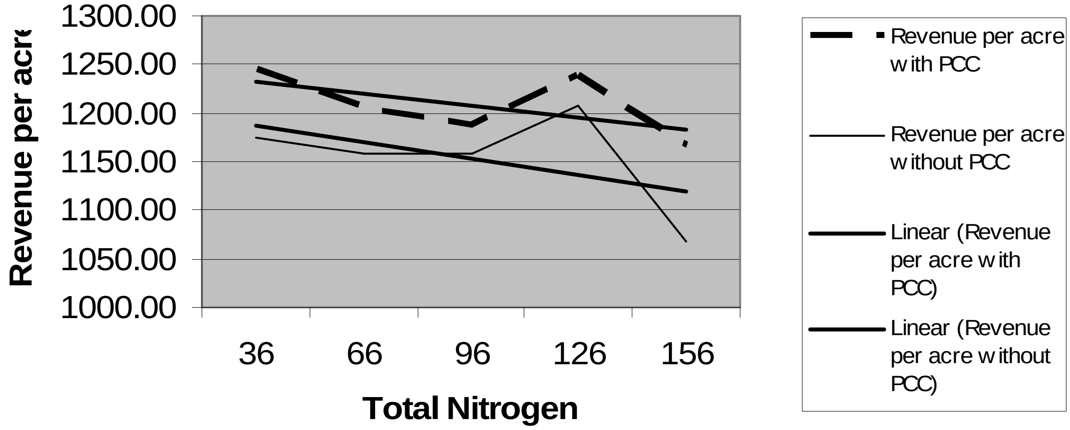
0620B

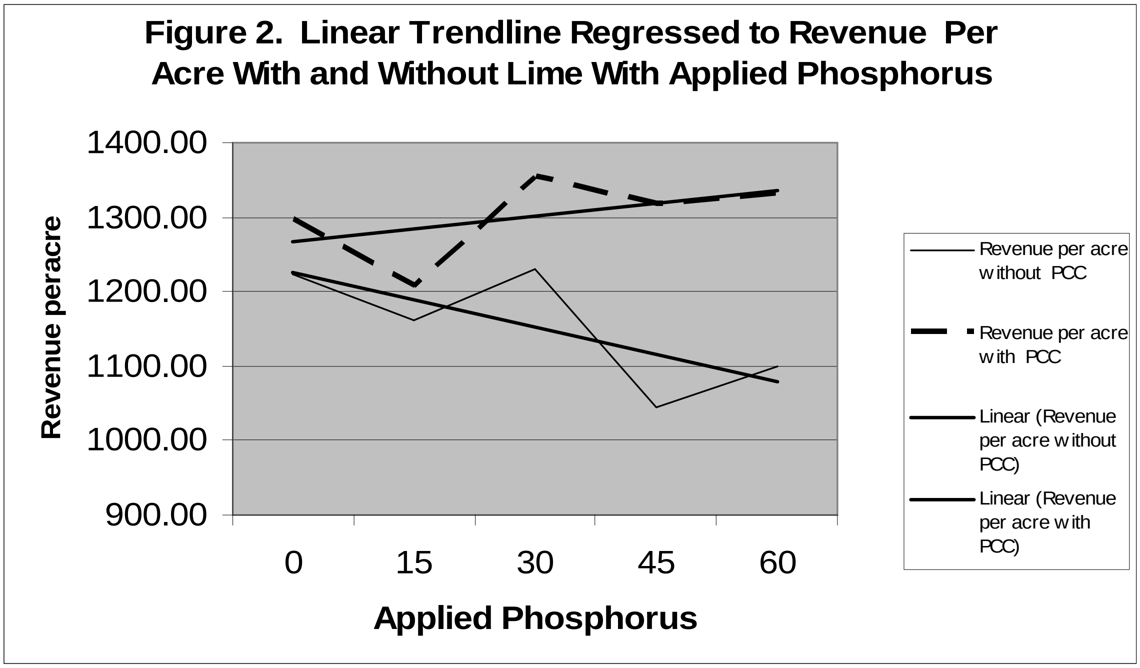
Phosphorus. Lbs/Acre	Factory lime (PCC) tons/acre	4 lf stand count	Harvest stand count	NDVI	Red/Nir	Plant Tissue NO3-N	Plant Tissue P2O5
0	4	17.20	17.10	0.62	0.24	22037	1818
15	4	17.44	17.11	0.58	0.28	21450	1915
30	4	17.44	16.67	0.59	0.27	20696	2002
45	4	17.83	17.89	0.61	0.25	22047	1877
60	4	17.78	16.89	0.60	0.26	22398	1902
300 BM	4	17.67	15.67	0.49	0.36	14145	2098
600 BM	4	18.89	16.89	0.52	0.33	15976	2109
	C.V%	**8.16**	**20.41**	**4.69**	**8.02**	**14.64**	**9.3**
	LSD (0.05)	**NS**	**NS**	**0.035**	**0.029**	**3801**	**238**

Figures 1 and 2 show the relationship of the nitrogen and phosphorus rates in the presence and absence of PCC. The trend line for nitrogen (figure 1) indicates an increase in production with 4 tons of PCC applied to the soil. The trend lines for nitrogen in the presence and absence of PCC were parallel. The data presented in this report indicate a credit for nitrogen from SMBSC PCC; however more research is needed to confirm such conclusion.

The trend lines for sugar beet revenue with phosphorus rates in the presence and absence of SMBSC PCC were not parallel. The higher rates of phosphorus gave greater separation in sugar beet revenue per acre, with SMBSC PCC applied at 4 ton per acre giving higher revenues per acre. This leads to evidence that SMBSC PCC may not have a phosphorus credit even though the SMBSC PCC contains phosphorus. One theory may be that the phosphorus is tied up by the $CaCO_3$ of the SMSC PCC.

Figure 1. Linear Trendline Regressed to Revenue Per Acre With and Without Lime With Total Nitrogen





Summary

The summaries relating to PCC benefits and credits will be expressed as tendencies and are not intended to be conclusions due to the limitations of the testing. Further testing is currently being conducted based on past testing and results of the research reported here.

1. There appeared to be a nitrogen credit with PCC as the benefit of added nitrogen was not apparent in the presence of applied PCC, contrary to the test where PCC was not applied.
2. In this test there did not appear to be a phosphorus credit with applied PCC, and if any influence with PCC was apparent it was the possible tie up of phosphorus with applied PCC.
3. NDVI, Red/NIR, plant phosphorus and nitrate appeared to be good indicators of nutrient treatment effects. The use of these measurements will be investigated.
4. The addition of PCC did appear to give a benefit to sugar beet production in reference to nitrogen or phosphorus aplications.

Organic Matter and It's Relationship with Nitrogen Guidelines for Sugarbeet

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Nitrogen fertilizer management is important for raising quality sugarbeet. A large amount of nitrogen that a sugarbeet takes up comes from the soil organic matter. It seems logical that the more we know about nitrogen from organic matter, the better we should be able to manage nitrogen. Information about organic matter effects on nitrogen management could be incorporated into nitrogen fertilizer guidelines either as a credit towards the N required or as a way to direct soil sampling strategies for nitrate-N.

To begin this process in the Southern Minnesota Beet Sugar Cooperative growing area, a study was started in 2006 to investigate the interaction between sugarbeet response to nitrogen fertilization and soil organic matter content.

The study was established at seven locations in the Southern Minnesota Beet Sugar Cooperative growing area, Table 1. Within each location two or three sites were set out. The soil at these sites varied in organic matter from 1.7 to 6.4 % and residual nitrate-N in the surface four feet from 7 to 108 pounds per acre. The treatments at each site were nitrogen fertilizer applied at 0, 30, 60, 90, and 120 lb N per acre as urea. The soil samples for organic matter and soil nitrate-N were taken before the treatments were applied. The sites were planted by the cooperators and machine lifted with a small plot lifter. Root yield and quality were determined and the return per acre was calculated using the current SMBSC payment.

Table 1. The soil nitrate-N in the surface four feet and organic matter concentration in the surface six inches for seven locations in 2006.

	Soil nitrate-N	Organic matter	
Site	lb N/A	%	Location
603	74	3.7	Morris
604	63	5.2	Morris
605	7	1.7	Hancock
606	12	2.9	Hancock
607	17	3.3	Gluek
608	40	6.4	Gluek
609	91	4.7	Wood Lake
610	81	5.4	Wood Lake
611	59	2.2	Danube
612	108	3.8	Danube
613	96	5.6	Danube
614	60	2.9	Olivia
615	17	4.5	Olivia
616	16	6.3	Olivia
617	102	4.9	Buffalo Lake
618	74	3.1	Buffalo Lake

Two sites were established near Morris in 2006. There was a significant response to the addition of nitrogen fertilizer at the lower organic matter concentration site, Table 2. The optimum nitrogen application for root yield was 90 lb/A while purity, extractable sucrose, and return were best with the application of 60 lb N/A. Root yield, extractable sucrose, and return were not significantly affected at the higher organic matter site 604.

Increasing nitrogen application significantly decreased purity and extractable sucrose per ton after the first 30 lb N/A was applied.

Table 2. Root yield, purity, extractable sucrose and return for sites 603 and 604 at the Morris location in 2006.

	Site 603					Site 604				
Nrate	Root yield	Purity	Extractable sucrose		Return	Root yield	Purity	Extractable sucrose		Return
lb/A	ton/A	%	lb/ton	lb/A	$/A	ton/A	%	lb/ton	lb/A	$/A
0	21.0	86.4	292	5140	827	26.1	89.5	303	7832	1085
30	20.6	86.6	3.4	5288	880	26.2	89.5	309	8045	1135
60	24.5	88.4	298	6143	1006	26.6	89.1	307	8118	1139
90	24.8	88.3	292	6105	984	28.1	88.9	302	8472	1178
120	22.9	86.2	291	5620	903	27.1	88.3	291	7831	1055
Nrate	0.04	0.009	0.05	0.09	0.06	NS	0.0001	0.002	NS	NS
C.V. (%)	10.3	1.3	2.5	11.6	10.8	11.0	0.4	1.9	10.5	10.5

Similar to the Morris location, two sites were established at the Hancock location, Table 3. This site was on an irrigated soil with a sandy texture. Root yield, extractable sucrose per acre and return were increased with the application of nitrogen fertilizer at the lower organic matter site 605. This increase was optimized with the application of 90 lb N/A. The quality parameters, purity and extractable sucrose per ton were not affected until 90 lb N/A was applied. These quality parameter were decreased with the 120 lb N/A application. At site 605, the return was not affected by the application of nitrogen fertilizer. The extractable sucrose per ton was decrease with increasing N application.

Table 3. Root yield, purity, extractable sucrose and return for sites 605 and 606 at the Hancock location in 2006.

	Site 605					Site 606				
Nrate	Root yield	Purity	Extractable sucrose		Return	Root yield	Purity	Extractable sucrose		Return
lb/A	ton/A	%	lb/ton	lb/A	$/A	ton/A	%	lb/ton	lb/A	$/A
0	20.9	90.9	308	5436	771	30.2	91.3	315	9541	1372
30	24.7	90.9	313	6498	928	29.4	90.3	303	8963	1257
60	30.8	90.9	307	7939	1116	27.1	90.2	306	8213	1148
90	35.3	90.5	296	8646	1170	32.5	88.8	287	9357	1256
120	26.8	89.1	284	6390	846	31.5	88.9	276	8845	1145
Nrate	0.001	0.04	0.03	0.0007	0.0009	0.06	NS	0.06	NS	NS
C.V. (%)	16.1	1.0	4.5	14.2	14.0	9.1	2.4	7.0	12.8	13.0

Sites 607 and 608 were located near Gluek on heavy textured soils. Root yield was not affected by the addition of nitrogen fertilizer at either site, Table 4. With the soil nitrate-N values of 17 and 40 lb/A, a response would have been expected. This location suffered droughty conditions during the year and while the yields are respectable, they were considerably less than the cooperative average. In general, the quality parameters at both sites were decreased with increasing nitrogen applications. The reduction in quality is reflected in the significant decrease in return at both sites from the application of nitrogen fertilizer. The droughty conditions had much to do with these results.

Table 4. Root yield, purity, extractable sucrose and return for sites 607 and 608 at the Gluek location in 2006.

	Site 607					Site 608				
Nrate	Root yield	Purity	Extractable sucrose		Return	Root yield	Purity	Extractable sucrose		Return
lb/A	ton/A	%	lb/ton	lb/A	$/A	ton/A	%	lb/ton	lb/A	$/A
0	22.0	91.3	292	5396	731	28.3	88.9	254	7203	863
30	22.8	90.8	285	5461	726	30.0	88.4	248	7438	865
60	18.2	91.0	286	4412	591	27.3	87.7	242	6613	750
90	20.5	90.2	266	4613	589	27.5	87.4	235	6478	711
120	20.3	90.1	269	4589	580	25.5	87.5	233	5952	656
Nrate	NS	NS	0.004	0.07	0.03	NS	0.09	0.09	0.04	0.03
C.V. (%)	13.2	0.9	3.8	13.8	14.3	9.5	1.1	5.2	10.8	14.4

There were two sites located in a producer's field near Wood Lake. The soil test nitrate-N values were 91 for site 609 and 81 for site 610. There was no response to nitrogen fertilizer application for root yield, extractable sucrose per acre and return at either site, Table 5. At site 609, purity and extractable sucrose per ton were decrease with the addition of nitrogen fertilizer. Only extractable sucrose per ton was decreased at the 610 site.

Table 5. Root yield, purity, extractable sucrose and return for sites 609 and 610 at the Wood Lake location in 2006.

	Site 609					Site 610				
Nrate	Root yield	Purity	Extractable sucrose		Return	Root yield	Purity	Extractable sucrose		Return
lb/A	ton/A	%	lb/ton	lb/A	$/A	ton/A	%	lb/ton	lb/A	$/A
0	25.3	90.3	295	6290	861	31.1	90.5	293	7688	1244
30	25.8	90.1	295	6410	876	30.6	90.7	296	7633	1244
60	28.1	89.9	295	6960	951	30.6	90.5	293	7542	1218
90	28.0	89.7	284	6695	888	30.5	89.9	286	7348	1166
120	26.9	88.9	280	6342	831	31.5	89.6	272	7226	1097
Nrate	NS	0.001	0.001	NS	NS	NS	NS	0.02	NS	NS
C.V. (%)	7.5	0.5	2.0	7.5	7.8	7.1	0.9	3.5	7.7	9.2

There were three sites at the Danube location. The results are reported in Table 6 and Table 7. All parameter measured at site 611 were affected by the application of nitrogen. The soil nitrate-N at this site was 59 lb/A. Optimum root yield, extractable sucrose per acre, and return was obtained with the 60 lb N/A application. This was within the current guidelines. Purity and extractable sucrose per ton were reduced significantly once the optimum N rate was reached. At Sites 612 and 613, the application of N fertilizer did not significantly affect any parameter measured, Table 6 and Table 7. The soil test nitrate-N values were 108 lb/A for site 612 and 96 lb/A for site 613.

Table 6. Root yield, purity, extractable sucrose and return for sites 611 and 612 at the Danube location in 2006.

	Site 611					Site 612				
Nrate	Root yield	Purity	Extractable sucrose		Return	Root yield	Purity	Extractable sucrose		Return
lb/A	ton/A	%	lb/ton	lb/A	$/A	ton/A	%	lb/ton	lb/A	$/A
0	21.7	90.8	311	5673	807	31.0	90.1	294	7640	1038
30	21.9	90.2	316	5835	840	29.7	89.9	289	7209	968
60	25.1	90.5	323	6820	995	30.1	89.7	293	7401	1004
90	23.2	90.4	314	6143	879	33.1	89.4	292	8084	1092
120	26.9	89.2	299	6784	939	30.3	89.2	280	7150	928
Nrate	0.0001	0.06	0.06	0.002	0.02	NS	NS	NS	NS	NS
C.V. (%)	6.2	0.9	3.6	7.3	8.8	15.7	0.7	3.0	15.7	15.8

Table 7. Root yield, purity, extractable sucrose and return for site 613 at the Danube location in 2006.

	Site 613				
Nrate	Root yield	Purity	Extractable sucrose		Return
lb/A	ton/A	%	lb/ton	lb/A	$/A
0	33.8	90.2	291	8289	1121
30	33.5	89.9	298	8387	1153
60	33.8	90.1	298	8486	1170
90	35.1	89.6	291	8614	1166
120	33.3	89.5	296	8292	1136
Nrate	NS	NS	NS	NS	NS
C.V. (%)	8.8	0.5	3.4	8.6	9.3

Similar to the Danube location, there were three sites at the Olivia location in 2006. The results for sites 614 and 615 are reported in Table 8 while the results for site 616 are reported in Table 9. Only root yield at site 614 was significantly affected by N application. The root yield was greatest with a 90 lb N/A application. The other parameters measured at all sites near Olivia were not significantly affected by N application. This was not expected as the soil nitrate-N values at all three site were in the responsive range.

Table 8. Root yield, purity, extractable sucrose and return for sites 614 and 615 at the Olivia location in 2006.

	Site 614					Site 615				
Nrate	Root yield	Purity	Extractable sucrose		Return	Root yield	Purity	Extractable sucrose		Return
lb/A	ton/A	%	lb/ton	lb/A	$/A	ton/A	%	lb/ton	lb/A	$/A
0	28.7	90.0	277	6682	867	29.8	91.0	293	7356	1001
30	25.8	90.1	275	5971	771	28.5	91.3	296	7107	975
60	30.4	90.2	277	7092	922	28.0	91.2	302	7106	987
90	31.0	90.0	270	7046	895	27.6	91.2	297	6912	951
120	26.1	89.9	274	6039	778	28.4	91.1	294	7024	951
Nrate	0.07	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	11.3	0.4	1.9	12.1	13.1	9.7	0.5	3.5	8.8	8.9

Table 9. Root yield, purity, extractable sucrose and return for site 616 at the Olivia location in 2006.

	Site 616				
Nrate	Root yield	Purity	Extractable sucrose		Return
lb/A	ton/A	%	lb/ton	lb/A	$/A
0	26.0	91.2	294	6414	874
30	25.0	91.4	297	6231	855
60	27.4	91.2	292	6707	906
90	26.6	91.2	293	6541	888
120	26.7	91.2	292	6542	885
Nrate	NS	NS	NS	NS	NS
C.V. (%)	11.7	0.5	1.6	11.3	11.1

There were two sites located near Buffalo Lake, Minnesota in 2006. Root yield, extractable sucrose per acre, and return were not significant affected by N application at either site, Table 10. Purity and extractable sucrose at site 618 were also not significantly affected by the nitrogen treatments. Extractable sucrose and purity were reduced with nitrogen application at site 617.

Table 10. Root yield, purity, extractable sucrose and return for sites 617 and 618 at the Buffalo Lake location in 2006.

	Site 617					Site 618				
Nrate	Root yield	Purity	Extractable sucrose		Return	Root yield	Purity	Extractable sucrose		Return
lb/A	ton/A	%	lb/ton	lb/A	$/A	ton/A	%	lb/ton	lb/A	$/A
0	30.3	91.1	300	7645	1059	27.9	90.9	294	6919	945
30	29.3	90.9	296	7264	991	32.1	91.0	289	7814	1053
60	32.0	90.7	292	7857	1066	30.2	90.7	285	7248	964
90	28.7	89.8	282	6811	898	29.8	90.2	284	7115	942
120	31.3	89.6	274	7221	928	28.6	90.1	283	6838	907
Nrate	NS	0.0005	0.004	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	12.6	0.6	3.3	12.4	12.8	11.2	0.9	3.4	12.4	14.0

This is the first year of this study. At this time, little inference can be made about how organic matter can be incorporated into nitrogen soil sampling and rate guidelines. Overall, when excess nitrogen fertilizer is applied, the sugarbeet root quality is decreased. In these studies, the root yield and sucrose yield response was not as consistent as has been the case in the past. However, if a grower followed the current U of MN/SMBSC N application guidelines, they did not fall short of the optimum return for the sugarbeet crop.

Whole Rotation Nitrogen Management for Sugarbeet Production

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Nitrogen fertilizer management through out the sugar beet crop rotation is paramount for the best quality and economic return to sugar beet production. Several aspects of nitrogen management in the rotation need to be investigated. In the Southern Minnesota Beet Sugar Cooperative (SMBSC) growing area, the common three year rotation is sugar beet-soybean-corn. Growers tend to fertilize corn aggressively to reduce the risk of lost yield. Unfortunately, excess nitrogen for sugar beet production causes reduced quality which affects economic returns. Little research exists that addresses the effects of excess nitrogen application for the previous corn crop on sugar beet yield and quality or what N rate adjustment for the following sugar beet crop is needed. This study was design with the objective to determine the effect of nitrogen management for a previous corn crop on sugar beet yield and quality.

Materials and Methods:

To achieve the proposed objective, a field study was conducted in the Southern Minnesota Beet Sugar Cooperative production area. Six sites were established in production fields. Three of the six sites were abandoned because of disease, drought, and miscommunication. Three sites, Maynard, Hector, and Raymond were used for this report. A three year rotation, soybean/corn/sugarbeet was used at each site. A soybean crop was grown at each site in the first year of the study. Five replications of three main plots 66 X 35 feet in size were established. After harvest soil samples for P, K, pH, and organic matter to a depth of six inches and soil samples for nitrate-N to a depth of four feet were taken. The main plots will then receive a nitrogen fertilizer treatments of 0, 120 (U of MN recommendation), or 200 (excess) pound per acre. Field corn was grown in the second year of the study. The corn was hand harvested for yield determination and soil samples to a depth of four feet for nitrate-N were taken after harvest. After soil sampling, the main plots were divided into 6 – 11 X 35 feet subplots and six nitrogen fertilizer treatments were applied (0, 40, 80, 120, 160, and 200 pounds per acre). Sugar beet was planted in the study in the third year. Roots were harvested for yield and quality determination. Final soil samples were taken in all plots to a depth of four feet for nitrate-N.

Results:

The study was established in growers production soybean field in year 1 at each site (Table 1). The soil nitrate-N to a depth of four feet late in the fall following soybean harvest was 50 lb/A at the Maynard site, 72 lb/A at the Hector site, and 51 lb/A at the Raymond site.

Table 1. The years each crop was grown at each site and the soil nitrate-N after the soybean crop.

Site name	Year 1 (soybean)	Year 2 (corn)	Year 3 (sugarbeet)	Soil nitrate-N lb/A (0-4 ft.)
Maynard	2002	2003	2004	50
Hector	2003	2004	2005	72
Raymond	2004	2005	2006	51

Field corn was grown at each site in year 2 of the experiment (Table 2). At the Maynard and Raymond sites, the application of nitrogen increased corn grain yields. The increase was small at the Maynard site. This was partially caused by a late season drought at this site. The increase at Maynard occurred from the first treatment of 120 lb N/A. The addition N added with the 200 lb N/A treatment did not increase grain yield beyond the 120 lb N/A treatment. At Raymond, the growing conditions were near perfect. The 0 lb N/A treatment had grain yields of 172 bushels per acre while the 120 lb N/A treatment yielded 231 bushels per year. The addition 80 lb N/A applied with the 200 lb N/A treatment did not significantly increase corn grain yields. No corn yields were taken at the Hector location.

Table 2. Corn yields for each site from year 2 of the study.

N rate	Maynard (03)	Hector (04)	Raymond (05)
lb/A	---------- Corn grain yield (bu/A) ----------		
0	108	-	172
120	125	-	231
200	125	-	239

Soil samples for soil nitrate-N were taken to a depth of 4 feet in the fall after corn harvest at all sites (Table 3). In comparing the three sites, Maynard and Hector had increased soil nitrate-N with increasing N fertilizer application for corn production. The Maynard site was more elevated than the Hector site because of the dry conditions during the 2003 growing season. The soil nitrate-N values at the Raymond site were not affected by the nitrogen applications for corn. The soil nitrate-N was not elevated by the 200 lb N/A treatments into a level that was not manageable for optimum sugarbeet production.

Table 3. Soil nitrate-N to a depth of 4 feet from samples taken late fall after corn harvest at each site.

	Maynard (50)	Hector(72)	Raymond(51)
Year 2 N rate	Soil nitrate-N (0-4 ft.) (lb/A)		
0	50	20	27
120	78	34	38
200	102	66	34

Sugarbeet was grown in year 3 of the rotation at each site. Root yield was only affected by year 3 N application treatments at all three of the sites (Table 4). At the Hector site, there was a significant interaction between the year 2 and year 3 N application treatments by it was in the magnitude of the response to N applied in year 3 and not an different response by one of the year 2 treatments. Root yield and extractable sucrose were increased by the first 80 lb N/A applied at the Maynard site (Table 5). At the Hector site, root yield and extractable sucrose were optimized at the 40 lb N/A application. The root yield at Raymond was affected by the year 3 N applications. The greatest root yield was at the 200 lb N/A applied for year 3. Extractable sucrose at the Raymond site was affected by the N applied before the corn crop. As the amount N fertilizer applied increased, the extractable sucrose at the Raymond site decreased. There was no extractable sucrose response to N applied directly before the sugarbeet crop.

Table 4. Statistical analysis for root yield and extractable sucrose per acre at Maynard, Hector, and Raymond.

	Maynard	Hector	Raymond	Maynard	Hector	Raymond
Source	Root yield			Extractable sucrose per acre		
Nrate yr 2	0.59	0.42	0.22	0.50	0.27	0.05
Nrate yr 3	0.01	0.03	0.02	0.05	0.01	0.35
Yr 2*Yr 3	0.18	0.06	0.45	0.16	0.01	0.41
C.V. (%)	11.6	8.0	9.3	13.0	7.3	9.8

Table 5. Root yield and extractable sucrose per acre for year 2 and year 3 N application treatments at Maynard, Hector, and Raymond.

	Maynard	Hector	Raymond	Maynard	Hector	Raymond
Yr 2 trt	Root yield (ton/A)			Extractable sucrose (lb/A)		
0	25.7	31.7	27.2	6294	8061	7576
120	23.1	31.3	27.0	5561	8000	7448
200	24.9	31.4	25.4	5862	7763	7050
Yr 3 trt						
0	22.0	30.7	26.4	5396	7957	7627
40	23.6	33.1	25.5	5751	8434	7306
80	25.4	32.1	25.3	6145	8195	7019
120	24.1	29.9	26.9	5829	7536	7405
160	25.9	33.1	26.4	5223	8047	7171
200	26.2	29.8	28.6	6090	7401	7592

The statistics and means for root sucrose and extractable sucrose are listed in Table 6 and 7. Root sucrose was decreased with increasing year 3 nitrogen applications are all sites. At the Hector site, root sucrose was decreased by the increasing year 2 nitrogen applications. The extractable sucrose per ton was decreased only by the increasing nitrogen rates applied directly before the sugarbeet production year.

Table 6. Statistical analysis for root sucrose and extractable sucrose per ton at Maynard, Hector, and Raymond.

	Maynard	Hector	Raymond	Maynard	Hector	Raymond
Source	Root sucrose			Extractable sucrose per ton		
Nrate yr 2	0.08	0.44	0.78	0.19	0.17	0.83
Nrate yr 3	0.05	0.02	0.01	0.01	0.01	0.01
Yr 2*Yr 3	0.25	0.65	0.21	0.25	0.51	0.17
C.V. (%)	3.5	2.8	3.2	4.3	3.6	4.0

Table 7. Root sucrose and extractable sucrose per ton for year 2 and year 3 N application treatments at Maynard, Hector, and Raymond.

	Maynard	Hector	Raymond	Maynard	Hector	Raymond
Yr 2 trt	Root sucrose (%)			Extractable sucrose (lb/ton)		
0	14.7	15.0	16.7	245	255	280
120	14.4	14.9	16.6	240	255	276
200	14.2	14.7	16.7	236	247	279
Yr 3 trt						
0	14.7	15.1	17.1	246	259	290
40	14.5	14.9	17.0	244	254	286
80	14.4	15.0	16.7	242	255	278
120	14.6	14.9	16.6	241	254	277
160	14.4	14.7	16.3	239	248	270
200	14.1	14.5	16.2	231	244	267

Soil samples to a depth of four feet for nitrate-N were taken after sugarbeet harvest to document if any residual N was left. At the Maynard and Hector sites, the residual nitrate-N was very small (Tables 8 and 9). The previous nitrogen treatments did not influence the amount. At Raymond, the amount of residual nitrate-N was greater than the other two sites and greater than normally expected (Table 10). The previous treatments did not affect the residual nitrate-N amounts.

Table 8. Soil nitrate-N to a depth of four feet, fall year 3 at Maynard site.

	Year 2 treatments (lb/A)		
Year 3 treatment	0	120	200
N rate (lb/A)	---------- Residual nitrate-N (lb/A) ----------		
0	25	17	20
40	34	23	18
80	28	21	25
120	25	18	22
160	32	27	26
200	28	31	46

Table 9. Soil nitrate-N to a depth of four feet, fall year 3 at Hector site.

	Year 2 treatments (lb/A)		
Year 3 treatment	0	120	200
N rate (lb/A)	---------- Residual nitrate-N (lb/A) ----------		
0	17	16	21
40	17	16	20
80	17	17	17
120	16	20	17
160	17	17	18
200	20	18	16

Table 10. Soil nitrate-N to a depth of four feet, fall year 3 at Raymond site.

	Year 2 treatments (lb/A)		
Year 3 treatment	0	120	200
N rate (lb/A)	---------- Residual nitrate-N (lb/A) ----------		
0	37	34	38
40	36	36	40
80	42	38	51
120	43	55	44
160	50	52	46
200	49	61	52

Conclusions:

Under the growing conditions of this study, the aggressive nitrogen management in corn production is not detrimental to root growth and extractable sucrose. In this study however, aggressive application of nitrogen for corn and for sugarbeet production can decrease quality. Depending on the payment system, this can have a negative economic effect. If a field has been historically over fertilized by nitrogen fertilizer or manure applications, residual nitrate-N values can be increased to the point that it will be a management problem to produce the best economic return.

CORRELATION OF SUGARBEET QUALITY TO CANOPY AND FIELD VARIABLES USING LANDSAT DATA AND A LARGE GIS DATABASE

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ABSTRACT

Satellite image data were paired with harvest sucrose concentrations in large numbers of sugarbeet fields from the 2003, 2004, and 2005 crop years in Southern Minnesota. Models linking canopy measures from late July to early September were analyzed. Field status variables representing planting date, disease ratings, weed pressure rating, and population rating were added in 2004 and 2005. Multiple linear regressions were used to link canopy spectral data and indices, and field ratings, to the harvest sucrose concentration. Harvest sucrose was adjusted to a common date of October 1. Models using a green band NDVI, (GNDVI) from early September were consistently correlated to harvest sucrose concentration. Correlations were weakest in 2003 and strongest in 2005. Models based on multiple spectral bands were more strongly correlated but no unique set of spectral bands was repeated. Model using a change in GNDVI from late July to early September as the indicator of canopy status were generally less correlated to harvest sucrose. Model parameters varied by year and were generally more variable between years than between varieties. Field status variables were not consistently retained in the models. The findings support the use of canopy spectra from early September as a means of predicting relative sucrose concentration across a cooperative for strategic harvest planning.

Keywords: Remote Sensing, Sugarbeet, Canopy Index, Sucrose, GIS

INTRODUCTION

Remote sensing has the potential to provide managers with useful information regarding both crop yield and quality. Historically remote sensing has been frequently used to derive estimates of crop biomass as yield, and yield variability. Midseason measures of canopy status are used to quantify stress in crops that are disease or nutrient related, that can be remediated to minimize yield losses due to stress. In contrast to commodity crops, economic yield in sugarbeet (*Beta vulgaris altissima*) is a combination of biomass yield and quality. Crop yield is typically measured as tons/ha (tons/acre) of harvested roots. Quality is characterized in the recoverable sucrose concentration of the harvested roots. Both can vary widely. Because of the seasonally limited capacity of processing plants, cooperatives typically establish a price structure for the crop that is directly related to the recoverable sucrose concentration in sugarbeets delivered to storage sites. Thus both cooperatives and individual producers have strong incentives to manage quality in the crop.

Yield and quality have opposing responses to nitrogen fertility in sugarbeet (Campbell and Kern, 1983; Carter, 1986). High levels of available nitrogen are associated with vigorous canopy and root growth, but tend to be associated with lower levels of recoverable sucrose concentration. Canopy spectral response of sugarbeet to varying levels of nitrogen has been studied in the context of its relationship to harvest quality in fertility trials (Humburg et al., 2002). That work indicated that indexes such as the NDVI and a Green NDVI, established in August, could be correlated to variation in recoverable sucrose at harvest near October 1. Techniques were needed to be able to develop the canopy/quality relationships for different varieties and over a wider geographic area if the relationships were to be useful to producers or cooperatives of producers.

If the links between remotely sensed canopy status and the subsequent harvest quality could be established with acceptable correlation a number of tools could be made available. Remotely sensed images could be used by producers as a retrospective tool to better understand variability within and among fields, much as yield maps currently provide to grain producers. Images acquired in August or September, prior to harvest, could be used with models from previous years to estimate the relative quality of sugarbeets in fields across the cooperative. Knowledge of relative levels of recoverable sucrose could be used by cooperative management to make decisions regarding the order of harvest to maximize the total sucrose recovered.

A project begun in 2003 combined Landsat5 and Landsat7 images with data from the Southern Minnesota Beet Sugar Cooperative (SMBSC) to begin studying canopy and quality relationships across the geographic area of the cooperative. The results of that initial year identified relationships between a Green NDVI (GNDVI) taken in early September and recoverable sucrose concentration in several common varieties of sugarbeet. Temporal changes in the GNDVI during the time period from the end of July to early September were also correlated to recoverable sucrose at harvest (Humburg et al., 2006). Estimating quality in fields prior to harvest would require the application of relationships from one or more prior years experience. Models developed from different years would allow for study of the stability and repeatability in canopy/quality relationships, and factors that influence them. To explore these relationships the study that was conducted for the 2003 crop was repeated in 2004 and 2005 for the sugarbeet crops under management of the SMBSC. Those experiments are described here with the following objectives:

1) Develop a data set representing three crop seasons for large numbers of fields in the sugarbeet varieties grown in the SMBSC area.

2) Compare the strength and nature of canopy/quality relationships from 2003, 2004, and 2005 for varieties common to those three years.
3) Develop baseline models for new varieties.

METHODS

The project described here represents the combination of satellite image with a GIS field database. The combination yields a database which pairs field variables such as the recoverable sucrose concentration for a given field with the satellite data specific to that field. The two data sources and their characteristics for the three years of the study are described below.

The SMBSC Field Database

Southern Minnesota Beet Sugar Cooperative builds an annual database of field information for members' sugarbeet fields. The database is used for a variety of functions, but is particularly useful for studies such as the one described here. The cooperative continues to expand the content of the database as new uses arise. In the 2003 crop year a subset of the total database was provided by SMBSC for use in the remote sensing project. Records for each field representing planted acres, harvested acres, plat description of the field location, field boundary coordinates, harvest date, harvested yield, percent sucrose, percent extractable sucrose, and variety were utilized. A similar subset of the 2004 and 2005 databases was provided for those crop years. The field data and coordinates for field boundaries were provided in the form of an ArcView shape file. Additional data in the 2004, and 2005 crop years included the planting date and numerical ratings of the field, determined in late August, for three categories of diseases, plus a rating weed pressure, and one representing the uniformity of the plant population in the field. The rating values for weed pressure, diseases, and plant population problems were combined by addition into a single category denoted WDP Rating for weeds, disease, and population. Planting date was expressed as the number of days from April 1 to the actual planting date for modeling purposes.

Varieties of sugarbeet used in Southern Minnesota are continually changing, but several varieties are present in large numbers within the database. Most varieties used by SMBSC growers are selected for tolerance to Beet Necrotic Yellow Vein Virus, commonly called Rhizomania. Many fields are planted to a mixture of varieties, and one of the varieties used in this study is actually a mixture of two or more Rhizomania tolerant varieties.

The Landsat Image Data Set

Landsat5 and Landsat7 images were used to obtain canopy spectral measures for fields in each of the three years reported. The Landsat platforms were utilized in this work because of the spatial resolution of the data and the area associated with a single row and path of these satellites. The SMBSC cooperative operates in a geographic area centered at approximately 44.79° N, 95.18° W.

Within the cooperative farmer growers annually manage sugarbeet fields with a total area in excess of 40,000 ha (100,000 acres). With an average field size of roughly 40 ha, the number of fields within the cooperative is typically over 1200. Of these fields all but a very few fall within the limits of Landsat path 28, row 29. As a result it is possible to obtain images of nearly all of the fields in the SMBSC growing area in a single frame from a Landsat overpass. The staggered orbital repeats of the two satellites provided an eight day repeat cycle for acquisition of images in the late July to early September time period. During the 2003 crop year Landsat7 image data were acquired July 18, August 19, and September 12 which were sufficiently free of cloud cover to provide canopy data for most of the cooperative area. During the 2004 crop year Landsat7 images from August 5, August 21, and September 6 were sufficiently free of clouds to yield canopy data for large numbers of fields. During the 2005 growing season only the Landsat5 images from the dates of July 31 and September 1 were sufficiently free of clouds to be useful.

The Landsat7 ETM sensor and the Landsat5 TM sensor obtain spectral measurements at bands numbered 1-7 and centered at wavelengths of 485, 560, 660, 830, 1650, 11,450, and 2215 nm respectively. Spatial resolution for bands 1-5 and 7 is 28.5 meters, while band 6 is acquired at coarser resolution. Since the data extraction process did not easily allow for variation in pixel spatial resolution the Landsat band 6 data were not utilized in this study.

Image Processing and Database Consolidation

Images from the July to September time period in each year were combined into a single image project for that year. The images were carefully registered one to another so that a single area of interest (AOI) could be established for any field that would reliably extract data from within the bounds of that field. Registration and assembly of data sets and the subsequent data extraction were accomplished using the ERDAS Imagine 8.3.1 image processing software, ArcView GIS 3.2, and PC ArcInfo 3.5.8. The Universal Transverse Mercator (UTM) map projection and NAD83 datum were utilized throughout the analysis. With the images registered into a single stack a set of perimeter coordinates was projected from an ArcView shape file onto the Landsat image. The attributes table from the shape file included an unique GIS identifier for each field and was used to highlight and identify any given field in the image. A series of checks were performed to verify the field identification and its content. Sugarbeets were distinguishable from other crops, particularly using band combinations from September images. The planted acreage and plat description of section, Township, and Range were useful in locating errors where a boundary was misplaced or a crop other than sugarbeet occupied the projected area. Once a field was located and its content confirmed an appropriate AOI was created to extract the canopy data while avoiding farmsteads, buildings, drainage ditches, fence lines and roads. Extracted pixel data were exported to ASCII files which were further processed to remove anomalous data associated with the scan-line correction malfunction in the Landsat7 data (Humburg et al., 2006). Pixel values in Landsat bands 1,2,3,4, and 5 were converted to approximate reflectance values using an empirical line method (Moran et al., 2001; Smith and Milton, 1999). The conversion required measured reflectance values for two or more pseudo-invariant objects, or PIOs, visible in each of the images. PIOs for the 2003 images consisted of a gravel pit containing clean water as a dark site, and a large lime pile as reflective bright site. In 2004 and 2005 the same gravel pit provided a dark site, while the tops of 3 very large white storage tanks at the sugarbeet processing plant were used to establish a bright target. Reflectance values of the water, lime pile, and tank sites were measured with a handheld Cropscan MSR5 spectroradiometer (Cropscan, Inc., Rochester, Minn.). The MSR5 instrument measured reflectance at five wavelengths, corresponding to Landsat bands 1, 2, 3, 4, and 5. The cropscan instrument does not provide a measurement at the 2215 nm wavelength of Landsat band 7 and these values were left unchanged.

Four indexes were calculated for the 2003 crop for each pixel of the extracted data. The index and pixel averages for each field were appended to the other records for that field in a spreadsheet. The results of the GNDVI model, calculated as $(\rho_{green}-\rho_{NIR})/(\rho_{green+}\rho_{NIR})$, in 2003 are reported here. In the 2004 and 2005 years the GNDVI was the only index calculated for each pixel. Subsets of the overall database for each year were created for the fields representing each distinct variety so that correlation between canopy measures and field quality could be determined for that variety.

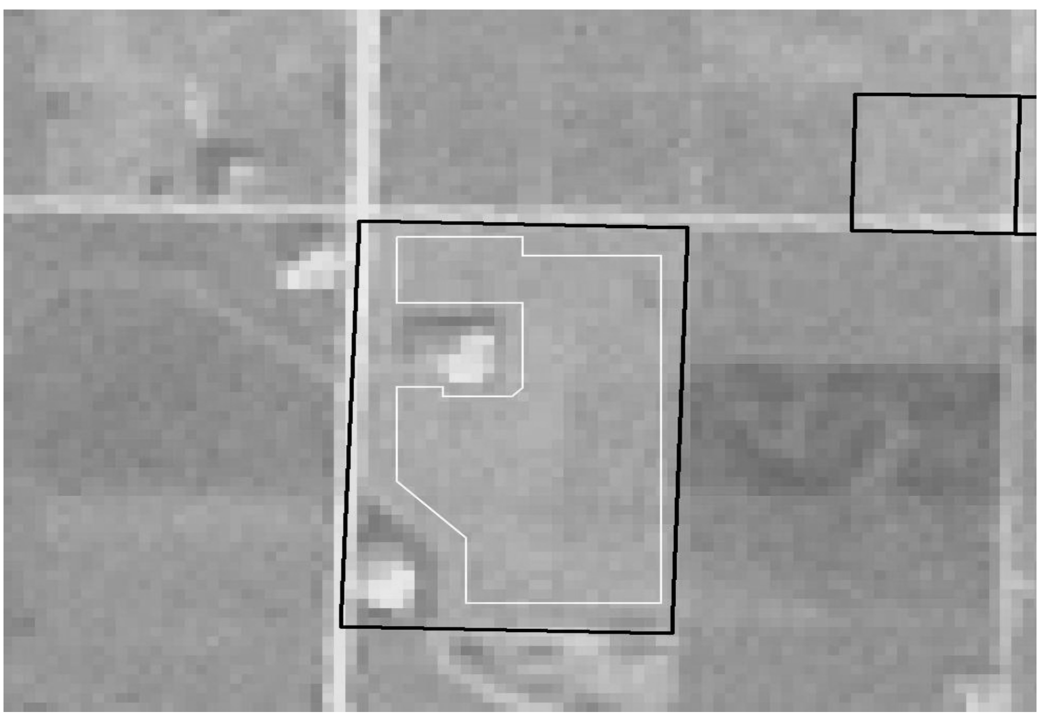

Figure 1, Gray-scale example of a sugarbeet field from the September 12, 2003, Landsat5 image. The black line is the field boundary as projected by the GIS database. The white line is the established AOI boundary used to extract canopy and exclude non-crop pixels.

Harvest date adjustment of extractable sucrose

The objectives of the work involve testing the correlation of canopy measures, along with other field variables, to harvest sucrose levels. Harvest dates for individual fields typically vary from October 1 to as late as November 1. Fields harvested later typically accrue additional sucrose. This variation among fields is unrelated to the status of the crop as indicated by the canopy in August or September, and can easily represent as much variability as would be present across the cooperative on a common date. As such it was necessary to adjust the sucrose concentration, as measured on the harvest date, to a common date. The sucrose concentration (%) was discounted from the harvest date to October 1 using an estimate of the rate of sucrose accrual. A linear accrual rate was determined by studying a model between the GNDVI index and the harvested sucrose level. For example, data for October 1 extractable sucrose from a given variety of sugarbeets and the GNDVI for that variety in early September were related in a linear regression model. Some of the scatter in this model would be attributable to error in the actual sucrose accrual rate and the resulting error in the October 1 estimate of the sucrose level. By altering the sucrose accrual rate alone the model will either improve in correlation or deteriorate. The value of accrual rate that optimized the model fit minimized the scatter due to this single variable. That rate was used as the most appropriate linear sucrose accrual rate for that variety of sugarbeet in that season. In the 2003 crop year this process was conducted with two common varieties and a single sucrose accrual rate of 0.3 % per week was applied to all of the data. In the 2004 and 2005 crop years individual accrual rates were determined for each variety and applied to discount the measured sucrose at harvest to the probable sucrose on October 1. Figure 2 gives an example of the effect of varying the sucrose accrual rate on a model between a GNDVI and recoverable sucrose.

Models examined

The experiment conducted in 2003 tested a variety of indices and changes in canopy indices for their ability to link canopy characteristics in the latter part of the growing season to harvest sucrose concentrations. That work identified the GNDVI index as consistently producing higher correlations between canopy and quality than other indices. Models examined across the three year time series use either the GNDVI index or individual spectral bands as inputs representing canopy status. While the 2003 models used only canopy spectral data as independent variables, the 2004 and 2005 models were allowed to use the WDP rating and the planting date to account for variability in the canopy and quality data. All of the model analyses conducted in the latter two years were structured as backward elimination multiple linear regressions. Individual variables were retained in the multivariate models at a probability threshold of 0.1.

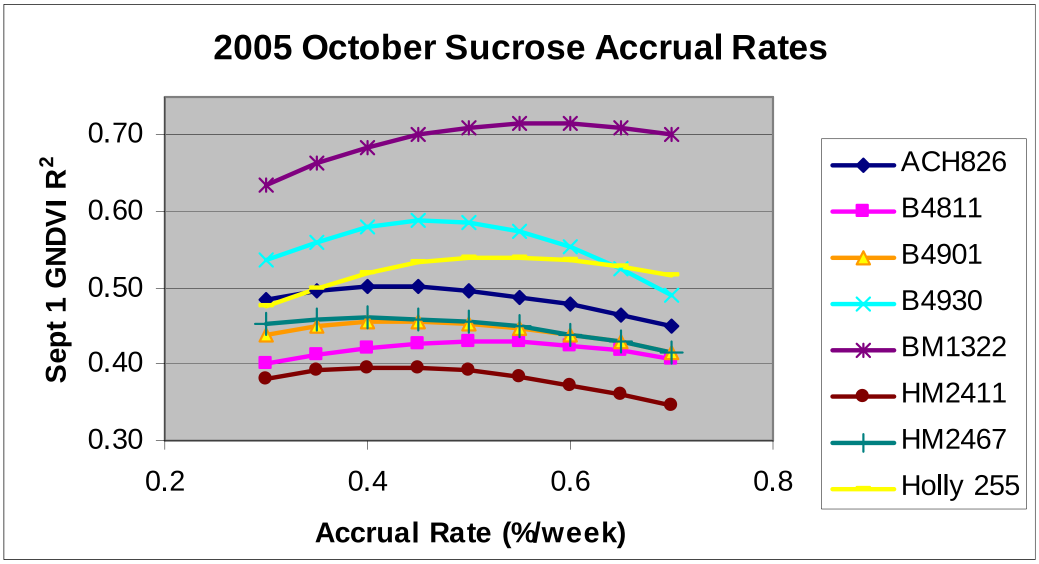

Figure 2. October sucrose accrual rates were estimated by finding the rate that minimized scatter in a regression of September GNDVI on recoverable sucrose concentration.

RESULTS

Model Correlations by Type and Year

Regression results based on a canopy index from a single image date for three crop years are given in Table 1. These results are for widely planted varieties that were used in two or more years of the study, and continue in use. All of the models in Table 1 were statistically significant ($P < 0.01$). The GNDVI index was retained in every MLR model at a probability level $P < 0.001$. The other field status variables of planting date after April 1, and the combined rating for weeds, disease, and population problems (WDP) were retained in only a few of the models. No model retained both the planting date and WDP variables. Model fit varies by year, with the 2004 and 2005 crop years producing successively higher correlations between canopy measures and October 1 sucrose concentration. The fields planted to an unknown mixture of Rhizomania tolerant varieties (Mixed Rhizo) generally produced poorer model fits than fields planted to pure stands of a single variety.

Results for multiple linear regressions using multiple wavelength bands, rather than an index of two bands, are given in Table 2. All of the models were statistically significant ($P < 0.01$). Correlations were higher when the models were allowed to select Landsat wavelengths. Model fit again varied by year, but in this case the 2004 year produced the lowest correlations. Highest correlation in these models was again found in the models based on the September 1, 2005 image. Most of the analyses retained three or four of the spectral bands, but two models retained only a single band as the canopy indicator. The combinations of wavelengths that were correlated to sucrose concentration appear to have varied by year. Specifically, the blue band (B1) appears in all of the September 1, 2005

Table 1. Multiple linear regression model results for models linking a canopy index and two field status estimates to October 1 sucrose concentration. Five sugarbeet varieties used in two or three years are shown.

Variety	Image Date	Model R^2	GNDVI	Planting Date	WDP Rating	Number of Fields
B4811	9/12/03	0.26	†	NA	NA	307
	9/6/04	0.36	†			362
	9/1/05	0.42	†			288
B4930	9/12/03	0.23	†	NA	NA	161
	9/6/04	0.32	†	†		106
	9/1/05	0.58	†			42
Mixed Rhizo	9/12/03	0.12	†	NA	NA	228
	9/6/04	0.13	†		†	210
	9/1/05	0.33	†		†	282
B4901	9/6/04	0.30	†			41
	9/1/05	0.45	†			82
ACH826	9/6/04	0.26	†		†	77
	9/1/05	0.56	†	†		42

† Indicates that this variable was retained in the model at $P < 0.1$.

Table 2. Multiple linear regression model summary for models linking 6 canopy spectral wavelengths and two field status variables to October 1 sucrose concentration. Five varieties in two or three years are shown.

Variety	Image Date	Model R^2	Planting Date	WDP Rating	B 1	B 2	B 3	B 4	B 5	B 7	Num. fields
B4811	9/12/03	0.56	NA	NA	†		†	†	†		307
	9/6/04	0.42	†			†	†		†		362
	9/1/05	0.59	†		†	†		†	†		288
B4930	9/12/03	0.41	NA	NA	†		†			†	161
	9/6/04	0.34				†			†	†	106
	9/1/05	0.67			†	†		†			42
Mixed Rhizo	9/12/03	0.24	NA	NA		†	†	†	†		228
	9/6/04	0.23		†		†		†	†		211
	9/1/05	0.48		†	†			†	†	†	282
B4901	9/6/04	0.34					†				41
	9/1/05	0.59			†			†		†	82
ACH826	9/6/04	0.31		†		†					77
	9/1/05	0.79		†	†			†	†	†	42

models for the varieties shown here. The same band is not retained in any of the models based on 2004 data. No other clear trend is apparent in the combinations of bands retained in models. Four of ten models utilized the WDP field rating value, while two models retained the planting date variable. No model utilized both of these field status variables.

Models relating a temporal change in a canopy index to harvest sucrose concentration varied widely by year. In 2003 the models based on a change in GNDVI from July 18 to September 12 yielded some of the strongest correlations to harvest sucrose concentration. Models based on change in the GNDVI from August 5 to September 6 in 2004 were less correlated to harvest sucrose levels. The 2005 season, with only a July 31 and September 1 image available, produced the lowest correlations in models using a temporal change in the GNDVI index between these two dates. The analysis for variety ACH826 in 2004 did not yield a statistically significant model. All other models were significant ($P < 0.01$).

Table 3. Multiple linear regression results for models linking a change in canopy index plus two field status variables to October 1 sucrose concentration. Five varieties from two and three years are addressed.

Variety	Image Difference Dates	Model R^2	ΔGNDVI	Planting Date	WDP Rating	Num. Fields
B4811	7/18 – 9/12 2003	0.41	†	NA	NA	282
	8/5 – 9/6 2004	0.18	†		†	340
	7/31 – 9/1 2005	0.07	†			259
B4930	7/18 – 9/12 2003	0.41	†	NA	NA	147
	8/5 – 9/6 2004	0.34	†	†		101
	7/31 – 9/1 2005	0.14	†			38
Mixed	7/18 – 9/12 2003	0.29	†	NA	NA	209
	8/5 – 9/6 2004	0.31	†		†	183
Rhizo	7/31 – 9/1 2005	0.29	†			249
B4901	8/5 – 9/6 2004	0.21	†	†		35
	7/31 – 9/1 2005	0.35	†		†	73
ACH826	8/5 – 9/6 2004	0.04*		†		70
	7/31 – 9/1 2005	0.36	†		†	34

* This model was not statistically significant.

Model Parameter Variation Between Years

The degree to which model parameters for a given variety vary with year was of interest. Single variable models, based on a canopy index value from a single image event each season were used to compare trends in models between varieties and between years. Figure 3 shows the best fit linear models obtained for B4811, B4930, and B4901. The models are based on the index at an early September date. Actual dates were September 12, 6, and 1 in 2003, 2004, and 2005 respectively. The figure shows the inverse relationship between canopy GNDVI index on these dates and the sucrose concentration on October 1. There is substantial variation in the slope of the relationship and in the actual range of index values in the different years.

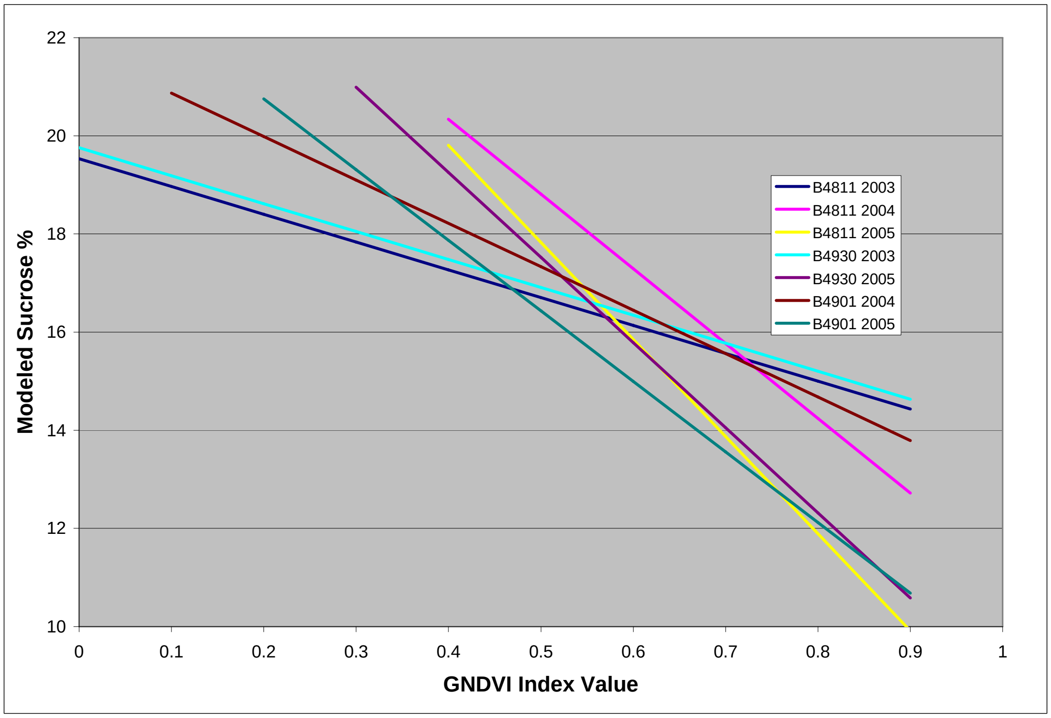

Figure 3. Single variable models for three common sugarbeet varieties using an early September GNDVI in three successive crop years.

Variation also exists between models for different varieties in a single year. Figure 4 illustrates the single variable models for eight distinct varieties from the 2005 experiment. Slopes of these lines range from a minimum of -14.4 for B4901 to a maximum of -22.6 in variety BM1322. This range is less than that occurring in a variety such as B4811 or B4930 between the three years of 2003-2005. Also graphed in Figure 4 is a line representing the model for the Mixed Rhizo class in 2005. This mixture of varieties has a low slope, similar to that of variety B4901.

New Varieties in 2005

Member growers of the SMBSC select sugarbeet varieties for a number of agronomic characteristics, and the annual composition of the crop changes each year as new varieties are adopted and older ones abandoned. Several new varieties were present in the 2005 data set in numbers that allowed for initial analyses of correlation between canopy status and harvest sucrose levels. Results are given in Table 4 for five varieties, previously unreported, that were studied for the first time in 2005. Varieties appearing in the 2005 data set in smaller numbers than these were not analyzed because of small sample sizes. Models in Table 4 are multiple linear regressions based on a GNDVI index from September 1 of 2005, and the two field status variables of Planting Date, and WDP. All but one of the varieties produced models that were statistically significant with $P < 0.01$.

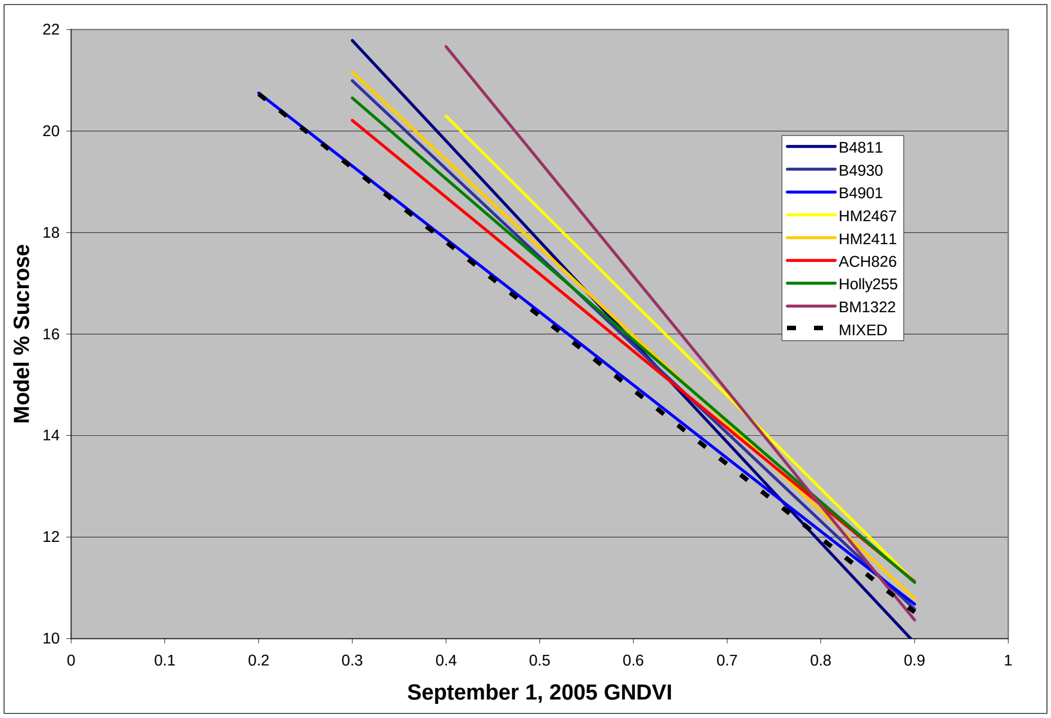

Figure 4. Single variable models for eight distinct varieties and a mixture of varieties. The models use a GNDVI index on September 1 of 2005.

The model for Vander 47150 was significant with P < 0.05. Only the model for variety HM2467, with 170 observed fields, retained the field status variables. The other models were based on canopy index alone.

The group of new varieties was also analyzed using the multiple Landsat spectral bands as independent variables in place of the index. The results from these analyses are given in Table 5. All of the models were significant with P < 0.01. Each model retained three or more of the band values, and none of the models now retained either of the field status variables.

Table 4. Multiple linear regession results for five relatively new varieties grown in 2005. A GNDVI index and two field status estimates were available as independent variables.

Variety	Model R^2	GNDVI	Planting Date	WDP Rating	Number of Fields
BM1322	0.74	†			29
HM2411	0.40	†			27
HM2467	0.51	†	†	†	170
Holly255	0.54	†			22
Vander 47150	0.23	†			19

Table 5. Multiple linear regression results for five relatively new varieties grown in 2005. Six of the Landsat spectral wavelengths and two field status ratings were available as independent variables.

Variety	Model R^2	Planting Date	WDP Rating	B1	B2	B3	B4	B5	B7	Num. Fields
BM1322	0.80				†	†	†			29
HM2411	0.58			†	†	†	†			27
HM2467	0.58			†	†		†		†	170
Holly255	0.77					†	†		†	22
Vander 47150	0.49					†	†		†	23

The models for all varieties were stronger in 2005 than previous years. Figure 5 provides an indication of the degree to which the aggregated predictions of nine models compare with the measured sucrose concentration for all of the fields planted to the nine most used varieties. Also shown in the figure are the data representing fields planted to an unknown mixture of varieties.

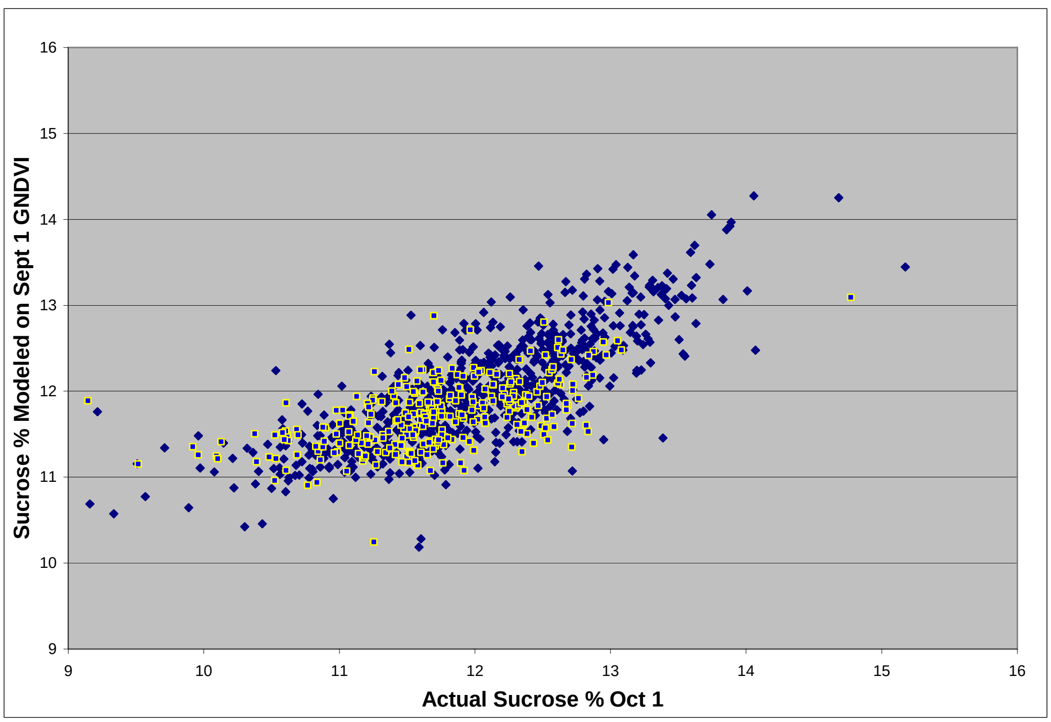

Figure 3. Modeled and measured sucrose concentration for nine varieties grown in 2005. Also shown in yellow are data for fields planted to an unknown mixture of varieties.

DISCUSSION

Variation in Model Correlation Between Years

Application of the models tested here to SMBSC sugarbeet crops favors simple, repeatable techniques. Models based on a simple spectral index acquired on a single day would be the most easily implemented. The index-based models from early September were studied for this reason. Results from these three years suggested that images acquired in early September were more correlated to harvest sucrose concentration than images acquired earlier. Within these three years the 2005 year produced the strongest correlations of canopy status and sucrose concentration. What might account for the variation in model correlation in these three years? One source of variation would have been atmospheric conditions at the time of the image acquisition. The 2003 and 2005 September images were nearly free of visible clouds. Some clouds and thin cloud cover or haze were present in the 2004 image. While every attempt was made to exclude fields in which clouds, haze, or shadows were detectable it is possible that some fields were affected by these. General atmospheric conditions may also vary over the geographic area encompassed by the fields within an annual data set. Since the reflectance calculations were made based on targets at two central locations in the image any variation from conditions at these points would introduce errors in the determination of band reflectances, and derived indices.

Rainfall and moisture status after the image date could affect harvest sucrose levels. If substantial moisture becomes available after the image date a release of mineralized nitrogen can cause additional vegetative growth in the crop and lower sucrose levels at harvest. The degree to which this might occur would depend upon local rainfall amounts, and local soil type. A more uniformly dry September would mean that early September canopy status would be a better estimator of harvest sucrose concentrations than if differential growth occurs after this time period.

Models that utilize a temporal change in the canopy index between two image dates are subject to many of the same sources of error. Thin clouds or undetected shadows of clouds can cause variation in either of the two images used to measure the change in canopy. Any errors associated with converting from digital numbers to pixel reflectance values will also be problematic. These models are also highly dependent upon the status of the canopy at the time of the first image. Canopy index would be expected to gradually increase as canopy builds to closure. At some point the index would be expected to peak and then decline as the exhaustion of available nitrogen and resulting stress causes visible wavelength reflectance to increase and NIR reflectance to decrease. Ideally a baseline image at approximately the time of peak canopy density and health would be acquired and the change in index from that point on would reflect the relative exhaustion of nitrogen and would be linked to harvest sucrose concentration. The limited temporal availability of the Landsat platforms, and the frequent presence of clouds in July and early August make the acquisition of optimally timed images difficult. While good quality images at optimal time intervals might represent the canopy status well, the three year series of data here suggest that obtaining those images and the correct time may not be possible.

Variation in Model Parameters Between Years and Varieties

Many of the factors that contributed to variation in model correlation may be sources of variability in the model parameters between years. The slope of the lines that link canopy index in September to a prediction of October 1 sucrose concentration varied markedly between the years of the study (Figure 3). These differences could result from differences in the crop moisture status between years as indicated above. Late season rainfall could cause additional vegetative growth and weaken the linkage between early September canopy status and the harvest sucrose concentration. Small changes in the process used to convert pixel values to reflectance values could also affect model slope by year. In 2003 a large lime pile at the SMBSC factory was used as a bright target in the process. In 2004 and 2005 the roofs of three large white tanks at the SMBSC site were used as bright targets. The same water filled gravel pit was used each year as a dark site. However, differences in the amount of vegetative growth in the water, or specular reflectance from the water surface could change that values extracted from this site between years. Differences in these targets and the image values extracted from them to develop the reflectance models could contribute to model parameter differences between years while not affecting correlation in individual years.

The process used to adjust actual harvest sucrose concentration back to a common date of October 1 was based on a simple linear model of sucrose accumulation. A constant accrual rate was applied to the number of days before after October 1 to the harvest date. It is almost certain that the actual sucrose accrual does not occur linearly during this time period. The linearization of this process contributes error and results in lower model correlation than would exist if actual October 1 sucrose level was known. If a more realistic model of sucrose accumulation during the September 15 to November 1 time period could be developed, perhaps to include temperature and weather, it might be possible to improve the performance of the canopy models.

The introduction of the field status variables reflecting planting date and ratings for weed pressure, disease, and population problems was intended to augment the models using canopy measures and allow those models to account for outliers. Fields with disease often exhibit stress symptoms much like nitrogen stress, but with opposite effects on sucrose accumulation. Low plant population can also result in soil visible in images and lower canopy index values but not necessarily higher sucrose concentration. Weeds can cause different reflectance values than pure sugarbeet canopy resulting in model error. Thus far these additional field variables have not contributed greatly to improved model performance and have only been retained in a portion of the analyses performed. The ratings for disease, weed pressure and population are assigned by a number of different agriculturalists that assist growers and supervise fields. Variation among staff in the application of the ratings may account for their limited appearance in models. Variation in planting date, while appearing in a few models, does not appear to be an important variable in harvest sucrose levels.

SUMMARY

Satellite image data representing canopy of approximately 3000 sugarbeet fields were extracted from Landsat images over three successive crop seasons. Image data were paired with data for harvest sucrose concentration and field status variables of planting date, weed pressure, disease rating, and population problems. Multiple linear regression analyses were used to link canopy reflectance variables and field status variables to the October 1 sucrose concentrations in the fields for a number of varieties. Canopy reflectance variables tested included a GNDVI index from early September, a change in GNDVI index from late July to early September, and six of seven Landsat band values from an early September image.

The strength of correlation between canopy GNDVI index from early September and October 1 sucrose concentration varied with year. Values of the coefficient of determination (R^2) for 2003 models were weakest, ranging from 0.23 to 0.30 for the most common distinct varieties. Correlations for the 2004 season were higher with the same varieties producing R^2 values of 0.26 to 0.36. The 2005 growing season yielded the strongest correlations with these varieties having correlation coefficients from 0.42 to 0.58. All of the models utilized the canopy index variable, while only five of ten models retained one or the other of the field status variables, and no model retained both of the field status variables.

Regression models that were allowed to select from six Landsat band values rather than a canopy index generally produced higher R^2 values than the index models. Coefficients of determination in 2003 for distinct varieties were 0.41 and 0.56. In 2004 the range of R^2 values was from 0.31 to 0.42 in the four most common varieties. The crop in 2005 produced the strongest correlations with R^2 values ranging from 0.59 to 0.79 in the same varieties. No single combination of wavelengths, or band values, emerged as uniquely linked to sucrose in the models analyzed. Again, the field status variables were less frequently retained with six of ten possible models retaining one or the other of these variables.

Regression models that were based upon a late season change in the GNDVI index were strongest in 2003 and weakest in 2005. Overall these models yielded weaker models with R^2 values ranging from 0.07 to 0.41.

Models using a GNDVI index from early September were consistently inversely related to October 1 sucrose concentration. The model slope varied more between years than it did between varieties. Factors that could be studied further to minimize the variation in models between years might include the method used to convert satellite pixel values to reflectance values, the moisture and precipitation characteristics of the individual season, and the models used to adjust sucrose concentration from the field harvest date to the October 1 model date.

Five new varieties appearing in the 2005 crop year were also studied in this single year. Models based on a September 1 GNDVI index produced models with R^2 values ranging from 0.23 to 0.74. Those same varieties produced models with R^2 values from 0.49 to 0.80 when the multiple linear regression models utilized the Landsat band reflectance values rather than the index. Again, no unique combination of bands was consistently retained in the models.

In most of the models analyzed the correlations for models based on individual varieties were higher than correlations obtained for fields that were planted to a mix of unidentified varieties.

The work suggests that models from a single image in early September, either in the form a GNDVI index or multiple band values, could be used to predict much of the variation in sucrose concentration that would exist between fields on October 1 in the SMBSC sugarbeet crop. That information could be used to recommend strategic harvest decisions to maximize the recoverable sucrose in the crop. A more thorough understanding of the factors that cause variation in models between seasons could improve these models and make the process more useful to the cooperative.

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Effect of Scalping on Root Respiration Rate

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Defoliation methods that differ in the extent of crown tissue removed affect root quality, incidence of storage diseases, leaf regrowth and root respiration rate. Root quality is enhanced by defoliation methods that scalp or top the root since potassium, sodium, amino nitrogen, and invert sugars are concentrated in the upper crown (Mahn et al., 2002). Scalping also reduces initial root respiration since crown tissues respire more rapidly than tissue in the true root (Wyse, 1978; Wyse and Peterson, 1979; Steensen and Augustinussen, 2003). Leaf regrowth in the piles, which is associated with increased respiration rate and invert sugar accumulation during storage, is also decreased by scalping (Wyse and Dexter, 1971; Steensen and Augustinussen, 2003). However, scalping is reported to increase the incidence and severity of storage rots since the injury caused by scalping provides an entry site for storage rot causing organisms (Mumford and Wyse, 1976; Wyse, 1978). Scalping, therefore, generally is believed to improve initial root quality and reduce initial root respiration rate. The effect of scalping on root quality and respiration rate after prolonged storage, however, is less clear.

Experimental Design

A small study was conducted to determine the effect of crown tissue removal during defoliation on root storage properties. Roots of Beta 4901 were mechanically defoliated on 16 Oct. 2006. Four defoliation treatments were used which removed approximately 0, 0.25, 0.5, and 1 inch of the root apex measured along the root longitudinal axis. Prior to storage at 6°C (43°F) and 95% relative humidity, roots were washed to remove any adhering soil, dipped in a solution of 10% bleach to minimize pathogen infection during storage, and any remaining petiole or leaf tissue was removed. Respiration rate was determined by infrared CO_2 analysis using an open system. Respiration was measured after 13, 32, 89, and 152 days in storage. Sucrose, glucose, fructose and raffinose content were determined from brei samples collected after 15, 91 and 152 days in storage. Glucose, fructose, and raffinose concentrations were determined by HPLC. Sucrose content was determined polarimetrically. For each treatment at each time point, measurements were made on three replicate samples, each comprised of ten roots.

Results

Respiration rate

The amount of crown tissue removed during defoliation had no statistically significant effect on respiration rate of roots stored for 13, 32, 89 or 152 days at 6°C and 95% relative humidity (Fig. 1). Across all treatments, respiration rate was similar after 13, 32 and 152 days in storage, but was approximately 25% lower after 89 days in storage. After 152 days in storage, storage rots were visible on some roots. The incidence of storage rot did not appear to be related to any crown removal treatment. Storage rots, however, likely contributed to the variability in respiration rate between replicates within a treatment at 152 days. No statistically significant interaction between defoliation treatment and time in storage was observed.

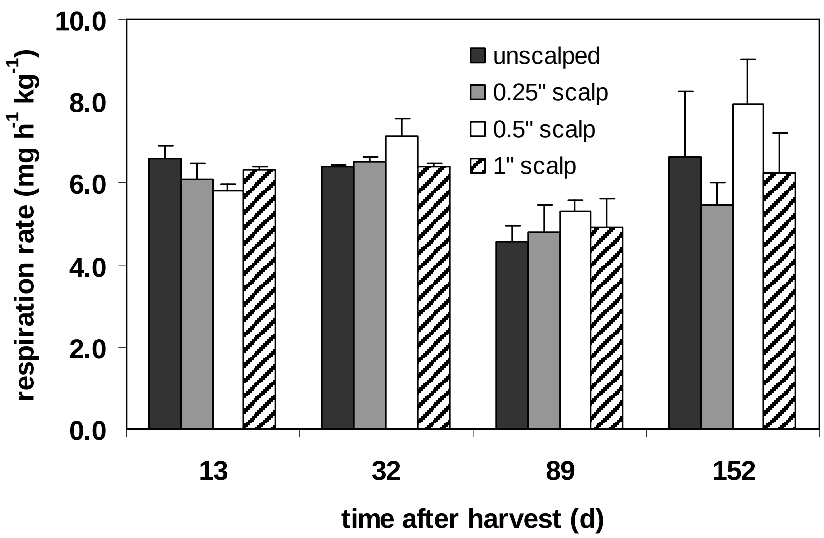

Fig. 1: Respiration rate of roots with 0, 0.25, 0.5 and 1 inch of the root apex removed during mechanical defoliation after 13, 32, 89 and 152 days in storage at 6^oC and 95% relative humidity.

Sucrose content

The amount of crown tissue removed during defoliation had no statistically significant effect on root sucrose content after 15, 91 or 152 days of storage at 6^oC and 95% relative humidity (Fig. 2). Across all treatments, sucrose content was significantly lower after 91 (12.9% sucrose) and 152 days (12.7%) in storage relative to 15 days in storage (14.2%). No statistically significant interaction between defoliation treatment and time in storage was observed.

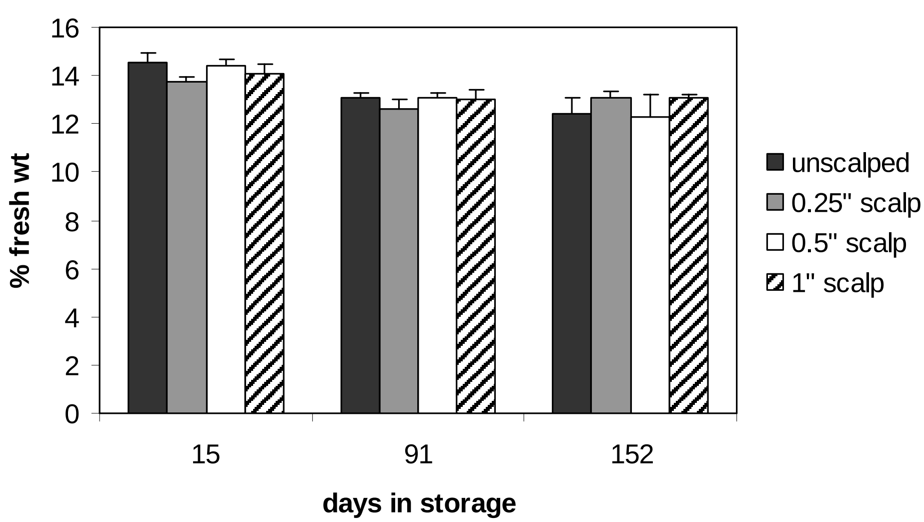

Fig. 2: Sucrose content of roots with 0, 0.25, 0.5 and 1 inch of the root apex removed during mechanical defoliation after 15, 91 and 152 days in storage at 6^oC and 95% relative humidity.

Carbohydrate impurities

The amount of crown tissue removed during defoliation had a statistically significant impact on glucose accumulation during storage (Fig. 3). Glucose concentrations were lower in roots with 0.25" of the crown removed relative to roots with 1" of the crown removed. No other significant differences related to the extent of crown removal, however, were found. The amount of crown tissue removed had no effect on fructose and raffinose concentrations after 15, 91, and 152 days in storage (Figs. 4 & 5). Over all treatments, glucose and fructose concentrations were significantly greater and raffinose concentrations were significantly lower after 152 days in storage relative to their respective concentrations after 15 days in storage. No significant interactions between defoliation treatment and time in storage was observed for any carbohydrate impurity.

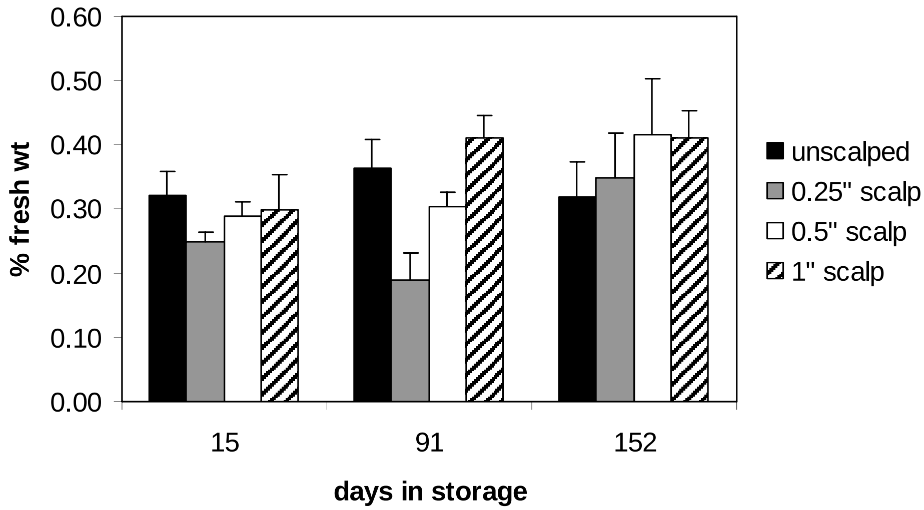

Fig. 3: Glucose content of roots with 0, 0.25, 0.5 and 1 inch of the root apex removed during mechanical defoliation after 15, 91 and 152 days in storage at 6°C and 95% relative humidity.

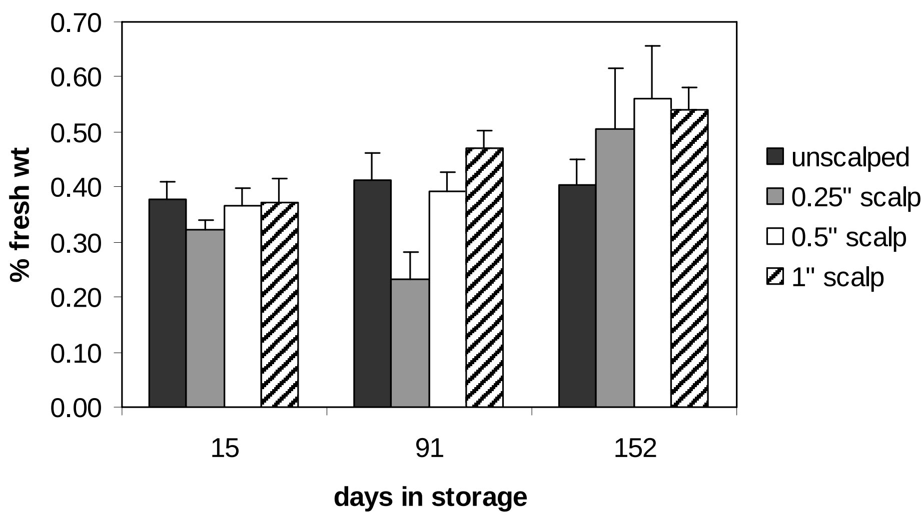

Fig. 4: Fructose content of roots with 0, 0.25, 0.5 and 1 inch of the root apex removed during mechanical defoliation after 15, 91 and 152 days in storage at 6°C and 95% relative humidity.

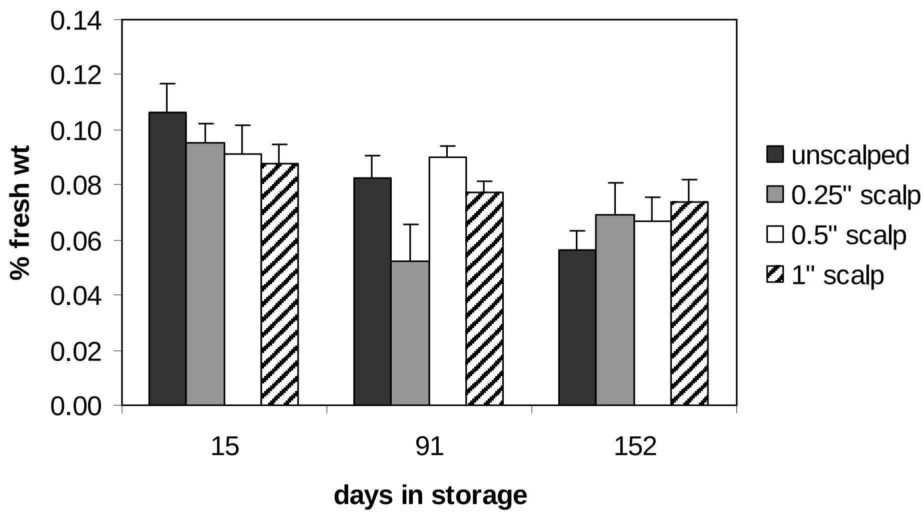

Fig. 5: Raffinose content of roots with 0, 0.25, 0.5 and 1 inch of the root apex removed during mechanical defoliation after 15, 91 and 152 days in storage at 6^{o}C and 95% relative humidity.

Conclusions

In this study, the amount of crown removed during defoliation had little or no effect on storage respiration rate, sucrose content or the accumulation of the carbohydrate impurities glucose, fructose and raffinose. Although generally suggesting that root quality and storageability are not impacted by the extent of crown removal during defoliation, these results, due to the limited scope of the experiment, are insufficient evidence to conclude that the removal of crown material does not affect root processing and storage properties. Because of the small number of replicates (n = 3), small differences in storage properties were not likely to be detected in this study. The study also examined storage properties in roots of a single variety harvested from a single location. Presently it is unknown whether sugarbeet variety and production environment influence the effect of crown removal on storage properties.

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SMBSC 2006 Sugar Beets Scalping Study

Southern Minnesota Beet Sugar Cooperative just completed the 5th year of the current scalping policy. The basis for scalping sugar beets has been proven through extensive research in reference to the influence of scalping on sugar beet processing and storage. In 2006 the SMBSC growing area experienced a frost period that negatively affected the sugar beet processing and storability. SMBSC required aggressive scalping to improve the storability and processing of the frost damaged sugar beets. In 2002, a study was conducted on frost damaged sugar that showed that after 37 days post frost a $6,913,352.00 loss was assumed. The following research was in response to the frost damaged sugar beets in 2006 and the need to collect information regarding the degree of sugar beet scalping needed to economically and efficiently remove the unwanted sugar beet root tissue.

Methods

Sugar beets were collected from two frost damaged sugar beet fields. Fifty sugar beets were collected for each of three main treatments. The main treatments were sugar beets unscalped, sugar beets scalped .75 inches from the top of the crown (normal scalp) and sugar beets scalped 1 inch above the soil surface (aggressive scalping to remove frost damaged sugar beet tissue). Sugar beets were collected from two fields with sugar beet varieties that express different growth habits. The two different growth habits tested were a sugar beet variety that grew close to the soil surface (Raymond site- Hilleshog 2467) and a sugar beet variety that grows significantly above the soil surface (Renville site – Beta 4811). Each individual sugar beet was scalped to the specific treatment and then the separate parts were weighed and shredded in a food processor to prepare for analysis. The separate sugar beet parts were analyzed by the SMBSC quality tare lab for sugar percent, brie nitrate and purity.

Results

(Raymond Site – Table 1)

Sugar beets scalped to a .75 inch scalp gave the highest revenue of treatments tested. The .75 inch scalp was 5.71% of the total sugar weight which was 1.41 tons per acre based on a 160 sugar beet per 100 feet of row stand count. The .75 scalp portion of the sugar beet was valued at -$6.93 due to the low quality in this portion of the sugar beet. The value of this portion of the sugar beet would agree with previous research conducted. The portion of the sugar beet scalped to within one inch of the soil surface was 5.91 tons per acre or 24.31% of the sugar beet.

(Renville Site - Table 2)

Sugar beets not scalped gave the highest revenue of treatments tested. Sugar percent of the sugar beet was not increased by scalping the sugar beet although purity was increased by scalping the sugar beet. The loss in tons per acre and the lack of increased sugar

Table 1. Raymond site scalping on frost effected sugar beets
Variety Hilleshog 2467

		160 std ct. Tons/Acre	% of ind. Beet	Sugar percent	Purity	PPM Nitrate	Ext. Suc. Percent	Ext. Suc. per ton	Ext. Suc. per acre	Revenue per acre
Whole Beet	Unscalped	24.64	100.00	17.38	87.63	28	14.05	281	4882	909.57
Whole Beet	.75 inch scalp	23.24	0.94	18.23	88.69	52	15.02	300	5476	967.74
Whole beet	scalped 1" above ground	17.25	69.99	18.47	90.425	27	15.21	304	5714	716.44
beet scalp	Portion 1" above ground - .75 inch scalp	5.99	24.31	15.48	84.49	28	8.30	166	2860	62.39
beet scalp	.75 inch scalp	1.41	5.71	12.17	66.79	36	5.81	116	1889	-6.93

Percent by scalping gave a reduction in revenue per acre. The sugar beet testing from this site did not have as much low quality material in the top .75 inch of the sugar beet which contributed to the unscalped sugar beet given higher revenue. The portion of the sugar beet scalped to within one inch of the soil surface was 6.41 tons per acre 22.47% of the sugar beet. The scalped portion of the sugar beet that grew significantly above the soil surface was not higher than the scalped portion of the sugar beet which grew close to the ground. This is contrary to the thought that scalping the sugar beet which grew significantly above the soil surface would result in substantial loss in tons per acre.

Table 2. Renville site scalping on frost effected sugar beets
Variety Beta 4811

		160 std ct. Tons/Acre	% of ind. Beet	Sugar percent	Purity	PPM Nitrate	Ext. Suc. Percent	Ext. Suc. per ton	Ext. Suc. per acre	revenue per acre
Whole Beet	Unscalped	28.24	100.00	16.83	88.64	79	13.80	276	4643	1007.98
Whole Beet	.75 inch scalp	27.09	0.96	16.75	89.17	73	13.83	277	4633	972.02
Whole beet	scalped 1" above ground	20.68	70.25	16.68	89.76	72	13.90	278	4678	769.25
beet scalp	Portion 1" above ground - .75 inch scalp	6.41	22.47	15.58	87.29	77	12.45	249	4007	185.05
beet scalp	.75 inch scalp	2.03	7.28	13.74	81.55	150	9.81	196	2739	36.44

(Combined data – Table 3)
The highest revenue was achieved when the sugar beet was scalped to a .75 inch scalp. The percent of the sugar beet scalped in a .75 inch scalp was 6.15% and was 1.69 tons per acre. The percent of the sugar beet left in the field when scalping 1 inch above the soil surface was 22.46% and 6.18 tons per acre. One should note that the loss in sugar beet weight is a very good incentive to harvest when ever possible since the loss in tons per acre when averaged between sites as a result of aggressive scalping resulted in a $135.16 per acre loss compared to .75 inch scalp. If one would consider that approximately 30%

of the SMBSC sugar beets were still in the field at the time of the frost event, which would result in approximately 35,000 acres across the SMBSC growing area. Then one can also assume that the cooperative left $4,730,600 in the field from frost damaged material. Thus, the sooner a sugar beet can be harvested (giving appropriate temperatures and the lack of mud for good storage) the more profitable the cooperative growers as a whole will be.

Table 3. Scalping on frost effected sugar beets 2006
Combined data for Varieties Beta 4811 and Hilleshog 2467
Weighted by sample number across two locations

		160 std ct. Tons/Acre	% of ind. Beet	%Sugar	APP PURITY	PPM Nitrate	Ext. Suc. Percent	Ext. Suc. per ton	Ext. Suc. per acre	revenue per acre
Whole Beet	Unscalped	23.57	100.00	16.91	88.09	41.11	13.75	275	6460	830.90
Whole Beet	.75 inch scalp	22.65	96.11	17.55	89.02	44.76	14.50	290	6526	875.70
Whole beet	scalped 1" above ground	18.82	76.79	17.65	90.12	47.62	14.61	292	5476	740.54
beet scalp	Portion 1" above ground - .75 inch scalp	6.18	22.46	15.52	85.77	50.55	10.20	204	1269	118.39
beet scalp	.75 inch scalp	1.69	6.15	12.89	73.53	87.96	7.64	153	270	12.87

<u>Summary</u>

1. The growth characteristics of the sugar beet did not influence the percent of the sugar beet scalped and left in the filed.
2. The revenue realized by scalping is dependent on quality of the crown material in the sugar beet which can be a function of nitrogen management as well as sugar beet population management.
3. This author believes this research emphasizes the importance of harvesting a storable and processable sugar beet when the opportunities are given by the SMBSC management.
4. In general sugar beet revenue was the highest when sugar beets were scalped to .75 inch from top of crown.

SMBSC Weed Control Program, 2006

The weed species that are difficult to control in sugarbeets have changed over the past decade. Weeds such as smartweed and velvetleaf are very difficult to control with the current herbicides available in sugarbeets. Weed control research in sugarbeets at SMBSC attempts to determine the best options to control these problem weeds and many others. The following weed control research is a screening of herbicides and herbicide combinations for the control of various weeds present in sugarbeet fields.

Methods

Weed control trials were established at two locations; Murdock and Hector. Treatments were applied to the middle four rows of six row, 35 foot long plots which were replicated four times. Herbicide treatments at Murdock and Hector were evaluated for weed control efficacy. The Murdock location was harvested in order to evaluate the herbicide treatments effect on yield. Herbicide treatments were applied at 12.5 gal/acre and 40 psi with a bicycle wheel sprayer.

Results

In the tables presented, an asterisks indicates 4 applications starting at the cotyledon stage of the sugarbeet and sequential applications made every 7 days.

Hector weed control (table 1A-1E)

Weeds present at the Hector research site were smartweed, amaranth species and venice mallow. The infestation of smartweed, amaranth species and venice mallow was rated as high, medium and low respectively.

Smartweed control was highly variable as indicated by the coefficient of variability (C.V.). The best control of smartweed with the microrate was achieved when all components of the microrate were present in the spray mixture. The addition of Nortron at 4oz. /acre to the microrate tended to increase control of smartweed by 10%. Progress alone or with Stinger did not give acceptable control of smartweed. Adding Nortron at 4 oz. /acre to the spray mixture did not compensate for removing Upbeet from the spray mixture. Dual Magnum or Outlook added to the microrate did not increase smartweed control. Nortron applied preemergence tended to give better smartweed control than Dual Magnum applied preemergence, when Progress was applied postemergence.

Amaranth species and lambsquarters control tended to be similar for most treatments tested. Lambsquarters control was reduced in the absence of methylated seed oil and Upbeet. When methylated seed oil and Upbeet were absent from the spray mixture, the rate of Stinger or Progress and use of Nortron at 4 oz. /acre became more important.

Venice mallow control was greatly influenced by the presence of Upbeet in the postemergence spray mixture and the application of Nortron or Dual Magnum preplant incorporated or preemergence.

Table 1A. SMBSC weed control program evaluation - Hector Mn, efficacy data
Experiment # 0632

Herbicide	Rate oz/acre	Appl. Time	Smart weed	Amaranth Species	Lambs Quarter	S. Beet Injury	Venice Mallow
No ppi/pre			86	90	95	6	99
Progress+Upbeet+Stinger+MSO (4X)	5.7+0.125+1.3+1.5%:	*					
Total cost / Acre	**$58.46**						
No ppi/pre			87	94	97	9	94
Progress+Upbeet+Stinger+Select Max+MSO (4X)	5.7+0.125+1.3+4+1.5%:	*					
Total cost / Acre	**$70.34**						
No ppi/pre			89	97	99	6	99
Progress+Upbeet+Stinger+Select Max+MSO	8.5+0.125+1.3+4+1.5%:	cotyl					
Progress+Upbeet+Stinger+Select Max+MSO	8.5+0.125+1.3+4+1.5%:	2 leaf					
Progress+Upbeet+Stinger+Select Max+MSO	11.5+0.125+1.3+4+1.5%:	4 leaf					
Progress+Upbeet+Stinger+Selec Max+MSO	16+0.125+1.3+4+1.5%:	6 leaf					
Total cost / Acre	**$81.19**						
No ppi/pre			56	81	91	9	96
Preogress+Stinger+MSo	8.5+1.3+1.5%:	cotyl					
Preogress+Stinger+MSo	8.5+1.3+1.5%:	2 leaf					
Preogress+Stinger+MSo	11.5+1.3+1.5%:	4 leaf					
Preogress+Stinger+MSo	16+1.3+1.5%:	6 leaf					
Total cost / Acre	**$48.44**						
No ppi/pre			34	80	81	6	77
Preogress+Stinger+MSo	8.5+1.3+1.5%:	cotyl					
Preogress+Stinger+MSo	8.5+1.3+1.5%:	2 leaf					
Preogress+Stinger+MSo	11.5+1.3+1.5%:	4 leaf					
Progress+Stinger+SelectMax +MSo	16+1.3+8+1.5%:	6 leaf					
Total cost / Acre	**$54.37**						
		CV%	18.44	9.11	7.69	59.09	9.67
		LSD	18.96	11.55	10	6.49	12.83

Table 1B. SMBSC weed control program evaluation - Hector Mn, efficacy data
Experiment # 0632

Herbicide	Rate oz/acre	Appl. Time	Smart weed	Amaranth Species	Lambs Quarter	S. Beet Injury	Venice Mallow
No ppi/pre			56	88	90	9	99
Progress(cot.)/Progress(2lf)/Progress(4lf)/Progress(4lf)	16/18/22/24	*					
Total cost / Acre	**$48.31**						
No ppi/pre			45	82	82	6	86
Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf).	16+1.3/18+1.3/22+1.3/24+1.3	*					
Total cost / Acre	**$57.88**						
No ppi/pre			59	78	84	11	90
Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf).	16+1.5/18+1.5/22+1.5/24+1.5	*					
Total cost / Acre	**$60.63**						
No ppi/pre			69	95	96	18	87
Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf).	16+2/18+2/22+2/24+2	*					
Total cost / Acre	**$67.50**						
		CV%	18.44	9.11	7.69	59.09	9.67
		LSD	18.96	11.55	10	6.49	12.83

Table 1C. SMBSC weed control program evaluation - Hector Mn, efficacy data

Experiment # 0632

Herbicide	Rate oz/acre	Appl. Time	Smart weed	Amaranth Species	Lambs Quarter	S. Beet Injury	Venice Mallow
No ppi/pre			95	99	99	8	99
Progress+Upbeet+Stinger+Nortron+MSO	5.7+0.125+1.3+4+1.5%:	cotyl					
Progress+Upbeet+Stinger+Nortron+MSO	5.7+0.125+1.3+4+1.5%:	2 leaf					
Progress+Upbeet+Stinger+Nortron+MSO	5.7+0.125+1.3+4+1.5%:	4 leaf					
Progress+Upbeet+Stinger+Nortron+MSO	5.7+0.125+1.3+4+1.5%:	6 leaf					
Total cost / Acre	**$67.21**						
No ppi/pre			85	92	96	4	96
Progress+Upbeet+Nortron+MSO	8+0.125+4+1.5%:	cotyl					
Progress+Upbeet+Nortron+MSO	8+0.125+4+1.5%:	2 leaf					
Progress+Stinger+Nortron	16+1.3+4	4 leaf					
Progress+Stinger+Nortron	16+1.3+4	6 leaf					
Total cost / Acre	**$56.28**						
No ppi/pre			78	91	93	8	97
Progress+Upbeet+Stinger+Select Max+MSO	8.5+.125+1.3+4+1.5%:	cotyl					
Progress+Upbeet+Stinger+Select Max+MSO	8.5+.125+1.3+4+1.5%:	2 leaf					
Progress	22	4 leaf					
Progress	24	6 leaf					
Total cost / Acre	**$60.97**						
No ppi/pre			65	85	89	10	98
Progress	16	cotyl					
Progress	18	2 leaf					
Progress+Upbeet+Stinger+Select Max+MSO	11.5+.25+2.5+6+1.5%	4 leaf					
Progress+Upbeet+Stinger+Select Max+MSO	16+.25+2.5+6+1.5%	6 leaf					
Total cost / Acre	**$81.87**						
No ppi/pre			90	97	99	16	96
Progress+Upbeet+Stinger+Select Max+MSO	18+.25+2.5+6+1.5%	cotyl					
Progress+Upbeet+Stinger+Select Max+MSO	24+.25+2.5+6+1.5%	2 leaf					
Progress+Upbeet+Stinger+Select Max+MSO	24+.25+2.5+6+1.5%	4 leaf					
Progress+Upbeet+Stinger+Select Max+MSO	24+.25+2.5+6+1.5%	6 leaf					
Total cost / Acre	**$147.25**						
		CV%	18.44	9.11	7.69	59.09	9.67
		LSD	18.96	11.55	10	6.49	12.83

Table 1D. SMBSC weed control program evaluation - Hector Mn, efficacy data

Experiment # 0632

Herbicide	Rate oz/acre	Appl. Time	Smart weed	Amaranth Species	Lambs Quarter	S. Beet Injury	Venice Mallow
Notron	120	PPI	49	83	83	3	88
Total cost / Acre	**$65.58**						
Nortron	120	Pre	30	85	85	1	92
Total cost / Acre	**$65.58**						
Nortron	120	Pre	95	96	97	4	99
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyl					
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	2 leaf					
Progress+Upbeet+Stinger+MSO	11.5+0.125+1.3+1.5%:	4 leaf					
Progress+Upbeet+Stinger+MSO	16+0.125+1.3+1.5%:	6 leaf					
Total cost / Acre	**$134.89**						
Nortron	120	Pre	92	98	99	9	99
Progress++Stinger+MSO	8.5+1.3+1.5%:	cotyl					
Progress++Stinger+MSO	8.5+1.3+1.5%:	2 leaf					
Progress++Stinger+MSO	11.5+1.3+1.5%:	4 leaf					
Progress++Stinger+MSO	16+1.3+1.5%:	6 leaf					
Total cost / Acre	**$114.03**						
Nortron	120	Pre	89	98	99	5	99
Progress+Stinger+MSO	8.5+1.3+1.5%:	cotyl					
Progress+Stinger+MSO	8.5+1.3+1.5%:	2 leaf					
Progress+Stinger+MSO	11.5+1.3+1.5%:	4 leaf					
Progress+Stinger+Select Max+MSO	16+1.3+1.5%:	6 leaf					
Total cost / Acre	**$119.95**						
		CV%	18.44	9.11	7.69	59.09	9.67
		LSD	18.96	11.55	10	6.49	12.83

Table 1E. SMBSC weed control program evaluation - Hector Mn, efficacy data
Experiment # 0632

Herbicide	Rate oz/acre	Appl. Time	Smart weed	Amaranth Species	Lambs Quarter	S. Beet Injury	Venice Mallow
Nortron	120	Pre	95	96	97	4	99
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyl					
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	2 leaf					
Progress+Upbeet+Stinger+MSO	11.5+0.125+1.3+1.5%:	4 leaf					
Progress+Upbeet+Stinger+MSO	16+0.125+1.3+1.5%:	6 leaf					
Total cost / Acre	**$134.89**						
Nortron	120	Pre	92	98	99	9	99
Progress+Stinger+MSO	8.5+1.3+1.5%:	cotyl					
Progress+Stinger+MSO	8.5+1.3+1.5%:	2 leaf					
Progress+Stinger+MSO	11.5+1.3+1.5%:	4 leaf					
Progress+Stinger+MSO	16+1.3+1.5%:	6 leaf					
Total cost / Acre	**$114.03**						
Nortron	120	Pre	89	98	99	5	99
Progress+Stinger+MSO	8.5+1.3+1.5%:	cotyl					
Progress+Stinger+MSO	8.5+1.3+1.5%:	2 leaf					
Progress+Stinger+MSO	11.5+1.3+1.5%:	4 leaf					
Progress+Stinger+Select Max+MSO	16+1.3+1.5%:	6 leaf					
Total cost / Acre	**$119.95**						
No ppi/pre			84	84	87	6	95
Progres+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	cotyl					
Progres+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	2 leaf					
Progress+Upbeet+Stinger+Select Maxt+MSO+Dual Mag	5.7+0.125+1.3+4+1.5%:	4 leaf					
Progres+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%+27:	6 leaf					
Total cost / Acre	**$86.16**						
No ppi/pre			86	93	94	8	89
Progres+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	cotyl					
Progres+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	2 leaf					
Progress+Upbeet+Stinger+Select Max+MSO+Outlook	5.7+0.125+1.3+4+1.5%+21:	4 leaf					
Progres+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	6 leaf					
Total cost / Acre	**$90.84**						
Dual Mag.(ppi)/Progress(cot.)/Progress(2lf)/Progress(4lf)	32/16/20/24		73	84	90	9	93
Total cost / Acre	**$48.75**						
			84	96	96	9	99
Nortron(ppi)/Progress(2lf)/Progress(4lf)	120/16/20						
Total cost / Acre	**$83.58**						
Dual Mag(ppi)./Progress(2lf)/Progress(4lf)/Progress+Outlook(6lf)	32/16/20/24+21		69	87	87	8	90
Total cost / Acre	**$69.26**						
Nortron(ppi)/Progress(2lf)/Progress+Outlook(4lf)	120/20/24+21		85	98	99	10	99
Total cost / Acre	**$108.09**						
		CV%	18.44	9.11	7.69	59.09	9.67
		LSD	18.96	11.55	10	6.49	12.83

Hector yield results (table 2A-2E)

Tons per acre were directly related to level of weed control. There was a tendency for sugar content and purity to increase as weed control decreased. This tendency has been observed before and it is theorized that the competition for nutrients is increased by the increase in weed pressure resulting from less effective treatments. Weed competition may also result in smaller sized sugarbeets which generally are higher in quality than larger sized sugarbeets. Treatments with Nortron generally gave higher extractable sugar per acre.

Table 2A. SMBSC weed control program evaluation - Hector Mn, Yield data
Experiment # 0632

Herbicide	Rate oz/acre	Appl. Time	Tons per acre	Sugar Percent	Purity	Extractable sucrose Per ton	Extractable sucrose Per acre	Revenue Per acre
No ppi/pre			22.73	13.48	90.73	225	5108	527.94
Progress+Upbeet+Stinger+MSO	5.7+0.125+1.3+1.5%:	cotyl						
Progress+Upbeet+Stinger+MSO	5.7+0.125+1.3+1.5%:	2 leaf						
Progress+Upbeet+Stinger+MSO	5.7+0.125+1.3+1.5%:	4 leaf						
Progress+Upbeet+Stinger+MSO	5.7+0.125+1.3+1.5%:	6 leaf						
Total cost / Acre	**$58.46**							
No ppi/pre								
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	cotyl	18.39	13.78	89.94	228	4150	431.29
Progress+Upbeet+Stinger+ SelectMax+MSO	5.7+0.125+1.3+4+1.5%:	2 leaf						
Progress+Upbeet+Stinger+ Select Max+MSO	5.7+0.125+1.3+4+1.5%:	4 leaf						
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	6 leaf						
Total cost / Acre	**$70.34**							
No ppi/pre								
Progress+Upbeet+Stinger+Select Max+MSO	8.5+0.125+1.3+4+1.5%:	cotyl	18.48	13.66	90.18	226	4156	429.85
Progress+Upbeet+Stinger+Select Max+MSO	8.5+0.125+1.3+4+1.5%:	2 leaf						
Progress+Upbeet+Stinger+Select Max+MSO	11.5+0.125+1.3+4+1.5%:	4 leaf						
Progress+Upbeet+Stinger+Select Max+MSO	16+0.125+1.3+4+1.5%:	6 leaf						
Total cost / Acre	**$31.19**							
No ppi/pre			17.63	13.43	89.92	221	3911	396.96
Preogress+Stinger+MSo	8.5+1.3+1.5%:	cotyl						
Preogress+Stinger+MSo	8.5+1.3+1.5%:	2 leaf						
Preogress+Stinger+MSo	11.5+1.3+1.5%:	4 leaf						
Preogress+Stinger+MSo	16+1.3+1.5%:	6 leaf						
Total cost / Acre	**$48.44**							
No ppi/pre								
Preogress+Stinger+MSo	8.5+1.3+1.5%:	cotyl	14.97	14.28	90.93	240	3579	400.07
Preogress+Stinger+MSo	8.5+1.3+1.5%:	2 leaf						
Preogress+Stinger+MSo	11.5+1.3+1.5%:	4 leaf						
Progress+Stinger+Select Max +MSo	16+1.3+8+1.5%:	6 leaf						
Total cost / Acre	**$54.37**							
		CV%	20.83	4.22	1.5	5.99	18.8	19.17
		LSD	5.70	0.8	1.9	18.76	1136.2	116.57

Table 2B. SMBSC weed control program evaluation - Hector Mn, Yield data
Experiment # 0632

Herbicide	Rate oz/acre	Appl. Time	Tons per acre	Sugar Percent	Purity	Extractable sucrose Per ton	Extractable sucrose Per acre	Revenue Per acre
No ppi/pre								
Progress(cot.)/Progress(2lf)/Progress(4lf)/Progress(4lf)	16/18/22/24	*	19.74	13.65	89.89	225	4366	441.29
Total cost / Acre	**$48.31**							
No ppi/pre								
Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf).	16+1.3/18+1.3/22+1.3/24+1.3	*	15.19	14.07	91.08	237	3541	383.84
Total cost / Acre	**$57.88**							
No ppi/pre								
Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf).	16+1.5/18+1.5/22+1.5/24+1.5	*	12.31	13.51	89.97	223	2709	272.03
Total cost / Acre	**$60.63**							
No ppi/pre								
Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf).	16+2/18+2/22+2/24+2	*	17.18	13.62	89.72	224	3770	376.98
Total cost / Acre	**$67.50**							
		CV%	20.83	4.22	1.5	5.99	18.8	19.17
		LSD	5.70	0.8	1.9	18.76	1136.2	116.57

Table 2C. SMBSC weed control program evaluation - Hector Mn, Yield data

Experiment # 0632

Herbicide	Rate oz/acre	Appl. Time	Tons per acre	Sugar Percent	Purity	Extractable sucrose Per ton	Extractable sucrose Per acre	Revenue Per acre
No ppi/pre			19.51	13.37	90.43	222	4304	433.73
Progress+Upbeet+Stinger+Nortron+MSO	5.7+0.125+1.3+4+1.5%:	cotyl						
Progress+Upbeet+Stinger+Nortron+MSO	5.7+0.125+1.3+4+1.5%:	2 leaf						
Progress+Upbeet+Stinger+Nortron+MSO	5.7+0.125+1.3+4+1.5%:	4 leaf						
Progress+Upbeet+Stinger+Nortron+MSO	5.7+0.125+1.3+4+1.5%:	6 leaf						
Total cost / Acre	**$67.21**							
No ppi/pre								
Progress+Upbeet+Nortron+MSO	8+0.125+4+1.5%:	cotyl	20.55	13.28	90.07	219	4503	448.98
Progress+Upbeet+Nortron+MSO	8+0.125+4+1.5%:	2 leaf						
Progress+Stinger+Nortron	16+1.3+4	4 leaf						
Progress+Stinger+Nortron	16+1.3+4	6 leaf						
Total cost / Acre	**$56.28**							
No ppi/pre								
Progress+Upbeet+Stinger+Select Max+MSO	8.5+.125+1.3+4+1.5%:	cotyl	19.71	13.43	89.95	221	4365	442.12
Progress+Upbeet+Stinger+Select Max+MSO	8.5+.125+1.3+4+1.5%:	2 leaf						
Progress	22	4 leaf						
Progress	24	6 leaf						
Total cost / Acre	**$60.97**							
No ppi/pre								
Progress	16	cotyl	24.41	13.27	89.32	217	4626	452.19
Progress	18	2 leaf						
Progress+Upbeet+Stinger+Select Max+MSO	11.5+.25+2.5+6+1.5%	4 leaf						
Progress+Upbeet+Stinger+Select Max+MSO	16+.25+2.5+6+1.5%	6 leaf						
Total cost / Acre	**$81.87**							
No ppi/pre								
Progress+Upbeet+Stinger+Select Max+MSO	18+.25+2.5+6+1.5%	cotyl	23.29	13.39	90.43	222	5176	526.88
Progress+Upbeet+Stinger+Select Max+MSO	24+.25+2.5+6+1.5%	2 leaf						
Progress+Upbeet+Stinger+Select Max+MSO	24+.25+2.5+6+1.5%	4 leaf						
Progress+Upbeet+Stinger+Select Max+MSO	24+.25+2.5+6+1.5%	6 leaf						
Total cost / Acre	**$147.25**							
		CV%	20.83	4.22	1.5	5.99	18.8	19.17
		LSD	5.70	0.8	1.9	18.76	1136.2	116.57

Table 2D. SMBSC weed control program evaluation - Hector Mn, Yield data

Experiment # 0632

Herbicide	Rate oz/acre	Appl. Time	Tons per acre	Sugar Percent	Purity	Extractable sucrose Per ton	Extractable sucrose Per acre	Revenue Per acre
Notron	120	PPI	16.58	12.96	88.88	210	3480	325.21
Total cost / Acre	**$65.58**							
Nortron	120	Pre	14.46	13.74	90.89	230	3323	353.61
Total cost / Acre	**$65.58**							
Nortron	120	Pre						
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyl	26.88	13.33	89.06	217	5762	556.28
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	2 leaf						
Progress+Upbeet+Stinger+MSO	11.5+0.125+1.3+1.5%:	4 leaf						
Progress+Upbeet+Stinger+MSO	16+0.125+1.3+1.5%:	6 leaf						
Total cost / Acre	**$134.89**							
Nortron	120	Pre	25.28	13.13	90.28	217	5478	537.57
Progress+Upbeet+Stinger+MSO	8.5+1.3+1.5%:	cotyl						
Progress+Upbeet+Stinger+MSO	8.5+1.3+1.5%:	2 leaf						
Progress+Upbeet+Stinger+MSO	11.5+1.3+1.5%:	4 leaf						
Progress+Upbeet+Stinger+MSO	16+1.3+1.5%:	6 leaf						
Total cost / Acre	**$114.03**							
Nortron	120	Pre	22.95	13.49	90.15	223	5093	517.24
Progress+Stinger+MSO	8.5+1.3+1.5%:	cotyl						
Progress+Stinger+MSO	8.5+1.3+1.5%:	2 leaf						
Progress+Stinger+MSO	11.5+1.3+1.5%:	4 leaf						
Progress+Stinger+Select Max+MSO	16+1.3+1.5%:	6 leaf						
Total cost / Acre	**$119.95**							
		CV%	20.83	4.22	1.5	5.99	18.8	19.17
		LSD	5.70	0.8	1.9	18.76	1136.2	116.57

Table 2E. SMBSC weed control program evaluation - Hector Mn, Yield data
Experiment # 0632

Herbicide	Rate oz/acre	Appl. Time	Tons per acre	Sugar Percent	Purity	Extractable sucrose Per ton	Extractable sucrose Per acre	Revenue Per acre
Nortron	120	Pre						
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyl	26.88	13.33	89.06	217	5762	556.28
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	2 leaf						
Progress+Upbeet+Stinger+MSO	11.5+0.125+1.3+1.5%:	4 leaf						
Progress+Upbeet+Stinger+MSO	16+0.125+1.3+1.5%:	6 leaf						
Total cost / Acre	**$134.89**							
Nortron	120	Pre	25.28	13.13	90.28	217	5478	537.57
Progress+Stinger+MSO	8.5+1.3+1.5%:	cotyl						
Progress+Stinger+MSO	8.5+1.3+1.5%:	2 leaf						
Progress+Stinger+MSO	11.5+1.3+1.5%:	4 leaf						
Progress+Stinger+MSO	16+1.3+1.5%:	6 leaf						
Total cost / Acre	**$114.03**							
Nortron	120	Pre	22.95	13.49	90.15	223	5093	517.24
Progress+Stinger+MSO	8.5+1.3+1.5%:	cotyl						
Progress+Stinger+MSO	8.5+1.3+1.5%:	2 leaf						
Progress+Stinger+MSO	11.5+1.3+1.5%:	4 leaf						
Progress+Stinger+Select Max+MSO	16+1.3+1.5%:	6 leaf						
Total cost / Acre	**$119.95**							
No ppi/pre	5.7+0.125+1.3+4+1.5%:		17.88	12.82	89.06	208	3686	334.29
Progres+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	cotyl						
Progres+Upbeet+Stinger+Select Msx+MSO	5.7+0.125+1.3+4+1.5%:	2 leaf						
Progress+Upbeet+Stinger+Select Max+MSO+Dual Mag	5.7+0.125+1.3+4+1.5%+27:	4 leaf						
Progres+Upbeet+Stinger+Select Max+MSO		6 leaf						
Total cost / Acre	**$86.16**							
No ppi/pre								
Progres+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	cotyl	22.25	13.16	90.10	217	4733	451.69
Progres+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	2 leaf						
Progress+Upbeet+Stinger+Select Max+MSO+Outlook	5.7+0.125+1.3+4+1.5%+21:	4 leaf						
Progres+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	6 leaf						
Total cost / Acre	**$90.84**							
Dual Mag.(ppi)/Progress(cot.)/Progress(2lf)/Progress(4lf)	32/16/20/24		18.35	13.72	90.10	227	4161	435.18
Total cost / Acre	**$48.75**							
Nortron(ppi)/Progress(2lf)/Progress(4lf)	120/16/20		21.49	13.59	89.80	224	4783	487.87
Total cost / Acre	**$83.58**							
Dual Mag(ppi)./Progress(2lf)/Progress(4lf)/Progress+Outlook(4lf)	32/16/20/24+21		17.18	13.04	89.85	214	3690	357.21
Total cost / Acre	**$69.26**							
Nortron(ppi)/Progress(2lf)/Progress+Outlook(4lf)	120/20/24+21		21.69	13.30	88.86	217	4712	464.13
Total cost / Acre	**$108.09**							
		CV%	20.83	4.22	1.5	5.99	18.8	19.17
		LSD	5.70	0.8	1.9	18.76	1136.2	116.57

Summary of results

1. Control of smartweed with the microrate was best achieved when all components of the microrate were present in the spray mixture.
2. The addition of Nortron at 4oz. /acre to the microrate tended to increase control of smartweed by 10%.
3. Progress alone or with Stinger did not give acceptable control of smart weed.
4. Adding Nortron at 4 oz. /acre to the spray mixture did not compensate for removing Upbeet from the spray mixture.
5. Dual Magnum or Outlook added to the microrate did not increase smartweed control.
6. Nortron applied preemergence tended to give better smartweed control than Dual Magnum applied preemergence, when Progress was applied postemergence.
7. Amaranth species and lambsquarters control tended to be similar for most treatments tested.
8. Lambsquarters control was reduced in the absence of methylated seed oil and Upbeet.
9. When methylated seed oil and Upbeet were absent from the spray mixture, the rate of Stinger or Progress and use of Nortron at 4 oz. /acre becomes more important.
10. Venice mallow control was greatly influenced by the presence of Upbeet in the postemergence spray mixture

11. The application of Nortron or Dual Magnum preplant incorporated or preemergence was beneficial for the control of venice mallow.

Murdock weed control (table 3A-3E)

Weed pressure at this site was rated low. Weeds present at the Murdock research site were lambsquarters and yellow foxtail.

Control of lambsquarters was very good with all treatments. The only treatment that was statistically lower than most treatments was Nortron applied preplant incorporated with no post application. The lambsquarters control was 89% percent in this treatment.

More differences were observed with the control of yellow foxtail compared to lambsquarters control in this experiment. Yellow foxtail control was best achieved when Select Max was applied in all applications at low rates or in the last application with a full rate. Control of yellow foxtail was significantly lower when no Select Max was applied or when Select Max was applied at low rates in the first one or two application of a four application weed control program. Nortron gave better yellow foxtail control than Dual Magnum.

Table 3A. SMBSC weed control program evaluation - Murdock Mn, efficacy data
experiment # 0631

Herbicide	Rate oz/acre	Appl. Timing	S. beet Injury	Lambs Quarter	Yellow Foxtail
			(Percent Control)		
No ppi/pre					
Progress+Upbeet+Stinger+MSO (4X)	5.7+0.125+1.3+1.5%:	*	3	96	78
Total cost / Acre	**$58.46**				
No ppi/pre					
Progress+Upbeet+Stinger+SelectMt+MSO (4X)	5.7+0.125+1.3+4+1.5%:	*	0	98	99
Total cost / Acre	**$70.34**				
No ppi/pre					
Progress+Upbeet+Stinger+SelectMt+MSO	8.5+0.125+1.3+4+1.5%:	cotyl	6	99	97
Progress+Upbeet+Stinger+SelectMt+MSO	8.5+0.125+1.3+4+1.5%:	2 leaf			
Progress+Upbeet+Stinger+SelectMt+MSO	11.5+0.125+1.3+4+1.5%:	4 leaf			
Progress+Upbeet+Stinger+SelectMt+MSO	16+0.125+1.3+4+1.5%:	6 leaf			
Total cost / Acre	**$81.19**				
No ppi/pre					
Preogress+Stinger+MSo	8.5+1.3+1.5%:	cotyl	5	99	72
Preogress+Stinger+MSo	8.5+1.3+1.5%:	2 leaf			
Preogress+Stinger+MSo	11.5+1.3+1.5%:	4 leaf			
Preogress+Stinger+MSo	16+1.3+1.5%:	6 leaf			
Total cost / Acre	**$48.44**				
No ppi/pre					
Preogress+Stinger+MSo	8.5+1.3+1.5%:	cotyl	0	99	94
Preogress+Stinger+MSo	8.5+1.3+1.5%:	2 leaf			
Preogress+Stinger+MSo	11.5+1.3+1.5%:	4 leaf			
Progress+Stinger+SelectM +MSo	16+1.3+8+1.5%:	6 leaf			
Total cost / Acre	**$54.37**				
		CV%	142.65	4.35	13.26
		LSD	4.46	5.96	15.14

Table 3B. SMBSC weed control program evaluation - Murdock Mn, efficacy data
experiment # 0631

Herbicide	Rate oz/acre	Appl. Timing	S. beet Injury	Lambs Quarter	Yellow Foxtail
			(Percent Control)		
No ppi/pre Progress(cot.)/Progress(2lf)/Progress(4lf)/Progress(4lf) **Total cost / Acre**	16/18/22/24 **$48.31**	*	0	99	73
No ppi/pre Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf). **Total cost / Acre**	16+1.3/18+1.3/22+1.3/24+1.3 **$57.88**	*	4	99	72
No ppi/pre Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf). **Total cost / Acre**	16+1.5/18+1.5/22+1.5/24+1.5 **$60.63**	*	0	93	78
No ppi/pre Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf). **Total cost / Acre**	16+2/18+2/22+2/24+2 **$67.50**	*	4	99	84
		CV%	142.65	4.35	13.26
		LSD	4.46	5.96	15.14

Table 3C. SMBSC weed control program evaluation - Murdock Mn, efficacy data
experiment # 0631

Herbicide	Rate oz/acre	Appl. Timing	S. beet Injury	Lambs Quarter	Yellow Foxtail
			(Percent Control)		
No ppi/pre Progress+Upbeet+Stinger+Nortron+MSO (4X) **Total cost / Acre**	5.7+0.125+1.3+4+1.5%: **$67.21**	*	0	99	77
No ppi/pre Progress+Upbeet+Nortron+MSO Progress+Upbeet+Nortron+MSO Progress+Stinger+Nortron Progress+Stinger+Nortron **Total cost / Acre**	8+0.125+4+1.5%: 8+0.125+4+1.5%: 16+1.3+4 16+1.3+4 **$56.28**	cotyl 2 leaf 4 leaf 6 leaf	0	93	69
No ppi/pre Progress+Upbeet+Stinger+SelectM+MSO Progress+Upbeet+Stinger+SelectM+MSO Progress Progress **Total cost / Acre**	8.5+.125+1.3+4+1.5%: 8.5+.125+1.3+4+1.5%: 22 24 **$60.97**	cotyl 2 leaf 4 leaf 6 leaf	5	98	90
No ppi/pre Progress Progress Progress+Upbeet+Stinger+SelectM+MSO Progress+Upbeet+Stinger+SelectM+MSO **Total cost / Acre**	16 18 11.5+.25+2.5+6+1.5% 16+.25+2.5+6+1.5% **$81.87**	cotyl 2 leaf 4 leaf 6 leaf	5	96	93
No ppi/pre Progress+Upbeet+Stinger+SelectM+MSO Progress+Upbeet+Stinger+SelectM+MSO Progress+Upbeet+Stinger+SelectM+MSO Progress+Upbeet+Stinger+SelectM+MSO **Total cost / Acre**	18+.25+2.5+6+1.5% 24+.25+2.5+6+1.5% 24+.25+2.5+6+1.5% 24+.25+2.5+6+1.5% **$147.25**	cotyl 2 leaf 4 leaf 6 leaf	7	96	98
		CV%	142.65	4.35	13.26
		LSD	4.46	5.96	15.14

Table 3D. SMBSC weed control program evaluation - Murdock Mn, efficacy data
experiment # 0631

Herbicide	Rate oz/acre	Appl. Timing	S. beet Injury	Lambs Quarter	Yellow Foxtail
			(Percent Control)		
Notron	120	PPI	0	89	76
Total cost / Acre	**$65.58**				
Nortron	120	Pre	2	99	55
Total cost / Acre	**$65.58**				
Dual Mag.(PPI)Nortron(Pre)/Progress(2lf)/Progress(4lf)	32/120/16/20		3	94	78
Total cost / Acre	**$102.33**				
EPTC (PPI)/Nortron(cotyl)Progress(2lf)/Progress(4lf)	46/120/16/20		3	99	86
Total cost / Acre	**$93.64**				
Nortron	120	Pre	3	99	84
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyl			
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	2 leaf			
Progress+Upbeet+Stinger+MSO	11.5+0.125+1.3+1.5%:	4 leaf			
Progress+Upbeet+Stinger+MSO	16+0.125+1.3+1.5%:	6 leaf			
Total cost / Acre	**$134.89**				
Nortron	120	Pre	2	99	89
Progress+Stinger+MSO	8.5+1.3+1.5%:	cotyl			
Progress+Stinger+MSO	8.5+1.3+1.5%:	2 leaf			
Progress+Stinger+MSO	11.5+1.3+1.5%:	4 leaf			
Progress+Stinger+MSO	16+1.3+1.5%:	6 leaf			
Total cost / Acre	**$114.03**				
Nortron	120	Pre	0	99	94
Progress+Stinger+MSO	8.5+1.3+1.5%:	cotyl			
Progress+Stinger+MSO	8.5+1.3+1.5%:	2 leaf			
Progress+Stinger+MSO	11.5+1.3+1.5%:	4 leaf			
Progress+Stinger+Select Max+MSO	16+1.3+1.5%:	6 leaf			
Total cost / Acre	**$119.95**				
		CV%	142.65	4.35	13.26
		LSD	4.46	5.96	15.14

Table 3E. SMBSC weed control program evaluation - Murdock Mn, efficacy data
experiment # 0631

Herbicide	Rate oz/acre	Appl. Timing	S. beet Injury	Lambs Quarter	Yellow Foxtail
			(Percent Control)		
Dual Mag.(PPI)Nortron(Pre)/Progress(2lf)/Progress(4lf) **Total cost / Acre**	32/120/16/20 **$102.33**	PPI	3	94	78
EPTC (PPI)/Nortron(cotyl)Progress(2lf)/Progress(4lf) **Total cost / Acre**	46/120/16/20 **$93.64**	Pre	3	99	86
Nortron Progress+Upbeet+Stinger+MSO Progress+Upbeet+Stinger+MSO Progress+Upbeet+Stinger+MSO Progress+Upbeet+Stinger+MSO **Total cost / Acre**	120 8.5+0.125+1.3+1.5%: 8.5+0.125+1.3+1.5%: 11.5+0.125+1.3+1.5%: 16+0.125+1.3+1.5%: **$134.89**	Pre cotyl 2 leaf 4 leaf 6 leaf	3	99	84
No ppi/pre Progress+Upbeet+Stinger+Select Max+MSO Progress+Upbeet+Stinger+Select Max+MSO Progress+Upbeet+Stinger+Select Max+MSO+Dual Mag Progress+Upbeet+Stinger+Select Max+MSO **Total cost / Acre**	5.7+0.125+1.3+4+1.5%: 5.7+0.125+1.3+4+1.5%: 5.7+0.125+1.3+4+1.5%+27: 5.7+0.125+1.3+4+1.5%: **$86.16**	cotyl 2 leaf 4 leaf 6 leaf	2	99	99
No ppi/pre Progress+Upbeet+Stinger+Select Max+MSO Progress+Upbeet+Stinger+Select Max+MSO Progress+Upbeet+Stinger+Select Max+MSO+Outlook Progress+Upbeet+Stinger+Select Max+MSO **Total cost / Acre**	5.7+0.125+1.3+4+1.5%: 5.7+0.125+1.3+4+1.5%: 5.7+0.125+1.3+4+1.5%+21: 5.7+0.125+1.3+4+1.5%: **$90.84**	cotyl 2 leaf 4 leaf 6 leaf	0	96	96
Dual Mag.(ppi)/Progress(cotyl)/Progress(2lf)/Progress(4lf) **Total cost / Acre**	32/16/20/24 **$48.75**		3	99	73
No ppi/pre Nortron(ppi)/Progress(2lf)/Progress(4lf) **Total cost / Acre**	120/16/20 **$83.58**		3	99	70
Dual Mag.(ppi)/Progress(cotl)/Progress(2lf)/Progress+Outlook(4lf) **Total cost / Acre**	32/16/20/24+21 **$69.26**		2	99	70
No ppi/pre Nortron(pre)/Progress(2lf)/Progress+Outlook(4lf) **Total cost / Acre**	120/20/24+21 **$108.09**		0	99	87
Notron **Total cost / Acre**	120 **$65.58**	PPI	0	89	76
Nortron **Total cost / Acre**	120 **$65.58**	Pre	2	99	55
Progress **Total cost / Acre**	18 **$9.00**	cotyl	2	93	42
		CV%	142.65	4.35	13.26
		LSD	4.46	5.96	15.14

Murdock yield results (table 2)

Tons per acre were directly related to level of weed control. There was a tendency was for sugar content and purity to increase as weed control decreased. This tendency has been observed before and it is theorized that the competition for nutrients is increased by the increase in weed pressure resulting from less effective treatments. Weed competition may also result in smaller sized sugarbeets which generally are higher in quality than larger sized sugarbeets. Treatments with Nortron generally gave higher extractable sugar per acre.

Table 4A. SMBSC weed control program evaluation - Murdock Mn, Yield data
experiment # 0631

Herbicide	Rate oz/acre	Appl. Time	Tons Per Acre	Sugar Percent	Purity	PPM Nitrate	Extractable Per ton	Extractable Per acre	Revenue Per acre
No ppi/pre									
Progress+Upbeet+Stinger+MSO (4X)	5.7+0.125+1.3+1.5%:	*	17.44	14.13	88.68	42	229	4002	425.27
Total cost / Acre	**$58.46**								
No ppi/pre									
Progress+Upbeet+Stinger+SelectMt+MSO (4X)	5.7+0.125+1.3+4+1.5%:	*	27.96	14.35	90.75	33	241	6694	749.18
Total cost / Acre	**$70.34**								
No ppi/pre									
Progress+Upbeet+Stinger+SelectMt+MSO	8.5+0.125+1.3+4+1.5%:	cotyl	20.94	14.33	91.19	50	242	5058	572.11
Progress+Upbeet+Stinger+SelectMt+MSO	8.5+0.125+1.3+4+1.5%:	2 leaf							
Progress+Upbeet+Stinger+SelectMt+MSO	11.5+0.125+1.3+4+1.5%:	4 leaf							
Progress+Upbeet+Stinger+SelectMt+MSO	16+0.125+1.3+4+1.5%:	6 leaf							
Total cost / Acre	**$81.19**								
No ppi/pre									
Preogress+Stinger+MSo	8.5+1.3+1.5%:	cotyl	18.95	14.34	89.64	37	237	4489	496.12
Preogress+Stinger+MSo	8.5+1.3+1.5%:	2 leaf							
Preogress+Stinger+MSo	11.5+1.3+1.5%:	4 leaf							
Preogress+Stinger+MSo	16+1.3+1.5%:	6 leaf							
Total cost / Acre	**$48.44**								
No ppi/pre									
Preogress+Stinger+MSo	8.5+1.3+1.5%:	cotyl	27.26	14.48	90.95	33	243	6697	772.15
Preogress+Stinger+MSo	8.5+1.3+1.5%:	2 leaf							
Preogress+Stinger+MSo	11.5+1.3+1.5%:	4 leaf							
Progress+Stinger+SelectM +MSo	16+1.3+8+1.5%:	6 leaf							
Total cost / Acre	**$54.37**								
		CV%	17.36	4.96	1.16	44.14	6.16	18.57	22.7
		LSD	5.78	0.98	1.48	27.39	20.32	1450.7	193.58

Table 4B. SMBSC weed control program evaluation - Murdock Mn, Yield data
experiment # 0631

Herbicide	Rate oz/acre	Appl. Time	Tons Per Acre	Sugar Percent	Purity	PPM Nitrate	Extractable Per ton	Extractable Per acre	Revenue Per acre
No ppi/pre									
Progress(cot.)/Progress(2lf)/Progress(4lf)/Progress(4lf)	16/18/22/24	*	17.45	15.14	91	43	257	4500	546.25
Total cost / Acre	**$48.31**								
No ppi/pre									
Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf).	16+1.3/18+1.3/22+1.3/24+1.3	*	23.20	21.98	89	95	370	8445	1325.71
Total cost / Acre	**$57.88**								
No ppi/pre									
Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf).	16+1.5/18+1.5/22+1.5/24+1.5	*	20.20	13.76	90	40	227	4578	478.49
Total cost / Acre	**$60.63**								
No ppi/pre									
Progress+Stinger 4X (Cot)/(2lf)/(4lf)/(6lf).	16+2/18+2/22+2/24+2	*	28.48	13.81	90	29	228	6489	683.09
Total cost / Acre	**$67.50**								
		CV%	17.36	4.96	1.16	44.14	6.16	18.57	22.7
		LSD	5.78	0.98	1.48	27.39	20.32	1450.7	193.58

Table 4C. SMBSC weed control program evaluation - Murdock Mn, Yield data
experiment # 0631

Herbicide	Rate oz/acre	Appl. Time	Tons Per Acre	Sugar Percent	Purity	PPM Nitrate	Extractable Per ton	Extractable Per acre	Revenue Per acre
No ppi/pre									
Progress+Upbeet+Stinger+Nortron+MSO (4X)	5.7+0.125+1.3+4+1.5%:	*	28.08	14.31	90	23	238	6636	731.69
Total cost / Acre	**$67.21**								
No ppi/pre									
Progress+Upbeet+Nortron+MSO	8+0.125+4+1.5%:	cotyl	27.97	13.77	90	58	228	6368	669.64
Progress+Upbeet+Nortron+MSO	8+0.125+4+1.5%:	2 leaf							
Progress+Stinger+Nortron	16+1.3+4	4 leaf							
Progress+Stinger+Nortron	16+1.3+4	6 leaf							
Total cost / Acre	**$56.28**								
No ppi/pre									
Progress+Upbeet+Stinger+SelectM+MSO	8.5+.125+1.3+4+1.5%:	cotyl	27.23	13.79	90	48	227	6167	643.80
Progress+Upbeet+Stinger+SelectM+MSO	8.5+.125+1.3+4+1.5%:	2 leaf							
Progress	22	4 leaf							
Progress	24	6 leaf							
Total cost / Acre	**$60.97**								
No ppi/pre									
Progress	16	cotyl	24.48	13.63	89	41	223	5468	560.43
Progress	18	2 leaf							
Progress+Upbeet+Stinger+SelectM+MSO	11.5+.25+2.5+6+1.5%	4 leaf							
Progress+Upbeet+Stinger+SelectM+MSO	16+.25+2.5+6+1.5%	6 leaf							
Total cost / Acre	**$81.87**								
No ppi/pre									
Progress+Upbeet+Stinger+SelectM+MSO	18+.25+2.5+6+1.5%	cotyl	17.60	14.04	90	61	232	4104	444.92
Progress+Upbeet+Stinger+SelectM+MSO	24+.25+2.5+6+1.5%	2 leaf							
Progress+Upbeet+Stinger+SelectM+MSO	24+.25+2.5+6+1.5%	4 leaf							
Progress+Upbeet+Stinger+SelectM+MSO	24+.25+2.5+6+1.5%	6 leaf							
Total cost / Acre	**$147.25**								
		CV%	17.36	4.96	1.16	44.14	6.16	18.57	22.7
		LSD	5.78	0.98	1.48	27.39	20.32	1450.7	193.58

Table 4D. SMBSC weed control program evaluation - Murdock Mn, Yield data
experiment # 0631

Herbicide	Rate oz/acre	Appl. Time	Tons Per Acre	Sugar Percent	Purity	PPM Nitrate	Extractable Per ton	Extractable Per acre	Revenue Per acre
Notron	120	PPI	30.32	14.01	91	41	234	7068	765.97
Total cost / Acre	**$65.58**								
Nortron	120	Pre	24.30	14.09	90	45	233	5616	602.07
Total cost / Acre	**$65.58**								
Dual Mag.(PPI)Nortron(Pre)/Progress(2lf)/Progress(4lf)	32/120/16/20	*	18.53	14.25	91	36	238	4419	492.59
Total cost / Acre	**$102.33**								
EPTC (PPI)/Nortron(cotyl)Progress(2lf)/Progress(4lf)	46/120/16/20	*	26.48	13.88	90	42	228	6062	642.10
Total cost / Acre	**$93.64**								
Nortron	120	Pre	30.53	14.29	92	41	242	7406	841.80
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyl							
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	2 leaf							
Progress+Upbeet+Stinger+MSO	11.5+0.125+1.3+1.5%:	4 leaf							
Progress+Upbeet+Stinger+MSO	16+0.125+1.3+1.5%:	6 leaf							
Total cost / Acre	**$134.89**								
Nortron	120	Pre	25.56	14.04	91	45	234	6035	664.53
Progress+Stinger+MSO	8.5+1.3+1.5%:	cotyl							
Progress+Stinger+MSO	8.5+1.3+1.5%:	2 leaf							
Progress+Stinger+MSO	11.5+1.3+1.5%:	4 leaf							
Progress+Stinger+MSO	16+1.3+1.5%:	6 leaf							
Total cost / Acre	**$114.03**								
Nortron	120	Pre	24.53	13.89	90	54	229	5631	598.54
Progress+Stinger+MSO	8.5+1.3+1.5%:	cotyl							
Progress+Stinger+MSO	8.5+1.3+1.5%:	2 leaf							
Progress+Stinger+MSO	11.5+1.3+1.5%:	4 leaf							
Progress+Stinger+Select Max+MSO	16+1.3+1.5%:	6 leaf							
Total cost / Acre	**$119.95**								
		CV%	17.36	4.96	1.16	44.14	6.16	18.57	22.7
		LSD	5.78	0.98	1.48	27.39	20.32	1450.7	193.58

Table 4E. SMBSC weed control program evaluation - Murdock Mn, Yield data
experiment # 0631

Herbicide	Rate oz/acre	Appl. Time	Tons Per Acre	Sugar Percent	Purity	PPM Nitrate	Extractable Per ton	Extractable Per acre	Revenue Per acre
Dual Mag.(PPI)Nortron(Pre)/Progress(2lf)/Progress(4lf)	32/120/16/20	PPI	18.53	14.25	91	36	238	4419	492.59
Total cost / Acre	**$102.33**								
EPTC (PPI)/Nortron(cotyl)Progress(2lf)/Progress(4lf)	46/120/16/20	Pre	26.48	13.88	90	42	228	6062	642.10
Total cost / Acre	**$93.64**								
Nortron	120	Pre							
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	cotyl	30.53	14.29	92	41	242	7406	841.80
Progress+Upbeet+Stinger+MSO	8.5+0.125+1.3+1.5%:	2 leaf							
Progress+Upbeet+Stinger+MSO	11.5+0.125+1.3+1.5%:	4 leaf							
Progress+Upbeet+Stinger+MSO	16+0.125+1.3+1.5%:	6 leaf							
Total cost / Acre	**$134.89**								
No ppi/pre									
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	cotyl	22.07	14.11	90	39	233	5156	560.24
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	2 leaf							
Progress+Upbeet+Stinger+Select Max+MSO+Dual Mag	5.7+0.125+1.3+4+1.5%+27:	4 leaf							
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	6 leaf							
Total cost / Acre	**$86.16**								
No ppi/pre									
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	cotyl	24.51	14.19	90	33	236	5783	636.26
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	2 leaf							
Progress+Upbeet+Stinger+Select Max+MSO+Outlook	5.7+0.125+1.3+4+1.5%+21:	4 leaf							
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	6 leaf							
Total cost / Acre	**$90.84**								
Dual Mag.(ppi)/Progress(cotyl)/Progress(2lf)/Progress(4lf)	32/16/20/24		22.13	14.06	91	44	235	5199	568.98
Total cost / Acre	**$48.75**								
No ppi/pre									
Nortron(ppi)/Progress(2lf)/Progress(4lf)	120/16/20		25.09	14.05	90	33	232	5812	625.05
Total cost / Acre	**$83.58**								
Dual Mag.(ppi)/Progress(cotyl)/Progress92lf)/Progress+Outlook(4lf)	32/16/20/24+21		20.36	14.17	90	34	235	4781	522.95
Total cost / Acre	**$69.26**								
No ppi/pre									
Nortron(pre)/Progress(2lf)/Progress+Outlook(4lf)	120/20/24+21		24.38	14.69	90	75	243	5908	670.77
Total cost / Acre	**$108.09**								
Notron	120	PPI	30.32	14.01	91	41	234	7068	765.97
Total cost / Acre	**$65.58**								
Nortron	120	Pre	24.30	14.09	90	45	233	5616	602.07
Total cost / Acre	**$65.58**								
Progress	18	cotyl	16.64	13.46	89	58	220	3674	370.33
Total cost / Acre	**$9.00**								
		CV%	17.36	4.96	1.16	44.14	6.16	18.57	22.7
		LSD	5.78	0.98	1.48	27.39	20.32	1450.7	193.58

Summary

1. Control of lambsquarters was very good with all treatments.
2. The only treatment that was statistically lower than most treatments was Nortron applied preplant incorporated with no post application.
3. Yellow foxtail control was best achieved when Select Max was applied in all applications at low rates or in the last application with a full rate.
4. Control of yellow foxtail was significantly lower when no Select Max was applied or when Select Max was applied at low rates in the first one or two application of a four application weed control program.
5. Nortron gave better yellow foxtail control than Dual Magnum
6. Tons per acre were directly related to level of weed control.
7. The tendency was for sugar content and purity to increase as weed control decreased. This tendency has been observed before and it is theorized that the competition for nutrients is increased by the increase in weed pressure resulting from less effective treatments. Weed competition may also result in smaller sized sugarbeets which generally are higher in quality than larger sized sugarbeets.
8. Treatments with Nortron generally gave higher extractable sugar per acre.

Sugarbeet herbicides, Milan, 2006. (Dexter) 'Beta 4811' sugarbeet seed treated with 45 grams of Tachigaren per 100,000 seeds was seeded 1.25 inches deep in 22-inch rows April 24. Preemerge ethofumesate was applied April 24 after planting. Postemergence treatments were applied May 12, May 18, May 29 and June 5. All treatments were applied in 17 gpa water at 40 psi through 8002 nozzles to the center four rows of six-row by 30-foot long plots. Sugarbeet injury and tear-thumb (*Polygonum sagittatum*), common lambsquarters and waterhemp control were evaluated June 12 and June 27.

Date of Application	**April 24**	**May 12**	**May 18**	**May 29**	**June 5**
Time of Day	10:30 am	1:00 pm	12:30 pm	12:00 pm	10:00 am
Air Temperature (°F)	42	55	63	80	82
Relative Humidity (%)	30	32	26	34	39
Soil Temp. (°F at 6")	50	52	59	78	70
Wind Velocity (mph)	14	15	6	3	3
Cloud Cover (%)	100	60	100	0	50
Soil Moisture	Good	Good	Good	Good	Good
Sugarbeet	preemerge	V1.0	V1.0-1.5	V2.1-3.5	V5.2-6.2
Tear-thumb(Smartweed)	---	cot-1 leaf	cot-2 leaf	3-5lf(1-4")	3-6" tall
Common Lambsquarters	---	cotyledon	cot-2 leaf	4-6lf(2-4")	3-6" tall
Waterhemp	---	cotyledon	cotyledon	3-4 leaf	2-5" tall

Treatment* (Date of Application)	Rate	June 12 Sgbt inj	June 12 Teth cntl	June 12 Colq cntl	June 12 Wahe cntl	June 27 Sgbt inj	June 27 Teth cntl	June 27 Colq cntl	June 27 Wahe cntl
	lb/A	%	%	%	%	%	%	%	%
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 12, 18, 29, June 5)	0.08+0.004+0.03+0.023+1.5%	0	100	100	94	0	84	86	41
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 12, 18)	0.12+0.004+0.03+0.023+1.5%								
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 29)	0.16+0.004+0.03+0.023+1.5%								
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 5)	0.22+0.004+0.03+0.023+1.5%	3	100	100	98	0	81	96	65
De&Ph&Et+Tfsu+Clpy+CletM (May 12)	0.25+0.008+0.06+0.031								
De&Ph&Et+Tfsu+Clpy+CletM (May 18)	0.33+0.008+0.06+0.031								
De&Ph&Et+Tfsu+Clpy+CletM (May 29, June 5)	0.5+0.008+0.06+0.031	13	100	100	100	0	89	100	100
Desmedipham&Phenmedipham&Ethofumesate (May 12)	0.25								
Desmedipham&Phenmedipham&Ethofumesate (May 18)	0.33								
Desmed&Phenmed&Ethofume (May 29,June 5)	0.5	5	73	100	100	0	63	100	100
Desmedipham&Phenmedipham (May 12)	0.25								
Desmedipham&Phenmedipham (May 18)	0.33								
Desmedipham&Phenmedipham (May 29, June 5)	0.5	0	49	100	100	0	40	100	100
Desmedipham (May 12)	0.25								
Desmedipham (May 18)	0.33								
Desmedipham (May 29, June 5)	0.5	1	0	100	100	0	0	100	100
De&Ph&Et+Tfsu+Clpy+CletM+MSO+Etho(May 12,18,29,June 5)	0.08+0.004+0.03+0.023+1.5%+0.094	1	100	100	93	0	84	95	55
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 12, 18)	0.08+0.004+0.03+0.023+1.5%								
De&Ph&Et+Tfsu+Clpy+CletM (May 29, June 5)	0.5+0.008+0.06+0.031	4	100	100	100	0	89	100	98
Desmedipham&Phenmedipham&Ethofumesate (May 12)	0.25								
Desmedihpam&Phenmedipham&Ethofumesate (May 18)	0.33								
Desm&Phen&Etho+Dimethenamid (May 29)	0.5+1								
Desmedipham&Phenmedipham&Ethofumesate (June 5)	0.5	10	83	100	100	0	73	100	100

Table continued on next page.

Sugarbeet herbicides, Milan, 2006. (continued)

Treatment* (Date of Application)	Rate	June 12 Sgbt inj	June 12 Teth cntl	June 12 Colq cntl	June 12 Wahe cntl	June 27 Sgbt inj	June 27 Teth cntl	June 27 Colq cntl	June 27 Wahe cntl
	lb/A	%	%	%	%	%	%	%	%
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 12, 18, June 5)									
	0.08+0.004+0.03+0.023+1.5%								
De&Ph&Et+Tfsu+Clpy+CletM+MSO+Dime (May 29)									
	0.08+0.004+0.03+0.023+1.5%+1	11	100	100	95	0	90	86	53
De&Ph&Et+Tfsu+Clpy+CletM (May 12)									
	0.25+0.008+0.06+0.031+0.5								
De&Ph&Et+Tfsu+Clpy+CletM (May 18)									
	0.33+0.008+0.06+0.031+0.5								
De&Ph&Et+Tfsu+Clpy+CletM+Dime (May 29)									
	0.5+0.008+0.06+0.031+0.5+1								
De&Ph&Et+Tfsu+Clpy+CletM (June 5)									
	0.5+0.008+0.06+0.031+0.5	20	100	100	100	0	99	100	100
Ethofumesate-Ethotron (April 24)	3.75	0	63	60	93	0	56	24	91
Ethofumesate-Nortron (April 24)	3.75								
De&Ph&Et+Tfsu+Clpy+Clet+MSO (May 12, 18, 29, June 5)									
	0.08+0.004+0.03+0.023+1.5%	0	100	100	100	0	97	100	100
Ethofumesate-Nortron (April 24)	3.75								
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 12, 18, June 5)									
	0.08+0.004+0.03+0.023+1.5%								
De&Ph&Et+Tfsu+Clpy+CletM+MSO+Dime (May 29)									
	0.08+0.004+0.03+0.023+1.5%+1	5	100	100	100	0	99	100	100
Ethofumesate-Nortron (April 24)	3.75								
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 12, 18)									
	0.12+0.004+0.03+0.023+1.5%								
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 29)									
	0.16+0.004+0.03+0.023+1.5%								
De&Ph&Et+Tfsu+Clpy+CletM+MSO (June 5)									
	0.22+0.004+0.03+0.023+1.5%	4	100	100	100	0	99	100	100
Ethofumesate-Nortron (April 24)	3.75								
De&Ph&Et+Tfsu+Clpy+CletM (May 12)									
	0.25+0.008+0.06+0.031								
De&Ph&Et+Tfsu+Clpy+CletM (May 18)									
	0.33+0.008+0.06+0.031								
De&Ph&Et+Tfsu+Clpy+CletM (May 29, June 5)									
	0.5+0.008+0.06+0.031	9	100	100	100	0	99	100	100
De&Ph&Et+Tfsu+Clpy+CletM+MSO+Meta (May 12, 18)									
	0.08+0.004+0.03+0.023+1.5%+0.5								
De&Ph&Et+Tfsu+Clpy+CletM+MSO+Meta (May 29)									
	0.08+0.004+0.03+0.023+1.5%+1								
De&Ph&Et+Tfsu+Clpy+CletM+MSO+Meta (June 5)									
	0.08+0.004+0.03+0.023+1.5%+1.5	13	100	100	100	0	89	100	93
De&Ph&Et+Tfsu+Clpy+CletM+MSO+Etho-Ethotron (May 12)									
	0.08+0.004+0.03+0.023+1.5%+3.75								
De&Ph&Et+Tfsu+Clpy+CletM+MSO (May 18, 29, June 5)									
	0.08+0.004+0.03+0.023+1.5%	1	100	100	100	0	93	100	88
EXP MEAN		5	87	98	98	0	79	94	88
C.V. %		64	7	5	2	0	7	5	9
LSD 5%		5	9	7	3	0	8	6	12
LSD 1%		7	12	9	3	0	11	9	16
# OF REPS		4	4	4	4	4	4	4	4

* MSO=methylated seed oil from Loveland; CletM=Select Max formulation of clethodim from Valent; Meta=metamitron (Goltix).

Experiment summary on next page.

Summary

Tear-thumb is a smartweed that looks similar to ladysthumb but tear-thumb has sharp spines on the stem while ladysthumb has no spines. Weed control evaluations often were lower on June 27 than on June 12 so the June 27 evaluations will be discussed. PRE ethofumesate followed by POST herbicide treatments gave 97 to 99% control of tear-thumb while the micro-rate alone gave 84% control and the conventional-rate gave 89% control. POST desmedipham & phenmedipham & ethofumesate gave 63% control of tear-thumb while POST desmedipham & phenmedipham gave 49% control and POST desmedipham gave 0% control. The micro-rate gave only 86% control of common lambsquarters and 41% control of waterhemp while PRE ethofumesate followed by the micro-rate gave 100% control of both species. All conventional rate treatments gave 100% control of common lambsquarters and waterhemp. Adding dimethenamid as a lay-by treatment to the micro-rate or conventional rate caused increased sugarbeet injury.

SMBSC Roundup Ready Weed Control, 2006

Weed control in sugarbeets is in an era of potential change. As the Sugarbeet Industry has become open to the production, processing and sale of GMO sugar, the doors have opened for potential production of Roundup Ready varieties. This will dramatically change weed control as we know it today in sugarbeets. Testing was conducted in 2006 to investigate the efficacy of Roundup alone and in combination with conventional herbicides. Sugarbeet yield and quality was evaluated as influenced by Roundup alone and in combination with conventional herbicides.

Methods

Weed control trials were established at two locations; Murdock and Hector. Treatments were applied to the middle four rows of six row, 35 foot long plots which were replicated four times. Herbicide treatments at Murdock and Hector were evaluated for weed control efficacy. Both locations were harvested in order to evaluate herbicide treatment effect on yield. Herbicide treatments were applied at 12.5 gal/acre and 40 psi. Intervals between treatments were approximately 7 days with the first treatment conducted at the cotyledon stage of sugarbeets and weeds.

Results

Note: Roundup plus ammonium sulfate is the standard for this experiment and thus all comparisons are to Roundup plus ammonium sulfate.

Hector yield (table 1)

All treatments were significantly greater than the untreated check when considering sugarbeet production. The addition of Upbeet and Gem to Roundup increased extractable sugar per acre. Select Max added to Roundup and conventional herbicides applied in the micro-rate tended to increase sugar production. Soil applied herbicides such as Nortron, Dual Magnum and Outlook all tended to decrease sugarbeet production.

Hector efficacy results (table 2)

Smartweed control and sugarbeet injury were evaluated at the Hector Roundup weed control site. Smartweed control was excellent when Roundup was in the spray mix. Conventional treatments with the micro-rate gave significantly less smartweed control compared to Roundup treatments. Nortron applied preplant incorporated, followed by the microrate in the first two postemergence applications and Progress plus Select max in the third postemergence application, gave significantly higher smartweed control but lower extractable sugar per acre compared to the standard micro rate applied four times. Betanex, Betamix and Progress added to Roundup significantly increased sugarbeet injury. The sugarbeet injury resulted in lower sugar production.

Summary of results

1. All treatments were significantly greater than the untreated check when considering sugarbeet production.
2. The addition of Upbeet or Gem to Roundup increased extractable sugar per acre.
3. Soil applied herbicides such as Nortron, Dual Magnum and Outlook all tended to decrease sugarbeet production.
4. Smartweed control was excellent when Roundup was in the spray mix.
5. Conventional treatments with the micro-rate gave significantly less smartweed control than Roundup treatments.

6. Nortron applied preplant incorporated followed by micro-rates in the first two postemergence applications and Progress plus Select max in the third postemergence application gave significantly higher smartweed control but lower extractable sugar per acre compared to the standard micro rate applied four times.
7. Betanex, Betamix and Progress added to Roundup significantly increased sugarbeet injury. The sugarbeet injury resulted in lower sugar production.

Results

Note: Roundup plus ammonium sulfate is the standard of this experiment and thus all comparisons are to Roundup plus ammonium sulfate.

Murdock yield (table 3)

All treatments with Roundup, except for treatments where Dual Magnum or Nortron was applied preplant incorporated, tended to give higher sugar per acre than Roundup alone. Dual Magnum followed by Roundup reduced the stand count (data not presented) which resulted in a reduction in tons per acre. The stand count was not reduced to a replant level, but was reduced enough to lower the tons per acre. The treatment with Nortron applied preplant and Roundup applied once postemergence gave lower weed control with resulted in a reduction in tonnage per acre. All treatments gave significantly higher tons per acre and sugar per acre than the untreated check.

Murdock efficacy results (table 4)

Sugarbeet injury was not visible in the treatments tested. All treatments with Roundup in the spray mixture gave excellent weed control except when Roundup was applied only once after Nortron had been applied preplant incorporated. The results achieved in this treatment were similar to that normally achieved with Nortron alone. One should realize that in this treatment the Roundup was applied without ammonium sulfate and was applied later in the season which reduced the weed control and therefore also reduced the tons per acre.

Summary of results

1. All treatments with Roundup, except for treatment where Dual Magnum or Nortron was applied preplant incorporated, tended to give higher sugar per acre than Roundup alone.
2. Dual Magnum followed by Roundup reduced the stand count (data not presented) which resulted in a reduction in tons per acre. The stand count was not reduced to a replant level, but was reduced enough to lower the tons per acre.
3. Nortron applied preplant followed by Roundup applied once postemergence gave lower weed control than other treatments and resulted in a reduction in tons per acre. All treatments gave significantly higher tonnage per acre and extractable sugar per acre than the untreated check.
4. Sugarbeet injury was not visible in the treatments tested.
5. All treatments with Roundup in the spray mixture gave excellent weed control except when Roundup was applied only once following Nortron applied preplant incorporated.
6. It is important to include ammonium sulfate with Roundup even when applying a preplant incorporated product and trying to control tough to kill weeds (such as big weeds).

Calculated Revenue

Table 5 shows each treatment with calculated revenue. The revenue is based on tons of sugarbeets multiplied by the price per ton minus the cost of herbicides. The cost of herbicides includes the product used plus the projected technology fee for Roundup ready technology. No weeding cost was calculated since all herbicide programs are considered an aggressive program to eliminate weeds so no weeding would be needed. In this comparison the treatment with Roundup alone compared to the conventional micro-rate treatment was similar in revenue. If Upbeet, Gem, or Select max were added to the spray mix the revenue was increase substantially. One needs to realize that this is the same variety being considered and there may be differences in varieties of conventional and Roundup ready.

Table 1. Round-up ready and conventional weed control evaluation - Hector Mn - Yield data

experiment # 0635

Application	Herbicide	Rate	Tons /acre	Sugar (%)	Purity	Exractable Sucrose. Percent	Per ton	Per acre
1								
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	20.40	15.65	91.99	13.41	268	5472
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
2								
2 leaf	Round-Up+Ammonium Sulfate+Betamix	17.5+2%+48:	17.76	15.17	91.29	12.85	257	4575
6 leaf	Round-Up+Ammonium Sulfate+Betamix	17.5+2%+48:						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
3								
2 leaf	Round-up+Ammonium Sulfate+Betanex	17.5+2%+48:						
6 leaf	Round-up+Ammonium Sulfate+Betanex	17.5+2%+48:	18.70	14.85	90.23	12.38	248	4652
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
4								
2 leaf	Round-up+Ammonium Sulfate+Progress	17.5+2%+36	16.53	15.69	91.11	13.28	266	4387
6 leaf	Round-up+Ammonium Sulfate+Progress	17.5+2%+56						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
5								
2 leaf	Round-up+Ammonium Sulfate+Upbeet	17.5+2%+.25	23.88	15.62	92.10	13.41	268	6420
6 leaf	Round-up+Ammonium Sulfate+Upbeet	17.5+2%+.25						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
6								
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	24.62	15.27	91.32	12.95	259	6369
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:						
Canopy closure	Round-up+ Ammonium Sulfate+ Gem	17.5+.2%+7:						
7								
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	18.76	15.51	91.45	13.19	264	4930
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:						
Canopy closure	Round-up+ Ammonium Sulfate+ Dual Mag.	17.5+.2%+27:						
8								
2 leaf	Round-up+Ammonium Sulfate+Stinger	17.5+.2%+2:	21.64	15.00	91.46	12.73	255	5510
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
9								
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	20.03	15.44	91.42	13.12	262	5266
6 leaf	Round-up+Ammonium Sulfate+Outlook	17.5+.2%+21:						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
10								
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	22.20	15.69	92.06	13.46	269	5972
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%+:						
Canopy closure	Round-up+ Ammonium Sulfate+Select max	17.5+.2%+6:						
11								
Cotyledon	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:	21.25	15.59	91.82	13.33	267	5662
2 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:						
4 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:						
6 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:						
12								
PrePlant	Nortron	112	19.35	15.20	91.80	13.12	259	5011
2 leaf	Progress+Upbeet+Stinger+Select max+MSO	8.5+.125+1.3+4+1+1.5%:						
4 leaf	Progress+Upbeet+Stinger+Select max+MSO	11.5+.125+1.3+4+1+1.5%:						
8 leaf	Progress+Select max	32+6:						
13								
Check			12.96	15.44	91.70	13.87	263	3408
		C.V.%	12.37	3.26	0.66	3.92	4.03	13.24
		LSD (0.05)	3.52	0.72	0.86	0.74	15	988

Table 2. Round-up ready and conventional weed control evaluation - Hector Mn -Efficacy data

experiment # 0635

Application	Herbicide	Rate	Smart weed % control	S. Beet % injury
1				
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	98	0
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:		
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:		
2				
2 leaf	Round-Up+Ammonium Sulfate+Betamix	17.5+2%+48:	98	13
6 leaf	Round-Up+Ammonium Sulfate+Betamix	17.5+2%+48:		
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:		
3				
2 leaf	Round-up+Ammonium Sulfate+Betanex	17.5+2%+48:	97	21
6 leaf	Round-up+Ammonium Sulfate+Betanex	17.5+2%+48:		
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:		
4				
2 leaf	Round-up+Ammonium Sulfate+Progress	17.5+2%+36	96	35
6 leaf	Round-up+Ammonium Sulfate+Progress	17.5+2%+56		
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:		
5				
2 leaf	Round-up+Ammonium Sulfate+Upbeet	17.5+2%+.25	96	0
6 leaf	Round-up+Ammonium Sulfate+Upbeet	17.5+2%+.25		
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:		
6				
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	98	0
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:		
Canopy closure	Round-up+ Ammonium Sulfate+ Gem	17.5+.2%+7:		
7				
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	98	8
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:		
Canopy closure	Round-up+ Ammonium Sulfate+ Dual Mag.	17.5+.2%+27:		
8				
2 leaf	Round-up+Ammonium Sulfate+Stinger	17.5+.2%+2:	98	1
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:		
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:		
9				
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	97	3
6 leaf	Round-up+Ammonium Sulfate+Outlook	17.5+.2%+21:		
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:		
10				
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	97	0
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%+:		
Canopy closure	Round-up+ Ammonium Sulfate+Select max	17.5+.2%+6:		
11				
Cotyledon	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:	59	6
2 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:		
4 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:		
6 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:		
12				
PrePlant	Nortron	112	79	4
2 leaf	Progress+Upbeet+Stinger+Select max+MSO	8.5+.125+1.3+4+1+1.5%:		
4 leaf	Progress+Upbeet+Stinger+Select max+MSO	11.5+.125+1.3+4+1+1.5%:		
8 leaf	Progress+Select max	32+6:		
13				
Check			0	0
		C.V.%	3.25	57.43
		LSD (0.05)	4	6

Table 3. Round-up ready and conventional weed control evaluation - Murdock, Mn- Yield data
Experiment # 0634

			Tons	Sugar		Extractable. Sucrose		
Application	**Herbicide**	**Rate (oz/acre)**	**/acre**	**(%)**	**Purity**	**Percent**	**per ton**	**per acre**
1								
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:						
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	30.29	15.18	90.33	12.68	254	7687
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
2								
2 leaf	Round-Up+Ammonium Sulfate+Betamix	17.5+2%+48:	33.71	15.26	89.82	12.66	253	8527
6 leaf	Round-Up+Ammonium Sulfate+Betamix	17.5+2%+48:						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
3								
2 leaf	Round-up+Ammonium Sulfate+Betanex	17.5+2%+48:	29.39	15.78	90.62	13.27	265	7803
6 leaf	Round-up+Ammonium Sulfate+Betanex	17.5+2%+48:						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
4								
2 leaf	Round-up+Ammonium Sulfate+Progress	17.5+2%+36	32.80	15.50	90.85	13.07	261	8569
6 leaf	Round-up+Ammonium Sulfate+Progress	17.5+2%+56						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
5								
2 leaf	Round-up+Ammonium Sulfate+Upbeet	17.5+2%+.25	32.15	15.59	90.93	13.16	263	8448
6 leaf	Round-up+Ammonium Sulfate+Upbeet	17.5+2%+.25						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
6								
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	30.82	15.45	90.75	13.00	260	8000
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:						
Canopy closure	Round-up+ Ammonium Sulfate+ Gem	17.5+.2%+7:						
7								
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	25.16	15.60	90.93	13.17	263	6629
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:						
Canopy closure	Round-up+ Ammonium Sulfate+ Dual Mag.	17.5+.2%+27:						
8								
2 leaf	Round-up+Ammonium Sulfate+Stinger	17.5+.2%+2:	31.89	15.80	90.78	13.32	266	8489
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
9								
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	31.92	15.88	90.62	13.36	267	8541
6 leaf	Round-up+Ammonium Sulfate+Outlook	17.5+.2%+21:						
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:						
10								
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	30.61	15.80	90.71	13.31	266	8119
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%+:						
Canopy closure	Round-up+ Ammonium Sulfate+Select max	17.5+.2%+6:						
11								
Cotyledon	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:	27.65	15.57	90.95	13.15	263	7265
2 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:						
4 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:						
6 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:						
12								
PrePlant	Nortron	112	29.94	15.81	90.82	13.34	267	7966
2 leaf	Progress+Upbeet+Stinger+Select max+MSO	8.5+.125+1.3+4+1+1.5%:						
4 leaf	Progress+Upbeet+Stinger+Select max+MSO	11.5+.125+1.3+4+1+1.5%:						
8 leaf	Progress+Select max	32+6:						
13								
Check			18.68	15.89	91.07	13.46	269	5023
14								
Preplant	Nortron	112	26.77	16.44	92.24	14.18	284	7565
8 leaf	Round-up+Ammonium Sulfate	17.5+.2%:						
		C.V. %	11.57	2.52	0.71	3.30	3	11
		LSD (0.05)	4.86	0.57	0.92	0.62	13	1223

Table 4. Round-up ready and conventional weed control evaluation - Murdock, Mn -Efficacy data

Experiment # 0634

Application	Herbicide	Rate	S. Beet % injury	Lambs quarters % control	Yellow foxtail % control
1					
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	0	99	99
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:			
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:			
2					
2 leaf	Round-Up+Ammonium Sulfate+Betamix	17.5+2%+48:	0	99	99
6 leaf	Round-Up+Ammonium Sulfate+Betamix	17.5+2%+48:			
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:			
3					
2 leaf	Round-up+Ammonium Sulfate+Betanex	17.5+2%+48:	0	99	99
6 leaf	Round-up+Ammonium Sulfate+Betanex	17.5+2%+48:			
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:			
4					
2 leaf	Round-up+Ammonium Sulfate+Progress	17.5+2%+36	0	99	99
6 leaf	Round-up+Ammonium Sulfate+Progress	17.5+2%+56			
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:			
5					
2 leaf	Round-up+Ammonium Sulfate+Upbeet	17.5+2%+.25	0	99	99
6 leaf	Round-up+Ammonium Sulfate+Upbeet	17.5+2%+.25			
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:			
6					
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	0	99	99
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:			
Canopy closure	Round-up+ Ammonium Sulfate+ Gem	17.5+.2%+7:			
7					
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	0	99	99
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:			
Canopy closure	Round-up+ Ammonium Sulfate+ Dual Mag.	17.5+.2%+27:			
8					
2 leaf	Round-up+Ammonium Sulfate+Stinger	17.5+.2%+2:	0	99	99
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:			
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:			
9					
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	0	99	99
6 leaf	Round-up+Ammonium Sulfate+Outlook	17.5+.2%+21:			
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:			
10					
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	0	99	99
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%+:			
Canopy closure	Round-up+ Ammonium Sulfate+Select max	17.5+.2%+6:			
11					
Cotyledon	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:	0	96	96
2 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:			
4 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:			
6 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:			
12					
PrePlant	Nortron	112	0	90	79
2 leaf	Progress+Upbeet+Stinger+Select max+MSO	8.5+.125+1.3+4+1+1.5%:			
4 leaf	Progress+Upbeet+Stinger+Select max+MSO	11.5+.125+1.3+4+1+1.5%:			
8 leaf	Progress+Select max	32+6:			
13					
Check			0	0	0
14					
Preplant	Nortron	112	0	71	58
8 leaf	Round-up+Ammonium Sulfate	17.5+.2%:			
		C.V. %		6	7
		LSD (0.05)	0	8	9

Table 5. Round-up ready and conventional weed control - Calculated revenue

Trt	Herbicide	Rate (oz/acre)	Revenue per acre
1			
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	739.77
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:	
2			
2 leaf	Round-Up+Ammonium Sulfate+Betamix	17.5+2%+48:	667.60
6 leaf	Round-Up+Ammonium Sulfate+Betamix	17.5+2%+48:	
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:	
3			
2 leaf	Round-up+Ammonium Sulfate+Betanex	17.5+2%+48:	623.93
6 leaf	Round-up+Ammonium Sulfate+Betanex	17.5+2%+48:	
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:	
4			
2 leaf	Round-up+Ammonium Sulfate+Progress	17.5+2%+36	685.02
6 leaf	Round-up+Ammonium Sulfate+Progress	17.5+2%+56	
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:	
5			
2 leaf	Round-up+Ammonium Sulfate+Upbeet	17.5+2%+.25	841.12
6 leaf	Round-up+Ammonium Sulfate+Upbeet	17.5+2%+.25	
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:	
6			
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	791.14
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	
Canopy closure	Round-up+ Ammonium Sulfate+ Gem	17.5+.2%+7:	
7			
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	629.65
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	
Canopy closure	Round-up+ Ammonium Sulfate+ Dual Mag.	17.5+.2%+27:	
8			
2 leaf	Round-up+Ammonium Sulfate+Stinger	17.5+.2%+2:	775.05
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:	
9			
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	763.30
6 leaf	Round-up+Ammonium Sulfate+Outlook	17.5+.2%+21:	
Canopy closure	Round-up+Ammonium Sulfate	17.5+.2%:	
10			
2 leaf	Round-up+Ammonium Sulfate	17.5+.2%:	812.51
6 leaf	Round-up+Ammonium Sulfate	17.5+.2%+:	
Canopy closure	Round-up+ Ammonium Sulfate+Select max	17.5+.2%+6:	
11			
Cotyledon	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:	735.54
2 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:	
4 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:	
6 leaf	Progress+Upbeet+Stinger+Select max+MSO	5.7+.125+1.3+4+1+1.5%:	
12			
PrePlant	Nortron	120	675.71
2 leaf	Progress+Upbeet+Stinger+Select max+MSO	8.5+.125+1.3+4+1+1.5%:	
4 leaf	Progress+Upbeet+Stinger+Select max+MSO	11.5+.125+1.3+4+1+1.5%:	
8 leaf	Progress+Select max	32+6:	
13			
Check			554.61

SMBSC 2006 Agrilliance Adjuvant Study

The effectiveness of the Micro-rate is dependent on the use of adjuvant to enhance the activity of the herbicides used. For many years adjuvants were not allowed to be used with Betanex, Betamix and Progress due to the potential injury to the sugar beets. With the introduction of the micro-rate mixtures, adjuvant was approved for use with these herbicides. Which adjuvant will give the best performance for the micro-rate has been a subject of debate since the introduction of the micro-rates. The research discussed here evaluates some new adjuvant to be used in the micro-rates.

Methods

Weed control trials were established at Hector, Mn. Treatments were applied to the middle four rows of six row, 35 foot long plots which were replicated four times. Herbicide treatments at Hector were evaluated for weed control efficacy. Sugarbeets were harvested in order to evaluate each herbicide treatment effect on yield. Herbicide treatments were applied at 12.5 gal/acre and 40 psi. Intervals between treatments were approximately 7 days with the first treatment applied at the cotyledon stage of sugarbeets and weed growth. Adjuvants evaluated in the testing were Destiny (MSO), AG5006 and AG5055. Herbicide treatments were separated into two categories. One category was the standard micro-rate and the other category was the mid-rate micro-rate.

Results

(Efficacy)

Weed control was influenced by the Adjuvant but not the rate of the adjuvant. Adjuvant AG5006 at 1.5% and AG5055 at 2.5% influenced herbicide treatment to give significantly greater smartweed control with both the standard and the mid-rate micro-rate. All adjuvant with the standard and mid-rate micro-rate gave similar control of Amaranth species (redroot pigweed. Water hemp, Palmer amaranth) except for MSO and the mid-rate micro-rate. Sugar beet injury was not influenced by the adjuvant except with standard micro-rate plus AG5055. The increase in injury observed with the addition of AG5055 to the standard micro-rate was not observed with the mid-rate micro-rate. The lack of increase in sugarbeet injury with the mid-rate micro-rate indicates that the sugarbeet injury observed with AG5055 may have been an anomaly and not the norm.

(Yield)

Tons per acre were significantly less for treatments with MSO for both the standard and mid-rate micro-rate and AG5055 with the standard micro-rate. The lower tons per acre with MSO and AG5055 with the standard micro-rate were the result of general lower weed control. The lower tons per acre with AG5055 with the micro-rate were the result of increased injury with that treatment. All other treatments gave similar sugarbeet production.

Summary

1. Weed control was influenced by the Adjuvant but not by the rate of the adjuvant.
2. Adjuvant AG5006 at 1.5% and AG5055 at 2.5% influenced herbicide treatments to give significantly greater smartweed control with both the standard and the mid-rate micro-rate compared to micro-rate with MSO.
3. All adjuvant with the standard and mid-rate micro-rate gave similar control of Amaranth species (redroot pigweed. Water hemp and Palmer amaranth) except with MSO and the mid-rate micro-rate.
4. The increase in injury observed with the addition of AG5055 to the standard micro-rate was not observed with the mid-rate micro-rate.
5. Tons per acre were significantly less for treatments with MSO for both the standard and mid-rate micro-rate and AG5055 with standard micro-rate.
6. The lower tons per acre with MSO and AG5055 with the standard micro-rate were the result of lower weed control.

7. The lower tons per acre with AG5055 with the micro-rate were the result of increased injury with that treatment.
8. All other treatments gave similar sugar beet production.

Table 1. SMBC 2006 Agrilliance adjuvant study

Herbicide	Rate oz/acre	Smart Weed	Venice Mallow	Amaranth Species	S. Beet injury
		(percent control)			% injury
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	70	78	91	7
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+.75%:	79	78	98	3
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+.75%:				
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+.75%:				
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+.75%:				
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.0%:	80	82	94	7
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.0%:				
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.0%:				
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.0%:				
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.5%:	83	83	98	7
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+AG5055	5.7+0.125+1.3+4+2.5%:	91	85	99	24
Progress+Upbeet+Stinger+Select Max+AG5055	5.7+0.125+1.3+4+2.5%:				
Progress+Upbeet+Stinger+Select Max+AG5055	5.7+0.125+1.3+4+2.5%:				
Progress+Upbeet+Stinger+Select Max+AG5055	5.7+0.125+1.3+4+2.5%:				
Progress+Upbeet+Stinger+Select Max+MSO	8.5+0.125+1.3+4+1.5%:	62	72	77	3
Progress+Upbeet+Stinger+Select Max+MSO	8.5+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+MSO	11.5+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+MSO	16+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+AG5006	8.5+0.125+1.3+4+1%:	85	92	99	3
Progress+Upbeet+Stinger+Select Max+AG5006	8.5+0.125+1.3+4+1%:				
Progress+Upbeet+Stinger+Select Max+AG5006	11.5+0.125+1.3+4+1%:				
Progress+Upbeet+Stinger+Select Max+AG5006	16+0.125+1.3+4+1%:				
Progress+Upbeet+Stinger+Select Max+AG5006	8.5+0.125+1.3+4+1.5%:	82	87	99	8
Progress+Upbeet+Stinger+Select Max+AG5006	8.5+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+AG5006	11.5+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+AG5006	16+0.125+1.3+4+1.5%:				
Progress+Upbeet+Stinger+Select Max+AG5055	8.5+0.125+1.3+4+2.5%:	82	85	96	7
Progress+Upbeet+Stinger+Select Max+AG5055	8.5+0.125+1.3+4+2.5%:				
Progress+Upbeet+Stinger+Select Max+AG5055	11.5+0.125+1.3+4+2.5%:				
Progress+Upbeet+Stinger+Select Max+AG5055	16+0.125+1.3+4+2.5%:				
	C.V. %	11.49	11.26	7.72	32.17
	LSD(0.05)	13	14	11	6

Table 2. SMBC 2006 Agrilliance adjuvant study

Herbicide	Rate oz/acre	Tons per acre	Sugar percent	Purity	Extractable Sugar per ton	Extractable Sugar per acre	Revenue per acre
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:	16.41	13.72	91.26	231	3784	405.37
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+MSO	5.7+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+.75%:	17.15	13.75	89.78	226	4180	404.90
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+.75%:						
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+.75%:						
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+.75%:						
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.0%:	21.10	13.49	89.72	222	4656	474.72
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.0%:						
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.0%:						
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.0%:						
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.5%:	22.74	13.24	89.28	216	4900	479.09
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+AG5006	5.7+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+AG5055	5.7+0.125+1.3+4+2.5%:	16.67	14.49	91.52	246	4074	471.67
Progress+Upbeet+Stinger+Select Max+AG5055	5.7+0.125+1.3+4+2.5%:						
Progress+Upbeet+Stinger+Select Max+AG5055	5.7+0.125+1.3+4+2.5%:						
Progress+Upbeet+Stinger+Select Max+AG5055	5.7+0.125+1.3+4+2.5%:						
Progress+Upbeet+Stinger+Select Max+MSO	8.5+0.125+1.3+4+1.5%:	20.43	13.79	90.37	229	4664	497.10
Progress+Upbeet+Stinger+Select Max+MSO	8.5+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+MSO	11.5+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+MSO	16+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+AG5006	8.5+0.125+1.3+4+1%:	20.61	13.66	90.36	227	4672	489.18
Progress+Upbeet+Stinger+Select Max+AG5006	8.5+0.125+1.3+4+1%:						
Progress+Upbeet+Stinger+Select Max+AG5006	11.5+0.125+1.3+4+1%:						
Progress+Upbeet+Stinger+Select Max+AG5006	16+0.125+1.3+4+1%:						
Progress+Upbeet+Stinger+Select Max+AG5006	8.5+0.125+1.3+4+1.5%:	20.75	14.41	90.17	239	4934	556.00
Progress+Upbeet+Stinger+Select Max+AG5006	8.5+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+AG5006	11.5+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+AG5006	16+0.125+1.3+4+1.5%:						
Progress+Upbeet+Stinger+Select Max+AG5055	8.5+0.125+1.3+4+2.5%:	19.00	14.15	90.92	237	4519	499.84
Progress+Upbeet+Stinger+Select Max+AG5055	8.5+0.125+1.3+4+2.5%:						
Progress+Upbeet+Stinger+Select Max+AG5055	11.5+0.125+1.3+4+2.5%:						
Progress+Upbeet+Stinger+Select Max+AG5055	16+0.125+1.3+4+2.5%:						
	C.V. %	9.98	5.04	1.59	6.24	10.34	14.63
	LSD(0.05)	2.96	1.02	1.99	21	703	87.65

ETIOLOGY OF RHIZOMANIA IN FIELDS PLANTED TO RESISTANT CULTIVARS

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The incidence of rhizomania in fields planted to resistant cultivars in Minnesota and North Dakota has steadily increased during the last 2 - 3 years. In 2006, we continued to investigate factors that were involved, or not involved, with development of rhizomania. Numerous ideas as to the cause of rhizomania in resistant cultivars have been put forth and the most commonly suggested include 1) problems with seed quality during production of hybrid seed, 2) soil physical or chemical factors, 3) inoculum density of the pathogen, and 4) emergence of new resistance-breaking strains of BNYVV. Research on all four of these was conduced and some were eliminated as factors involved with break down of resistance.

METHODS

Seed Purity. Studies were conducted to determine whether rhizomania in fields planted to resistant cultivars could be associated with seed purity issues. Our two basic questions were whether the plants exhibiting severe rhizomania symptoms possessed the *Rz1* resistance gene, and secondly, whether the observed distribution of rhizomania in the field was consistent with what one would expect if a portion of the seed did not have the *Rz1* resistance gene.

Blinker Rz1 Study. Plants for this study were collected from individual grower's fields located near Crookston, Moorhead, and Renville, MN. Plants exhibiting the typical fluorescent yellow foliage that is associated with rhizomania, and asymptomatic plants, were collected from each field. Multiple locations in each field were sampled, and 10 to 20 beets were collected from each location. The sampled plants were individually rated for rhizomania severity on 0 – 4 scale with 0 = no symptoms and 4 = extremely severe root stunting, constriction, and bearding. Foliage from each plant was collected and scanned using a hyperspectral radiometer to quantify the degree of leaf chlorosis, and root and rhizosphere soil was collected so *Beet necrotic yellow vein virus* (BNYVV) could be baited from individual plants if deemed necessary. After roots were rated and rhizosphere soil collected, symptomatic and asymptomatic plants were separated and those in each group were bulked for sucrose determination. Subsamples of root tissue from each plant were tested for BNYVV by the enzyme-linked immunosorbent assay (ELISA) test and leaf tissue was sent to the various cooperating seed companies to test for the presence of the *Rz* gene. Collected data was subjected to a variety of statistical tests to determine whether the *Rz1* gene was actually present in severely diseased plants, and, if it was present, whether it had a significant effect on disease severity and percent sucrose. Over 500 individual beets were included in this study.

Spatial Analysis Study. Four fields were selected to test whether the incidence and distribution of rhizomania in fields planted to resistant varieties was random, and possibly a result of planting a percentage of seed that did not possess the *Rz* gene. Within each field, four areas were sampled. Each sampling area was fifty feet x 20 rows. The number of symptomatic plants and the total number of plants in each sampling area was determined. Approximately 15 symptomatic plants and 15 asymptomatic sugar beets were collected to determine root yield and sugar differences between healthy and diseased plants, within the sampled area. The sugar beets were rated for rhizomania severity on a scale from 0-4, and the diseased and healthy plants were bulked separately at each location. This gave a total of four paired samples for each field. Each sample was processed for sucrose content and yield. BNYVV was assayed by ELISA on feeder root tissue of the taproot.

A white tarp measuring approximately 3ft by 10ft was placed at each sample location so that it could be identified in aerial photography (Fig. 1A). Immediately after the fields were sampled on the ground, digital images were acquired at an altitude of approximately 1700 ft mean sea level (800 ft above ground) using fixed wing aircraft. The images were acquired with an Olympus 765 UZ digital camera. The nominal field of view of the camera was 43° by 38°. This resulted in an area of about 8 acres with 1.05 ft resolution. Images were processed using ENVI version 4.3 (RSI, Boulder, CO) (Fig. 1B). The actual sampling area was selected in each field image resulting in four images per field. Within each image, pixels were classified using unsupervised classification with three classes. The classes represent healthy beets, diseased beets and background (soil). An area and percent of each class was calculated for each image. Statistical analysis was done on each classified image to determine the spatial distribution of diseased plants in the sampled area.

A B

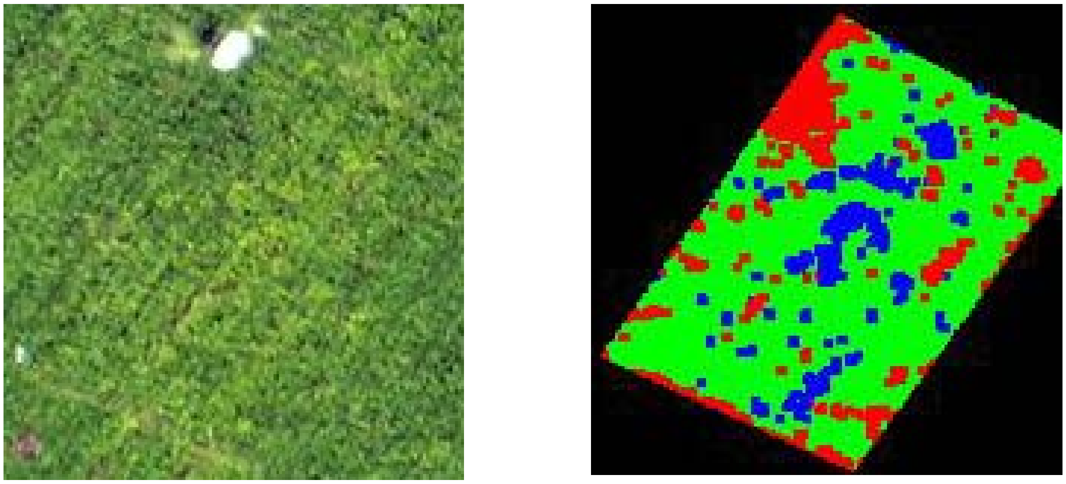

Figure 1. Aerial image of sugar beet sampling area. Image on left is original image and image on right is classification where light areas = healthy beets, and dark areas = blinkers. The blinkers developed in an aggregated pattern.

Soil Characteristics. Fields with discrete patches of diseased sugar beets were selected for this study. At each sampling location in each field, four soil samples were taken inside and four outside of the disease patch. Each individual sample was a composite of four, 1” diameter cores taken to a depth of 1’. Soil cores were dried, ground, and sent to Servi-Tech Laboratories for a complete chemical and physical analysis. Paired t-test analysis was conducted to determine if any of the measured variables from samples taken inside and outside of disease patches were significantly different.

Soil Inoculum Density. Currently, the only way to quantify inoculum density of BNYVV in the soil is to conduct the most probably number assay, which is a very time consuming and inaccurate procedure. For this reason, we attempted to develop a molecular technique that would detect and quantify BNYVV directly from the soil. A soil dilution series with varying amounts of BNYVV-infested rhizosphere soil was made and used in these studies. Rhizosphere soil is essentially the same as tare soil, i.e., that which remains attached to the collected sugar beet roots. The rhizosphere soil we used came from severely infected sugar beets that possessed extremely “hairy” roots and therefore, it contained a very high proportion of decayed infected root material and sporosori of *Polymyxa betae*, the soil fungus that vectors BNYVV. Initially, only the undiluted rhizosphere soil was used. Rhizosphere soil was pulverized using a bead beater and total RNA was extracted using an RNA extraction kit and following manufacturer’s instructions. The total RNA was then used in a real time quantitative PCR assay to test for the presence and quantity of viral RNA using primers and probes specific for BNYVV RNA2.

Emergence of New Resistance-Breaking Strains of BNYVV. This study was a continuation from 2005 and the same methods were used. Symptomatic and asymptomatic plants were taken to the TAES plant pathology lab in Amarillo and total RNA was extracted from all plants. Extracted RNA was used to generate cDNA, which in turn was used as template for PCR amplification. Specific primers for RNA 3, the RNA species which has been associated with symptom expression and disease severity, were used to amplify the entire P25 ORF on RNA 3. DNA bands of the expected size were generated. The DNA bands were excised from the electrophoresis gel and these were gel purified and sent off for sequencing. Sequence data was analyzed using a variety of DNA analysis software programs, to determine whether differences between wild type and resistance breaking isolates could be identified.

RESULTS AND DISCUSSION

Seed Purity. Results of the blinker and spatial analysis studies were similar to those from previous years and supported our conclusion that incidence and severity of rhizomania in fields planted to resistant cultivars is not a result of seed purity or seed production issues. In the blinker study, healthy, asymptomatic plants had a significantly greater percentage of plants that possessed the *Rz* gene than those in the blinker group. Healthy plants also had significantly higher root weight and percent sucrose and a lower disease rating than the blinkers (Table 1). More importantly however, when only the blinkers were analyzed, 81% tested positive for the *Rz* gene. Furthermore, there was no difference in disease rating, the number of blinkers that tested positive by ELISA for BNYVV, or the average BNYVV value (virus concentration in infected plant tissue) between blinkers that possessed the *Rz* gene and those that didn't (Table 2). This means that without question the *Rz* gene was overcome by BNYVV.

Table 1. Disease rating and yield data from all samples[x]

Symptom	Percent *Rz*	Disease Rating[z]	Mean Root Wt.(lbs)	Sucrose (%)
Healthy	98*	0.5*	2.04*	15.84*
Blinker[y]	81	2.5	0.96	14.47

[x] Healthy means followed by an asterisk are significantly different from blinker means.
[y] Blinker is the term used to describe an individual sugar beet infected by BNYVV, which exhibits the fluorescent yellow foliage typically associated with rhizomania, surrounded by healthy beets with dark green foliage.
[z] Severity of rhizomania was based on a 0 – 4 scale, where 0 = healthy disease free roots and 4 = severe stunting, root constriction, and massive root proliferation.

Table 2. Results for Blankers only[x]

Rz Category	Percent in Category[y]	Disease Rating[z]	BNYVV Positive	BNYVV Value
***Rz* Positive**	81	2.5 NS	94NS	1.0NS
***Rz* Negative**	19	2.8	97	1.1

[x] Blinker is the term used to describe an individual sugar beet infected by BNYVV, which exhibits the fluorescent yellow foliage typically associated with rhizomania, surrounded by healthy beets with dark green foliage.
[y] Means in the top row followed by an asterisk are significantly different from those in the second row.
[z] Severity of rhizomania was based on a 0 – 4 scale, where 0 = healthy disease free roots and 4 = severe stunting, root constriction, and massive root proliferation.

An interesting aspect of the blinker study (data not shown) became apparent when data from the American Crystal area was compared to results from the Southern Minn area. In healthy beets, sucrose was higher in those from the Crystal area but this could have been due to the fact that fields in the Crystal area were sampled two weeks later in the season than those in the Southern Minn area. However, when only the blinkers were evaluated, the mean disease rating was higher in beets from the American Crystal area and mean sugars were not significantly different. This result suggests that disease was more severe in the American Crystal area and losses were greater.

A second interesting result of the blinker study was observed when a subset of data from a single field in Southern Minnesota planted to Beta 4811 was analyzed. Beta 4811 has displayed exceptionally strong resistance to rhizomania and is widely planted in the southern production area. Although no discrete spots of rhizomania existed in this field, one end of the field exhibited an exceptionally large number of blinkers. These were sampled and it was quickly realized that some of the blinkers had large, perfectly formed roots with no symptoms of rhizomania while others were severely infected and displayed typical symptoms of rhizomania. When only the blinkers were analyzed, those possessing the *Rz* gene had significantly lower disease ratings than those without the *Rz* gene. Furthermore, when the total blinkers were divided between those with severe root symptoms and those without, there were several interesting differences between the two groups of plants. Those blinkers without root symptoms had a significantly higher incidence of the *Rz* gene, significantly lower disease severity and significantly higher sucrose content and root weight. These results suggest that the virus population in this field is in the midst of an evolutionary shift. The genetics of 4811 are such that resistance is still active against most BNYVV in the field but some isolates may be beginning to develop the ability to break that resistance. The isolates of BNYVV obtained from the blinkers with the *Rz* gene, both those with and without severe root symptoms, will be highly valuable for future study and further molecular analysis.

A third interesting aspect of the Blinker study had to do with the impact of nitrate nitrogen on disease and sucrose content. In every sample that was tested, except two, healthy, asymptomatic beets always had higher sucrose content than blinkers in paired tests. However, in the two exceptions where the healthy beet sample had a lower sucrose content, the ppm of nitrate in the samples exceeded 130 ppm in one and 200 ppm in the other. In one of these, the disease rating of the blinker sample was 2.8 and the sucrose content 14.4, while in the paired healthy sample the disease rating was 0.5 but the sucrose content was only 11.8. The exact same trend was observed in the other sample. These results demonstrate the extreme importance of nitrogen management, even in fields with high disease pressure. In most cases, ppm nitrate was significantly higher in healthy than in blinker samples and this may partially explain the fluorescent yellow coloration of BNYVV infected plants. However, dispite higher ppm of nitrate in the healthy plants, proper nitrogen management allowed high root yields and high sucrose contents. It was only when excessive nitrogen was present that sucrose content was severely reduced and nitrogen caused a greater loss in sucrose than disease.

In the spatial distribution study, the spatial patterns of the pixels were statistically determined to ascertain whether they follow a random or aggregated pattern. In all fields, the distribution of the pixels followed an aggregated pattern (Fig. 1B), with spatial autocorrelations ranging between 0.54 and 0.81 on the scale where 0 represents a random distribution and 1 represents a strongly aggregated distribution. Plant disease, resulting from a mixture of susceptible and resistant seeds, or plants with and without the *Rz* gene would display a uniform or random pattern in the field, and would not be distributed in aggregated patterns. Aggregated stress patterns usually arise from soil inhabiting infectious agents such as fungi, bacteria or viruses and are restricted in movement or due to localized soil chemical constituents. The results of this study verified statistically what is visually obvious even from ground level, i.e., disease is occurring in clusters and this spatial pattern could not reasonably occur from planting mixed seed or seed that lacked the *Rz* gene due to problems during hybrid seed production. The results from these two studies support the hypothesis that resistance breaking isolates of BNYVV have emerged and are causing rhizomania in Minnesota.

Soil Characteristics. Analysis of soil chemical and physical characteristics from inside and outside discrete patches of plants exhibiting severe symptoms of rhizomania revealed no significant differences. In this study, samples were taken only to the depth of one foot and it is possible that differences may have been found in the lower soil horizons. However, result of this study do not support the idea that rhizomania in fields planted to rhizomania resistant cultivars is due to variability in the soil.

Soil Inoculum Density. Our attempts to develop a molecular test to directly detect and quantify BNYVV directly from the soil were unsuccessful. Rhizosphere soil for this study was obtained in late September and to date we have only conducted a single round of experiments. It is recognized that soils often have properties that interfere with extraction of RNA, especially soils with high organic matter. Although initial tests were unsuccessful, we believe the technology exists to successfully extract and quantify BNYVV RNA from the soil but it will take further experimentation to identify the factors that interfere with the extraction and amplification process.

Emergence of New Resistance-Breaking Strains of BNYVV. In this study, isolates of BNYVV were obtained from fields in both Minnesota and California. In resistance breaking isolates from California we were able to detect a specific unique amino acid motif, VLE, that distinguished these isolates from wild type isolates. Isolates of wild type BNYVV that were unable to cause rhizomania in infected resistant plants did not possess the VLE motif but rather displayed an ALD or ACD motif. Using a specific application of real time PCR termed allelic discrimination, we were able to use the amino acid motif as a marker to identify resistance breaking isolates of BNYVV without the time and expense of full length sequencing. Unfortunately, resistance breaking isolates from Minnesota did not possess this marker and we are still unable to distinguish those using molecular tests.

Virus isolates baited from soil samples collected from rhizomania patches and surrounding asymptomatic areas in the field were genotyped using real-time allelic discrimination assays. Most of the isolates (11 out of 13) baited from the diseased areas carried the resistant breaking VLE motif. By contrast, just two out of 22 isolates collected from the surrounding green areas were resistance breaking isolates and the rest were wild type strains. The near exclusive presence of resistance breaking isolates of BNYVV in rhizosphere soil from rhizomania patches suggests that they have gained a fitness advantage over wild type isolates, under the specific host-environment (*Rz1* cultivars) to which they had been exposed in the field. Also, the occurrence of mixed infections (resistance breaking and wild type) revealed that sometimes, during development of rhizomania in the field, wild type and resistance breaking isolates can coexist in the same *Rz1*-plant. However, this condition is apparently very unstable.

The almost complete exclusion of wild type isolates of BNYVV from the rhizomania patches suggests that over time resistance breaking isolates likely will become the dominant stain in the field. Therefore, new sources of resistance to BNYVV, other than *Rz1*, need to be incorporated into regionally adapted cultivars in order to maintain a viable sugar beet industry. However, in order to insure long term effectiveness of any genetic resistance, it is imperative to elucidate the mechanisms involved in resistance breakdown because incorporation of new dominant resistance genes will be exposed to the same selection pressures as was *Rz1*. The fact that we have identified on numerous occasions, severely diseased plants in fields planted to a cultivar with the *Rz2* resistance gene supports this contention.

SMBSC Evaluation of Fungicides for Control of Cercospora Leaf Spot Control

In 2006 the recommended sequence for cercospora leaf spot control was to first apply Eminent, 14 days later apply a tryphenyl tin hydroxide product and then 14 days later apply a strobilurin product. This three application scenario of fungicide usage was based on fungicide screening test and sensitivity testing of the cercospora leaf spot population to the various fungicides.

Methods:
Sugarbeets were planted at two locations. One location was 3 miles south and the second location was located 4 miles north of Renville, MN. The site south of Renville was taken to harvest but the Rhizoctonia root rot present at this site made the data highly variable and that data will not be presented. The site north of Renville was taken to harvest and that data is presented in this report.

Hilleshog 2467 was the variety planted at the north CLS site. Hilleshog 2467 has a CLS rating of 4.89 averaged over 3 years. The sugarbeet stand was 190 sugarbeets per 100 ft. of row on June 1. The stand count at harvest time was 170 sugarbeets per 100 ft. of row. Fungicide applications were made on the following dates:

1st application: 7-19-06
2nd application: 8-3-06
3rd application: 8-17-06
4th application: 8-31-06 (some treatments only)

Applications were made every 14 days or as close to 14 days as the weather would allow. Plots were harvested on 10-11-06 with a 2 row research harvester. One quality sub-sample was collected from each plot.

Result and discussion
The results will be discussed in categories of fungicide sequences and chemistry classes.

Recommended sequences:
As mentioned earlier, the recommended sequence of fungicides in 2006 was Eminent in the first application, a tryphenyl tin hydroxide fungicide in the second application and a strobilurin fungicide in the third application. Data presented in table 1 & 2 shows the treatments with Eminent, Supertin and Headline in different sequences. Treatments also included Eminent + Supertin alternated with Headline sequence and Eminent + Manzate in another treatment sequence. The results showed no significant differences in sugar percent, sugar per ton, sugar per acre, tons per acre or purity of the sugar beet in this experiment. The check of no-fungicide treatments was significantly lower in all sugar beet production factors regardless of treatment. A trend was observed that adding Manzate to Eminent tended to increase extractable sucrose per acre compared to the other

treatments in table 1. Cercospora leaf spot ratings were not different for any of the treatments in table 1. The treatment with Manzate added to Eminent tended to give higher Cercospora leaf spot rating at the 08-25-06 date. By the 10-10-06 date, the trend of higher Cercospora leaf spot ratings with this treatment had dissipated. The change of Cercospora leaf spot ratings between 08-25-06 and 10-10-06 was lowest with the Eminent plus Manzate alternated with Headline treatment and tended to give higher revenue per acre when comparing the other treatments in table 1.

Enable and Eminent

Tables 3 and 4 compare Eminent and Enable alternated with Supertin and Headline. The data shows no significant differences between the treatments in table 3 for sugar beet yield and quality variables. Topsin added to Supertin did not increase sugar beet yield or quality. The three application scenario with Enable, Supertin and Headline sequences was not significantly different from the four applications scenario in either production or efficacy.

The one advantage of a four spray program with Enable, Supertin, Headline and Supertin was that the change in Cercospora leaf spot rating from 08-25-06 to 10-10-06 was negative instead of positive. The other treatments compared in treatment 4 showed no significant difference between these dates.

Gem and Headline

Tables 5 & 6 compare Gem and Headline alternated with Supertin and one treatment which excluded Supertin. There was no significant difference between treatments for sugarbeet yield and quality variables. There was a tendency for sugarbeet yield and quality to increase with the Gem, Eminent and Supertin alternation from first to second and vice versa. Cercospora leaf spot ratings were higher with the Gem, Eminent and Supertin alternation compared to Eminent, Headline and Supertin alternation. However, when comparing a more similar treatment of a triazole, strobilurin and tryphennyl tin hydroxide but using Gem in one treatment and Headline in the other treatment, there is no significant difference in Cercospora leaf spot control.

Table 1. 2006 SMBSC Renville north location CLS fungicide testing -Standard recommendation

Treatment Description	Application rate/acre	Tons per acre	Sugar percent	Purity	Ext. Suc. per acre
Eminent Supertin Headline	13 oz. 5 oz. 9 oz.	26.42	16.77	88.94	7296
Eminent Headline Supertin	13 oz. 9 oz. 5 oz.	24.47	16.74	89.71	6796
Eminent + Supertin Headline Eminent + Supertin	13 + 5 oz. 9 oz. 13 + 5 oz.	24.21	17.59	90.73	7217
Eminent + Manzate Headline Eminent + Manzate	13 oz. + 2 lb. 9 oz. 13 oz. + 2 lb.	26.39	17.05	89.91	7521
Check		16.62	14.91	88.44	3993
Check		15.91	13.79	87.23	3445
	C.V.%	10.41	8.07	1.36	11.69
	LSD (0.05)	3.57	1.79	1.70	1145

Table 2. 2006 SMBSC Renville north location CLS fungicide testing- Standard recommendation

Treatment Description	Application rate/acre	8/25/2006 CLS rating	10/10/2006 CLS rating	CLS rating Change	Revenue per acre
Eminent Supertin Headline	13 oz. 5 oz. 9 oz.	2.53	4.06	1.54	944.50
Eminent Headline Supertin	13 oz. 9 oz. 5 oz.	2.63	4.00	1.38	884.18
Eminent + Supertin Headline Eminent + Supertin	13 + 5 oz. 9 oz. 13 + 5 oz.	2.50	4.00	1.50	994.90
Eminent + Manzate Headline Eminent + Manzate	13 oz. + 2 lb. 9 oz. 13 oz. + 2 lb.	2.83	4.00	1.18	1000.23
Check		7.50	7.75	0.25	448.68
Check		7.50	8.00	0.50	337.77
	C.V.%	21.82	17.34		14.88
	LSD (0.05)	0.84	1.08		189.42

Table 3. 2006 SMBSC Renville north location CLS fungicide testing - Enable and Eminent comparison

Treatment Description	Application rate/acre	Tons per acre	Sugar percent	Purity	Ext. Suc. per acre
Eminent	13 oz.	26.42	16.77	88.94	7296
Supertin	5 oz.				
Headline	9 oz.				
Enable	8 oz.	25.82	17.74	91.02	7825
Supertin	5 oz.				
Headline	9 oz.				
Enable	8 oz.	25.05	17.29	90.32	7250
Supertin + Topsin	3.75 oz. + 7.6 oz.				
Headline	9 oz.				
Enable	8 oz.	25.36	17.38	89.81	7363
Supertin	5 oz.				
Headline	9 oz.				
Supertin	5 oz.				
Check		15.91	13.79	87.23	3445
Check		16.62	14.91	88.44	3993
	C.V.%	10.41	8.07	1.355	11.69
	LSD (0.05)	3.57	1.79	1.70	1145

Table 4. 2006 SMBSC Renville north location CLS fungicide testing - Enable and Eminent comparison

Treatment Description	Application rate/acre	8/25/2006 CLS rating	10/10/2006 CLS rating	CLS rating Change	revenue per acre
Eminent	13 oz.	2.53	4.06	1.54	944.50
Supertin	5 oz.				
Headline	9 oz.				
Enable	8 oz.	2.28	3.94	1.66	1092.51
Supertin	5 oz.				
Headline	9 oz.				
Enable	8 oz.	1.60	3.13	1.53	976.70
Supertin + Topsin	3.75 oz. + 7.6 oz.				
Headline	9 oz.				
Enable	8 oz.	3.35	3.25	-0.10	994.18
Supertin	5 oz.				
Headline	9 oz.				
Supertin	5 oz.				
Check		7.5	8	0.50	337.77
Check		7.5	7.75	0.25	448.68
	C.V.%	21.82	17.34		14.88
	LSD (0.05)	0.84	1.08		189.42

Table 5. 2006 SMBSC Renville north location CLS fungicide testing - Gem and Headline comparison

Treatment Description	Application rate/acre	Tons per acre	Sugar percent	Purity	Ext. Suc. per acre
Gem	3.5 oz.	23.20	17.10	89.90	6652
Eminent	13 oz.				
Supertin	5 oz.				
Eminent	13 oz.	21.88	16.48	89.54	5975
Gem	3.5 oz.				
Supertin	5 oz.				
Eminent	13 oz.	24.47	16.74	89.71	6796
Headline	9 oz.				
Supertin	5 oz.				
Eminent	13 oz.	25.94	17.46	90.25	7617
Headline	9 oz.				
Eminent	13 oz.				
Headline + Eminent	9 oz.				
Check		16.62	14.91	88.44	3993
Check		15.91	13.79	87.23	3445
	C.V.%	10.41	8.07	1.355	11.69
	LSD (0.05)	3.57	1.79	1.70	1145

Table 6. 2006 SMBSC Renville north location CLS fungicide testing - Gem and Headline comparison

Treatment Description	Application rate/acre	8/25/2006 CLS rating	10/10/2006 CLS rating	CLS rating Change	revenue per acre
Gem	3.5 oz.	2.80	5.31	2.51	889.38
Eminent	13 oz.				
Supertin	5 oz.				
Eminent	13 oz.	3.43	4.94	1.51	765.82
Gem	3.5 oz.				
Supertin	5 oz.				
Eminent	13 oz.	2.63	4.00	1.38	884.18
Headline	9 oz.				
Supertin	5 oz.				
Eminent	13 oz.	2.19	3.00	0.81	1037.92
Headline	9 oz.				
Eminent	13 oz.				
Headline + Eminent	9 oz.				
Check		7.50	7.75	0.25	448.68
Check		7.50	8.00	0.50	337.77
	C.V.%	21.82	17.34		14.88
	LSD (0.05)	0.84	1.08		189.42

SENSITIVITY OF *CERCOSPORA BETICOLA* TO FOLIAR FUNGICIDES IN 2006.

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

Like many other fungi, *C. beticola* has the ability to adapt and become less sensitive to the fungicides used to control them, especially if they are applied frequently over a period of time. We began testing *C. beticola* populations for sensitivity to tin in 1996, and continued and expanded sensitivity testing to additional fungicides in subsequent years. From 1997-2000 we evaluated sensitivity to tin and thiophanate methyl. We utilized our extensive culture collection of *C. beticola* isolates from 1997-2000 to establish baseline sensitivities to Eminent, Headline and Gem and to evaluate shifts in sensitivity to tin and Topsin. Fungicide sensitivity testing of field isolates of *C. beticola* to the five commonly used fungicides in our area has been conducted in the years 2003 - 2006.

OBJECTIVES

The 2006 objectives were:

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

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

3) Distribute results of sensitivity testing in a timely manner in order to make disease management decisions based on test results.

METHODS AND MATERIALS

In 2006, with financial support of the Sugarbeet Research and Extension Board of ND and MN, DuPont, Sipcam Agro, BASF Corporation and Bayer Crop Science, we conducted extensive testing of *C. beticola* isolates collected from throughout the sugarbeet production regions of ND/MN for sensitivity to Tin, Eminent, Headline and Gem. Due to the widespread resistance to Topsin, sensitivity testing to Topsin will only be conducted every three years; testing was not done in 2006.

Sugar beet leaves with Cercospora leaf spot (CLS) were collected from commercial fields by agronomists from all factory districts. Leaves were delivered to our lab, and processed immediately to insure viability of spores. From each field sample *C. beticola*, spores were collected from a minimum of five spots/leaf from five leaves. The spores were mixed, and composite of 200 µl of spores transferred to each of two Petri plates containing water agar amended with Tin at 1 ppm or non-amended (water agar alone).

For tin sensitivity, a bulk spore germination procedure was used. Germination of 100 random spores on the tin amended water agar was counted 16 hrs after plating and percent germination calculated.

Germination on non-amended media was calculated and this plate was used as a source of single spore sub cultures for subsequent Eminent, Headline and Gem sensitivity testing.

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

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

RESULTS AND DISCUSSION

Cercospora disease developed late in the 2006 season and the majority of the CLS samples were delivered to our lab in September; 16% of the samples were delivered in August, 76% delivered in September and 8% delivered in October. Due to the diligent collection efforts of the grower cooperative agronomists, 988 field samples were received for testing representing all production areas and factory districts were received and tested. An additional 364 samples were received from fungicide trial plots of Dr. Mohamed Khan (Foxhome), Dr. Larry Smith (Crookston) and Mark Bredehoeft (Renville), and tested for fungicide sensitivity. For this report, only results from the field samples are included; the fungicide trial results are not included. Some samples that were submitted for testing were not done, because the spores did not germinate despite repeated attempts. Of the 988 samples received, 956 samples (97%) were tested. We postulate that the fields from which these samples were collected had recently been treated with a fungicide that interfered with spore germination in the lab, or that the lesions may have been bacterial leaf spot and not Cercospora leaf spot.

Tolerance to triphenyl tin hydroxide was first reported in 1994, with tolerance levels between 1-2 ppm. The incidence of tin tolerance increased between 1997 and 1999, but incidence of isolates tolerant to triphenyl tin hydroxide at 1.0 ppm has been declining since the introduction of tetraconazole for resistance management in 1999, trifloxystrobin in 2002 and pyraclostrobin in 2003. In 1998, the percentage of isolates with tolerance to triphenyl tin hydroxide at 1.0 ppm was 64.6%, in 1999 it was 54.3%, in 2000 it was 17.7%, in 2001 was 14.9%, in 2002 was 9.0%, in 2003 was 1.1%, in 2004 was 1.1%, in 2005 was 0.97% and in 2006 was 0.0% (Fig. 1). None of the isolates tested in 2006 showed resistance to tin fungicide. The decline in tin tolerance is associated with the use of additional fungicides with different chemistry which resulted in a reduction of average number of tin applications from 2.4 in 1998 to less than one since 2001 (Fig. 1). The average number of tin applications in 2006 was 0.56 (Fig. 1).

A baseline sensitivity curve was developed for tetraconazole using *C. beticola* isolates from 1997-1999 that had not been previously exposed to tetraconazole and the year 2000 from our culture collection. There appears to be a slow increase in the average EC50 value of CLS isolates from 1998 to 2005 (Fig. 2). The average EC_{50} values of these *C. beticola* isolates from our culture collection are 0.13 (1997), 0.09 (1998), 0.12 (1999), and 0.23 (2000) using a radial growth procedure. The average EC_{50} value of field-collected isolates from 2002 was 0.21 ppm, from 2003 was 0.12 ppm, from 2004 was 0.24, from 2005 was 0.29 and from 2006 was 0.14. These values include isolates with an EC_{50} value of >1.0 ppm.

In 2002, 1.2 % of the isolates tested had an EC_{50} value of >1 to tetraconazole compared to 6.0% of the isolates in 2003, 10.8% of the isolates in 2004, 12.4% in 2005, and in 2006 was 7.3% (Fig 3). The trend from 2003 - 2005 has been for increased resistance to tetraconazole as indicated by an increase in both average EC_{50} values and the incidence of isolates with EC_{50} values >1 ppm. This is the first indication of a decrease in resistance to tetraconazole, and along with the reduction in tin resistance, may indicate that our collective resistance management program and recommendations are working. Sensitivity to tetraconazole in 2006 appears to be similar across factory districts, but the average EC_{50} value was highest in the SMBSC district, but SMBSC had no isolates with an EC50 > 1.0 (Figs. 4 and 5).

Baseline sensitivity to the QOI fungicides Headline and Gem was done using *C. beticola* isolates from our culture collection not previously exposed to pyraclostrobin and trifloxystrobin.and will be used to monitor shifts in sensitivity to these fungicides. Sensitivity of C. *beticola* to both of these fungicides has remained relatively stable (Figs. 6 and 7) since these fungicides have been used commercially (Headline four years, Gem three years). There a slight shift toward resistance compared to the baseline with both strobilurin fungicides (Fig. 8), but the shift in is less than 10X and may be attributed to natural variation or experimental noise. However, substantial variability exists among the isolates tested, with a thousand-fold difference in EC_{50} values among the isolates to pyraclostrobin and trifloxystrobin, indicating the potential for reduced sensitivity is present in the population. It should be emphasized that we have found isolates in the population that have an EC_{50} value >1.0 ppm for both Headline and Gem. It is important to know that there are numerous examples in many crops where resistance has developed to strobilurin (QOI) fungicides due to overapplication and misapplication of these fungicides. Because Gem and Headline are strobilurin/QOI fungicides, it is important to continue to monitor sensitivity of *C. beticola* to these two fungicides.

Because *C. beticola* has a history of developing resistance to fungicides, and has a high degree for variablility in cultures, the potential for resistance development to fungicides is always there. We must continue to monitor C. beticola populations in our area for fungicide sensitivity/resistance and develop disease management strategies with this goal as a priority.

SUMMARY

1. Tin tolerance at 1.0 ppm has basically disappeared in our region, probably due to the use of alternate fungicides that has resulted in the reduction in the number of tin applications from 2.14 in 1998 to less than one each year since 2001.

2. Resistance to Topsin at 5.0 ppm is widespread across all production areas of the state, and is not declining. Topsin was not tested in 2006.

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

4. Sensitivity to Headline and Gem remains relatively stable, but there are rare isolates identified with a thousand-fold decrease in sensitivity. There has been a slight change in sensitivity to Gem and Headline compared to the baseline since use and testing of these compounds began three and four years ago respectively. This change is not a cause for concern.

5. It appears that the fungicide resistance management plan that we are following is working.

6. A combination of alternation and combinations of fungicides with different modes of actions will continue to be necessary to prevent reduced sensitivity of *C. beticola* to currently registered fungicides.

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

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

Fig 1. Sensitivity to TPTH of *C. beticola* isolates collected in ND and MN from 1998 to 2006 at 1.0 ppm as measured by bulk spore germination

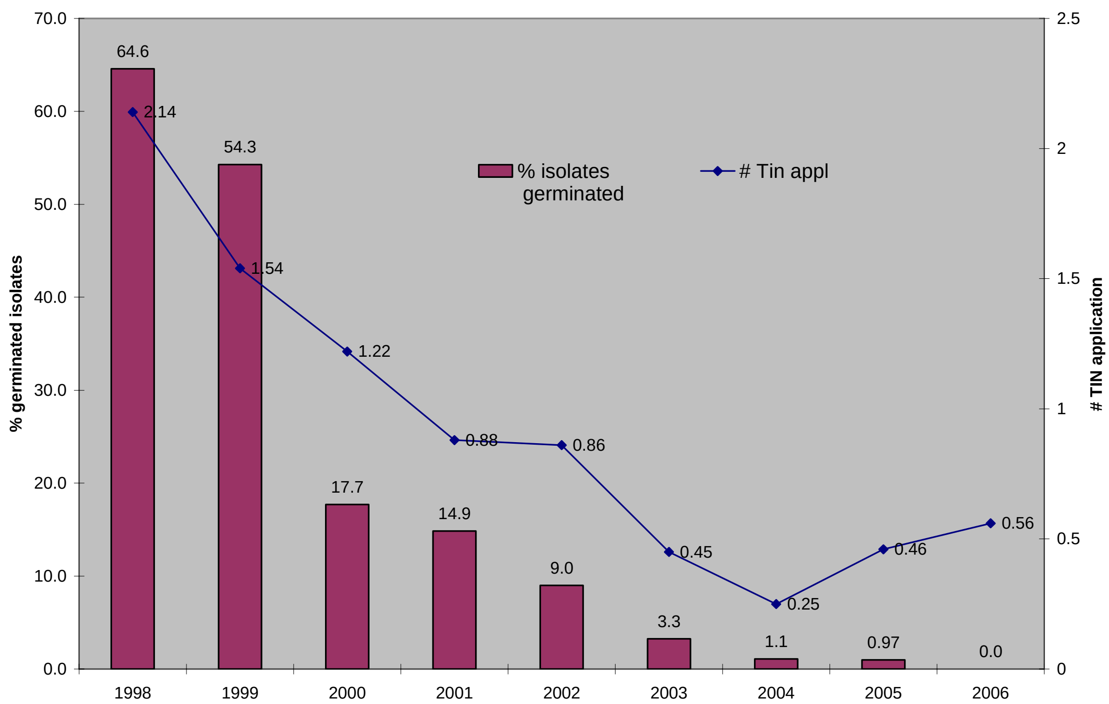

Fig 2. Average EC-50 value of Cercospora beticola isolates collected from 1997-2006 to tetraconazole.

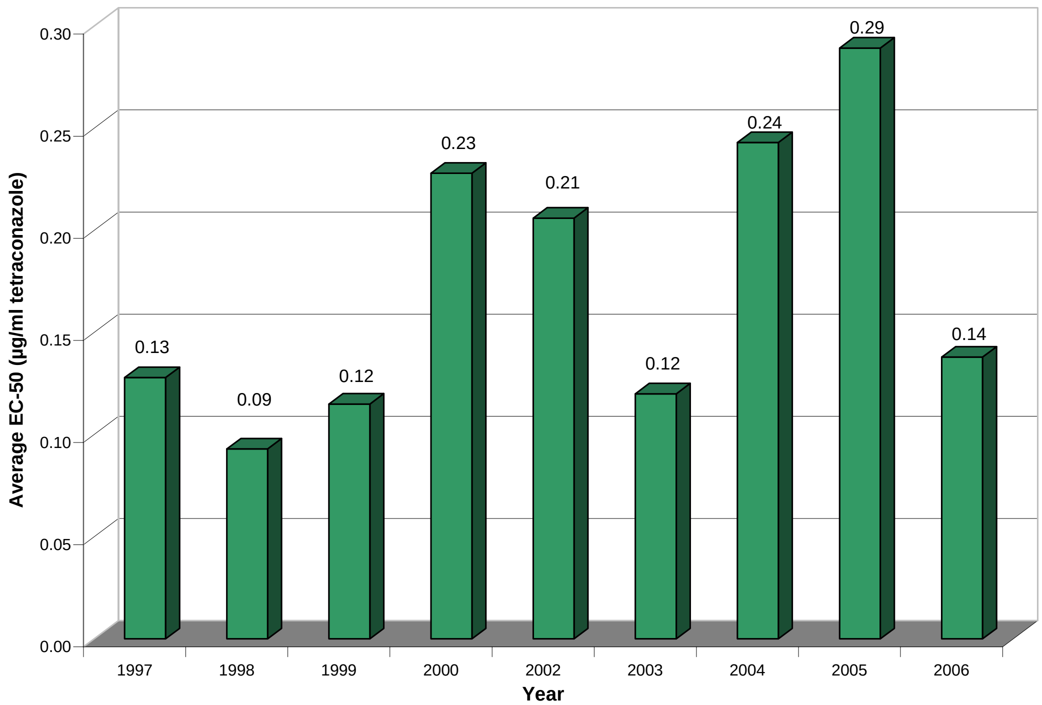

Fig. 3 Sensitivity of C. beticola isolates collected in ND and MN from 1997-2006 to tetraconazole

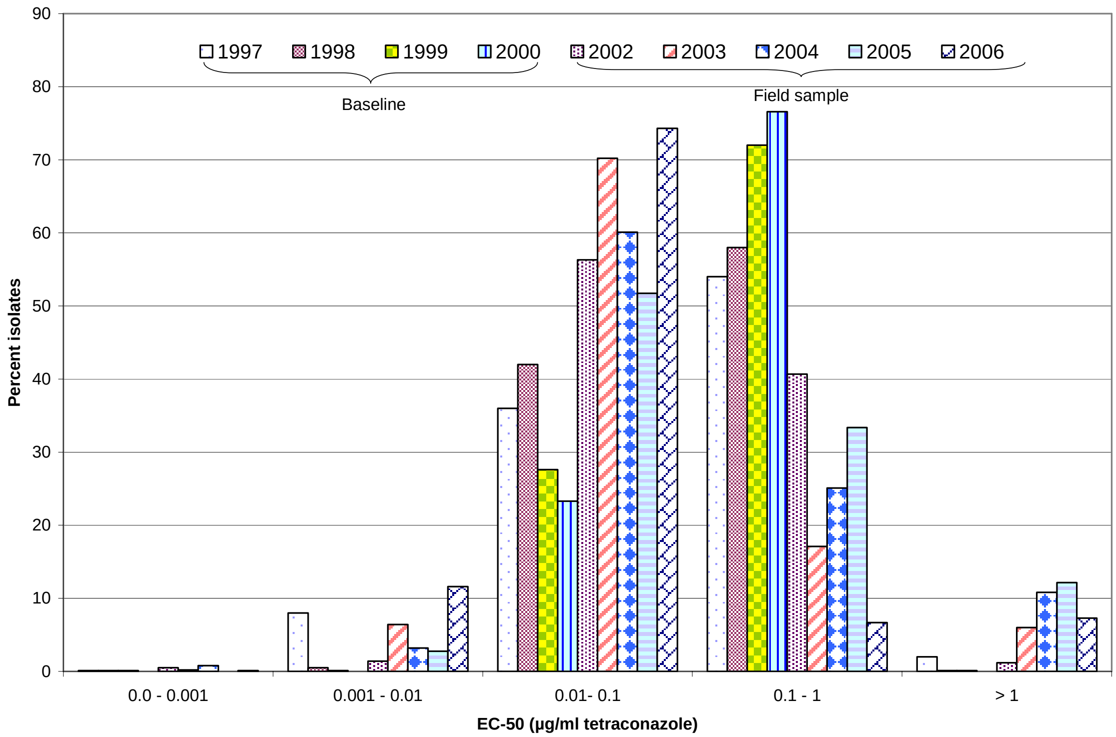

Fig 4. Sensitivity of *C. beticola* to tetraconazole by factory district 2005-2006

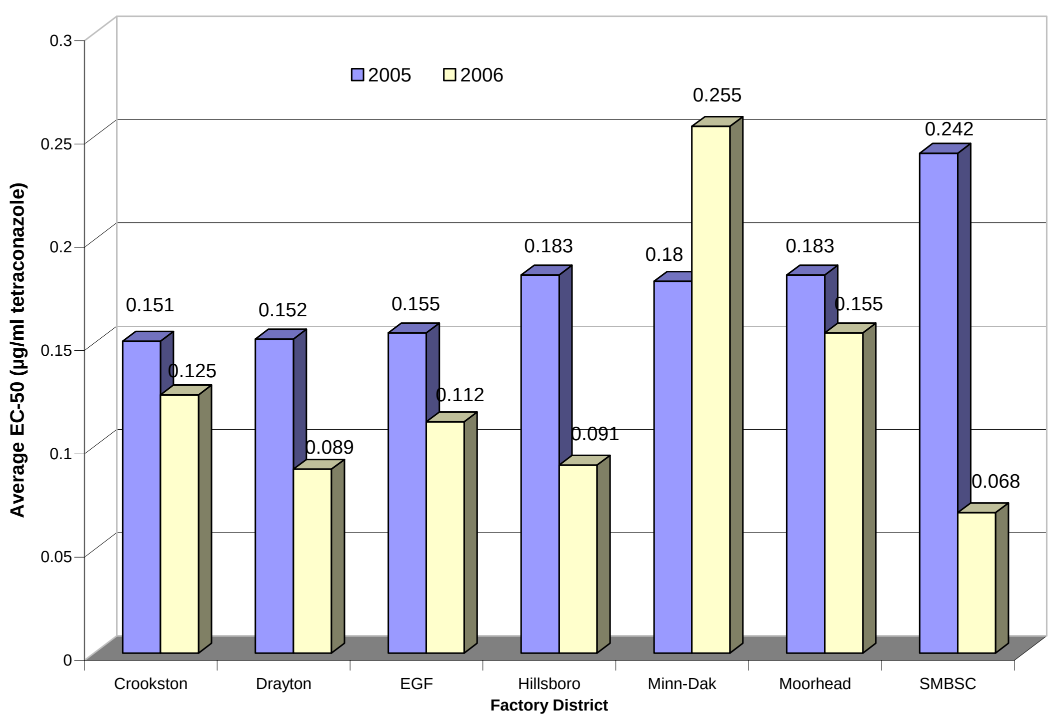

Fig 5. Percent of *C. beticola* isolates with EC-50 > 1 µg/ml of tetraconazole collected in 2006 by factory district

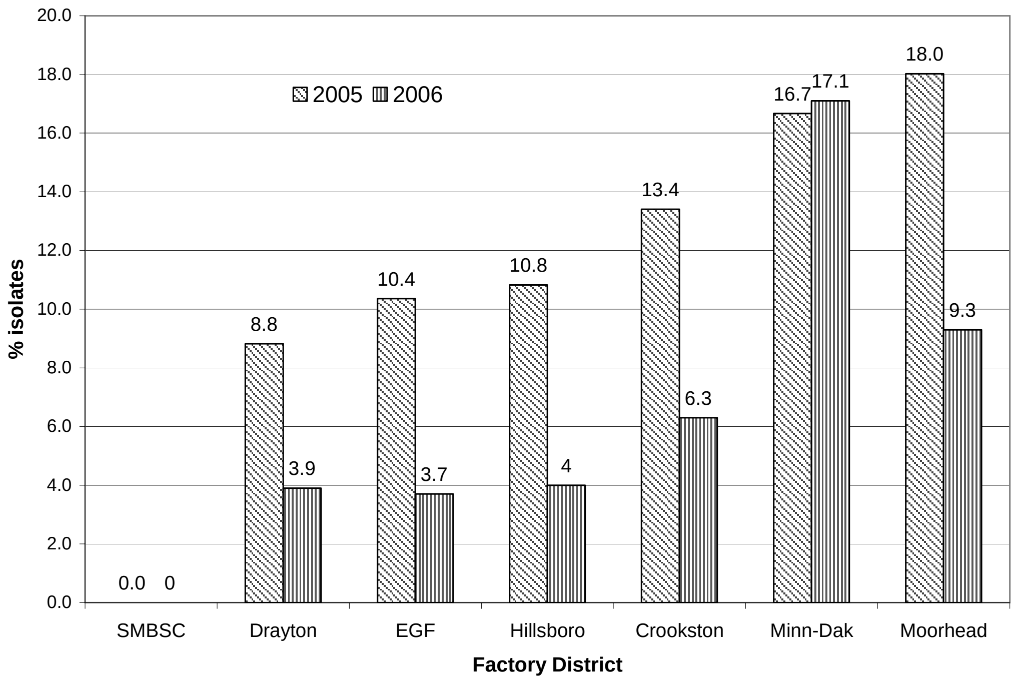

Fig 6. Sensitivity of *C. beticola* isolates to pyraclostrobin (Headline) collected from 2003-2006

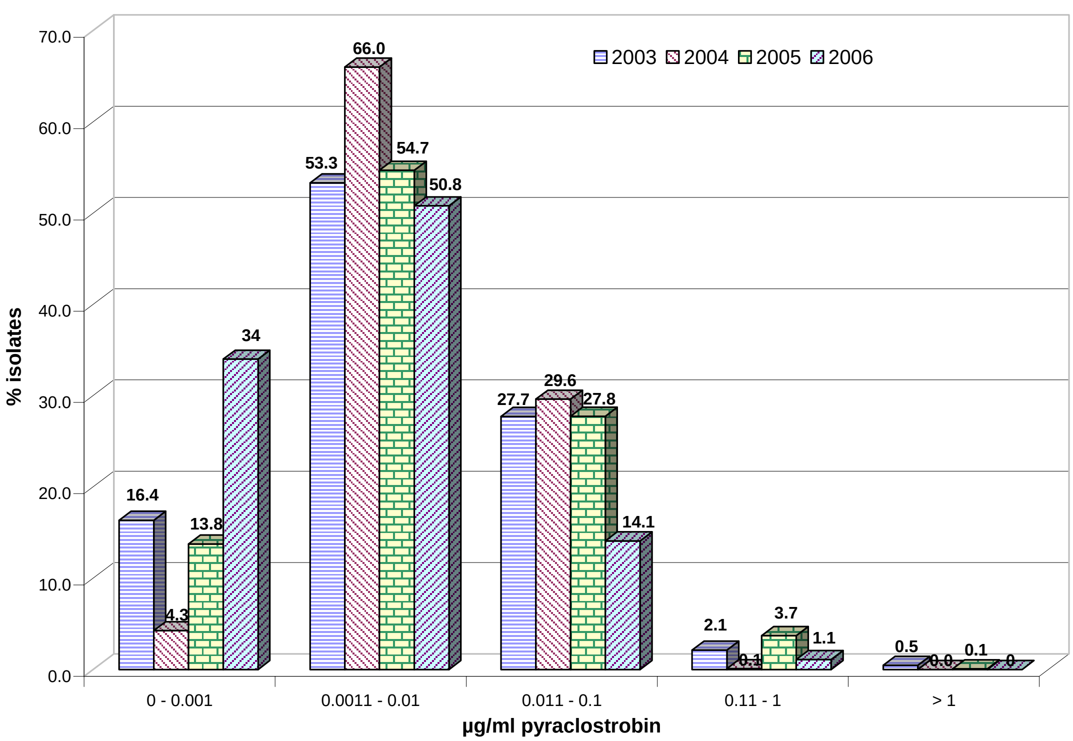

Fig 7. Sensitivity of *C. beticola* isolates collected in MN and ND to trifloxystrobin (Gem) from 2004-2006.

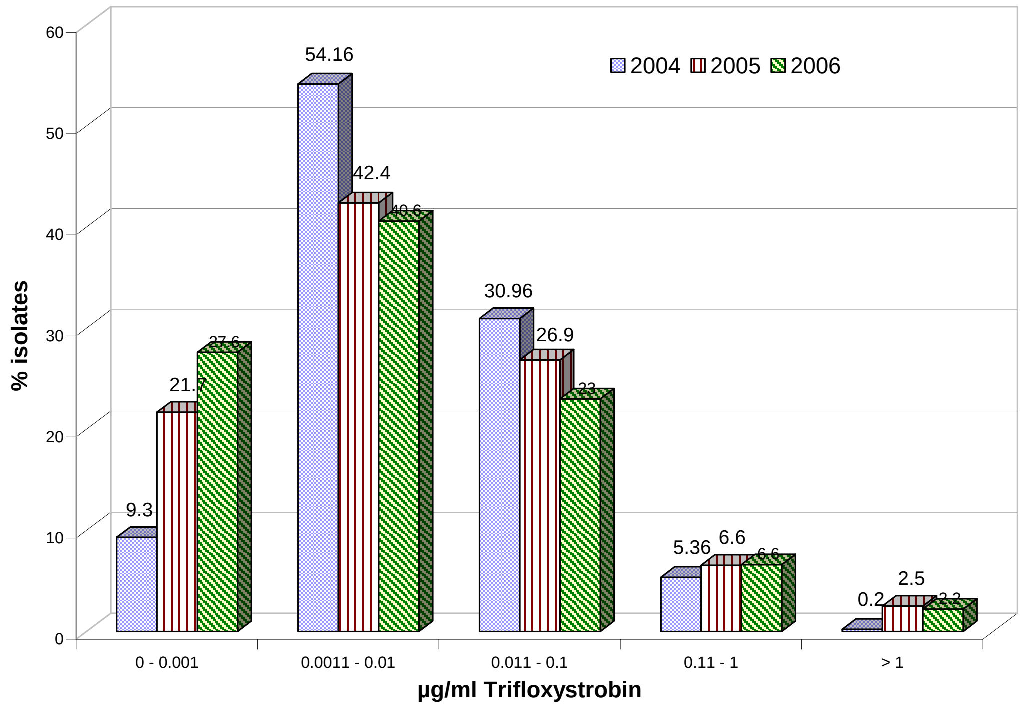

Fig. 8. Sensitivity of C. *beticola* isolates from ND and MN to Gem and Headline from 2003-2006 compared to the pre-registration baseline.