Southern Minnesota Beet Sugar Cooperative
PO Box 500 ● 83550 County Road 21 ● Renville, Minnesota 56284-0500

Dear Shareholder:

Enclosed is the 2005 Research Report and Agronomic Practice Database (APD) information. The 2005 Research Report contains the results of all SMBSC research projects, as well as, projects done in cooperation with other researchers. The SMBSC Research Report and APD information will not be posted on SMBSC's website due to confidentiality reasons. Please retain your copy of the SMBSC Research Report and APD information each year for your reference.

The APD information is generated from information collected from you, the shareholder, and then queried into various comparisons. These comparisons are generated for the purpose of uncovering those agronomic practices which result in higher extractable sugar per acre and higher revenue per acre for the shareholder. Shareholder names are not attached to the data queried which maintains the total confidentiality of the APD. SMBSC will continue to develop additional comparisons each year.

The quality of the APD is solely contingent upon the quality of the data being collected from the shareholder and input into the APD. SMBSC greatly appreciates all who participate and provide agronomic practice information. SMBSC intends to make this process of collecting information much easier, for the shareholder, as new information systems are developed. The power of the APD increases, with time, as years are combined, trend lines are developed and participation continues to grow.

SMBSC will continue to manage the APD in order to uncover those agronomic practices which improve shareholder profitability and SMBSC's competitive edge. SMBSC goes to great lengths to maintain shareholder confidentiality and we hope you will do the same with this information. Thank you for taking the time each year to provide meaningful data into the APD. SMBSC hopes you find the 2005 Research Report and APD information useful in the management decisions you will be making towards improving the profitability of your future sugar beet crops.

Sincerely,

Kelvin Thompsen

Kelvin Thompsen
Vice President, Agriculture

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2005 Southern Minnesota Beet Sugar Cooperative Official Variety Trial Research

Five Official Coded Variety Trials and three Bio-Tech Round-Up Ready trials were conducted in the SMBSC growing area in 2005. Trial sites were chosen based upon a known or probable occurrence of Rhizomania infection. The 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 ranged from 100 to 132 lbs. per acre. A pre-emergence weed control product was applied at four of the five locations. Three of the four locations that received a pre-emergence herbicide, received ethofumesate and the other location received metolachlor. Planting of the Official Variety Trials began on April 27th and were completed on May 4th. Seed bed conditions were good to excellent and seed spacing was four inches at all locations.

Seedling emergence was very good at all locations due to a timely rainfall just after planting. The end of May and early June received an extended wet period and resulted in eventual discard of two replications at one of the sites. 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 foot of row or approximately 35,000 to 38,000 plants per acre. Thinning of the plot area at each location was completed by June 17.

Rhizomania severity across the five locations ranged from slight to severe. Based upon observation of susceptible Aphanomyces checks, two locations had a noticeable infection of *Aphanomyces cochlioides.* Due to the uniformity of diseases when present, all locations were combined and analyzed for use in creating the three-year variety mean. These data were used for approving or disapproving candidate varieties. In addition, the Aphanomyces infection at the Clara City site was both uniform and severe. This provided an opportunity to acquire root evaluations that were used in combination with the Shakopee Aphanomyces nursery data for assessment of variety tolerance to Aphanomyces.

The SMBSC Beet Seed Policy indicates 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 full for 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 acre, respectively. In addition, the Aphanomyces and Cercospora Leafspot (CLS) ratings of candidate varieties must not exceed 5.0. Application of the Beet Seed Policy criteria provided for approval of one new variety for use in the 2006 crop year. One variety will be available for one last year of sales due to poor variety trial performance and Rhizomania resistance gene dosage. Seven varieties were approved for unlimited sales for the 2006 crop year and one variety was approved as a specialty variety for Aphanomyces tolerance. Three varieties met the criteria for Test Market use in 2006. One of the Test Market varieties from 2005 will remain a Test Market in 2006 due to a concern over susceptibility to CLS, which will require further observation. The other two Test Market Varieties were varieties having only two years of variety trial data and possessing the potential for full approval in 2007. The 2005 trial specifications and the three, two and one-year variety performance data are provided in the tables on the following pages.

Table 1. Mean of the Three Year 2006 SMBSC Varieties Approved for Unlimited Sales - Based Upon Approval Criteria

CONVERTED

Entry - Converted			*Rec/T (lbs)* 3 yr avg	% of mean	*Rec/A (lbs)* 3 yr avg	% of mean	*%ES* 3 yr avg	% of mean	*Yield (T/A)* 3 yr avg	% of mean	*Sugar %* 3 yr avg	% of mean	*Cercospora Leaf Spot* 3 yr avg	% of mean	*Emerg-ence (%)* 3 yr avg	% of mean	*Aphano-myces* 3 yr avg	% of mean	*Purity (%)* 3 yr avg	% of mean
2006 APPROVED VARIETIES																				
Beta 4901R	RZM	199.99	248.92	97.76	6248.56	102.23	12.45	97.76	25.23	105.14	15.04	98.70	4.55	104.38			4.88	100.16	89.61	99.21
Beta 4930R	RZM	198.74	251.46	98.76	6110.54	99.98	12.58	98.77	24.41	101.71	15.18	99.59	4.14	95.12	72.79	103.87	4.39	90.23	89.86	99.48
Hilleshog 2411Rz	RZM	197.79	257.50	101.13	5907.94	96.66	12.88	101.13	22.89	95.41	15.32	100.51	4.18	95.89	74.00	105.59	5.32	109.26	90.60	100.30
Hilleshog 2467Rz	RZM	204.63	258.83	101.65	6294.10	102.98	12.94	101.66	24.35	101.46	15.55	102.05	4.91	112.65			4.93	101.18	90.27	99.94
HOLLY 255	APH & RZM	200.25	251.53	98.79	6201.32	101.46	12.58	98.79	24.35	101.46	15.03	98.62	4.38	100.56			5.24	107.55	90.44	100.13
VDH H46177	APH & RZM	198.84	258.75	101.62	5942.04	97.22	12.94	101.60	22.91	95.49	15.33	100.56	4.12	94.51	63.45	90.54	5.04	103.58	90.93	100.67
VDH H47150		199.76	255.37	100.29	6079.39	99.47	12.77	100.30	23.84	99.33	15.24	99.97	4.22	96.88			4.29	88.04	90.57	100.28
			254.62	**100.00**	**6111.98**	**100.00**	**12.73**	**100.00**	**24.00**	**100.00**	**15.24**	**100.00**	**4.36**	**100.00**	**70.08**	**100.00**	**4.87**	**100.00**	**90.32**	**100.00**

2006 SPECIALTY VARIETIES (% of Mean is of Approved Mean)

Beta 4811R	APH & RZM	200.03	245.55	96.44	6331.52	103.59	12.28	96.41	25.62	106.78	14.82	97.23	4.46	102.32	77.20	110.16	3.72	76.40	89.81	99.43

2006 PREVIOUSLY APPROVED VARIETIES NOT MEETING CRITERIA - FINAL YEAR OF SALES (% of Mean is of Approved Mean)

Candidate Varieties	Specialty	RST+ RSA																		
Crystal R826	APH & RZM	192.21	250.78	98.49	5727.99	93.72	12.54	98.51	22.67	94.49	15.07	98.85	4.64	106.53	73.07	104.27	4.59	94.20	90.10	99.75

TEST MARKET VARIETIES FOR LIMITED SALES WITH 3 YEARS OF DATA (% of Mean is of Approved Mean)

Beta 1322		210.24	254.91	100.11	6730.77	110.12	12.75	100.13	26.25	109.40	15.29	100.29	5.04	115.63			4.37	89.68	90.17	99.83

Table 2. Comparison of 2006 Approved Varieties to Candidate Test Market Varieties Based on 2 Year Data, 2004 - 2005

CONVERTED

Entry - Converted			*Rec/T (lbs)* 2 yr avg	% of mean	*Rec/A (lbs)* 2 yr avg	% of mean	*%ES* 2 yr avg	% of mean	*Yield (T/A)* 2 yr avg	% of mean	*Sugar %* 2 yr avg	% of mean	*Cercospora Leaf Spot* 2 yr avg	% of mean	*Emerg-ence (%)* 2 yr avg	% of mean	*Aphano-myces* 2 yr avg	% of mean	*Purity (%)* 2 yr avg	% of mean
2006 APPROVED VARIETIES																				
Beta 4901R	RZM	201.92	232.00	97.85	5671.19	104.07	11.60	97.85	24.62	106.50	14.16	98.72	4.68	106.24	71.57	102.98	4.81	98.22	89.20	99.19
Beta 4930R	RZM	195.96	233.24	98.37	5317.61	97.58	11.67	98.40	23.23	100.49	14.24	99.28	4.04	91.60	73.17	105.28	4.37	89.24	89.52	99.54
Hilleshog 2411Rz	RZM	198.96	240.39	101.39	5316.74	97.57	12.02	101.39	22.18	95.92	14.43	100.61	4.07	92.28	71.88	103.42	5.19	105.88	90.26	100.37
Hilleshog 2467Rz	RZM	203.87	238.95	100.78	5617.61	103.09	11.95	100.76	23.61	102.13	14.55	101.44	4.92	111.69	69.06	99.37	4.93	100.67	89.93	100.00
HOLLY 255	APH & RZM	201.56	239.69	101.09	5474.38	100.46	11.99	101.10	22.84	98.80	14.39	100.33	4.50	102.16	71.19	102.44	5.18	105.67	90.09	100.18
VDH H46177	APH & RZM	198.23	242.05	102.09	5238.84	96.14	12.10	102.07	21.73	94.00	14.48	100.96	4.10	92.96	60.12	86.51	5.10	104.04	90.53	100.67
VDH H47150		199.52	233.37	98.43	5508.71	101.09	11.67	98.44	23.62	102.17	14.15	98.65	4.54	103.06			4.72	96.28	89.97	100.05
			<u>237.09</u>	<u>100.00</u>	<u>5449.29</u>	<u>100.00</u>	<u>11.86</u>	<u>100.00</u>	<u>23.12</u>	<u>100.00</u>	<u>14.34</u>	<u>100.00</u>	<u>4.41</u>	<u>100.00</u>	<u>69.50</u>	<u>100.00</u>	<u>4.90</u>	<u>100.00</u>	<u>89.93</u>	<u>100.00</u>
2006 SPECIALTY VARIETIES (% of Mean is of Approved Mean)																				
Beta 4811R	APH & RZM	194.56	227.61	96.00	5371.03	98.56	11.38	95.99	23.75	102.71	13.92	97.09	4.44	100.68	72.70	104.60	3.90	79.54	89.28	99.28
2006 PREVIOUSLY APPROVED VARIETIES NOT MEETING CRITERIA - FINAL YEAR OF SALES (% of Mean is of Approved Mean)																				
Crystal R826	APH & RZM	192.27	234.76	99.01	5081.91	93.26	11.74	99.03	21.55	93.20	14.28	99.60	4.52	102.61	67.20	96.70	4.85	98.94	89.58	99.61
TEST MARKET VARIETIES FOR LIMITED SALES WITH 3 YEARS OF DATA (% of Mean is of Approved Mean)																				
Candidate Varieties	**Specialty**	**RST+ RSA**																		
Beta 1322		205.43	234.87	99.06	5796.37	106.37	11.75	99.07	24.73	106.97	14.32	99.88	5.08	115.21			4.18	85.25	89.45	99.46
Hilleshog 2423Rz		201.46	244.26	103.02	5364.02	98.44	12.22	103.04	21.85	94.49	14.51	101.20	3.72	84.34			4.67	95.36	90.52	100.66
VDH H46527		200.48	236.69	99.83	5484.87	100.65	11.84	99.83	22.98	99.40	14.26	99.46	4.32	97.96			4.92	100.36	89.97	100.05

Table 3. Mean of the One Year Performance of 2006 SMBSC Approved and Test Market Varieties, 2005 Data.

CONVERTED

Entry - Converted	*Rec/T (lbs)* 2005	% of mean	*Rec/A (lbs)* 2005	% of mean	*%ES* 2005	% of mean	*Yield (T/A)* 2005	% of mean	*Sugar %* 2005	% of mean	*Cercospora Leaf Spot* 2005	% of mean	*Emerg-ence (%)* 2005	% of mean	*Aphano-myces* 2005	% of mean	*Purity (%)* 2005	% of mean
2006 APPROVED VARIETIES																		
Beta 4901R	218.01	95.94	5660.40	101.76	10.90	95.94	26.14	106.43	13.62	97.56	4.87	112.88	73.42	104.45	4.44	92.58	87.94	98.92
Beta 4930R	225.38	99.18	5544.20	99.67	11.27	99.20	24.65	100.36	13.90	99.57	3.83	88.77	72.05	102.50	4.18	87.16	88.63	99.70
Hilleshog 2411Rz	234.48	103.19	5626.60	101.15	11.72	103.16	24.16	98.37	14.28	102.29	3.79	87.85	75.29	107.11	4.93	102.80	89.33	100.48
Hilleshog 2467Rz	230.65	101.50	5622.20	101.08	11.53	101.48	24.42	99.42	14.24	102.01	5.09	117.98	72.97	103.81	4.97	103.63	88.50	99.55
HOLLY 255	228.96	100.76	5777.60	103.87	11.45	100.78	25.23	102.72	13.95	99.93	4.56	105.70	74.73	106.31	5.25	109.47	89.44	100.61
VDH H46177	228.67	100.63	5195.40	93.40	11.43	100.60	22.82	92.91	13.93	99.79	3.80	88.08	61.37	87.30	4.88	101.76	89.50	100.67
VDH H47150	224.53	98.81	5510.40	99.07	11.23	98.84	24.51	99.79	13.80	98.85	4.26	98.74	62.23	88.53	4.92	102.59	88.96	100.07
	227.24	**100.00**	**5562.40**	**100.00**	**11.36**	**100.00**	**24.56**	**100.00**	**13.96**	**100.00**	**4.31**	**100.00**	**70.29**	**100.00**	**4.80**	**100.00**	**88.90**	**100.00**
2006 SPECIALTY VARIETIES (% of Mean is of Approved Mean)																		
Beta 4811R	218.26	96.05	5515.00	99.15	10.91	96.03	25.40	103.41	13.54	96.99	4.38	101.52	70.30	100.01	3.49	72.77	88.38	99.42
2006 VARIETIES WITH ONE MORE YEAR OF SALES (% of Mean is of Approved Mean)																		
Crystal R826	219.80	96.73	4885.40	87.83	10.99	96.73	22.15	90.18	13.65	97.78	4.49	104.07	72.66	103.37	4.82	100.51	88.25	99.27
2006 TEST MARKET VARIETIES FOR LIMITED SALES (% of Mean is of Approved Mean)																		
Beta 1322	230.53	101.45	6229.80	112.00	11.53	101.48	27.07	110.21	14.23	101.93	5.43	125.86	74.28	105.67	3.41	71.11	88.47	99.52
Hilleshog 2423Rz	233.03	102.55	5463.60	98.22	11.65	102.54	23.34	95.03	14.10	101.00	3.59	83.21			4.44	92.58	89.83	101.05
VDH H46527	227.18	99.97	5532.80	99.47	11.36	99.99	24.30	98.94	13.95	99.93	4.46	103.38	75.22	107.01	4.84	100.92	88.94	100.04

2005 Southern Minnesota Beet Sugar Cooperative Variety Strip Trial Research

There were ten variety strip trials conducted in the SMBSC growing area in 2005. Eight variety strip trials were conducted in the core growing regions of the cooperative and two were conducted in the north and northwest areas. The objective of the eight strip trials located in the core area of the cooperative is to create a means to observe variety performance in shareholder fields. The purpose of the strip trials in the northern region is the same with an additional purpose to provide insight into variety performance in the predominant soil types and cropping history found in this area in the absence of Official Variety Trials.

The same six varieties were placed at each of the ten strip trial locations in 2005 in order to test these varieties across a wide selection of growing areas and conditions. All variety strip trials were planted with shareholder planters. The eight trials placed in the core growing region 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 6. The harvest of the two northern locations consisted of hand harvesting twenty - 10 foot-row samples per variety for quality analysis and estimating yield by using the sample weight over the 10 feet of harvest row. Data from the two northern area strip trials can be found on pages 7 and 8. 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 edaphic and environmental conditions at each of the sites. Two varieties at each of the northern locations were treated with a priming technique to observe if priming had an influence on overall performance in the northern growing area. These entries are denoted with the word “Prime” next to the variety name.

2005 Shareholder/Ag-Staff Variety Strip Trial Data from the Core Growing Regions of SMBSC: Combined Across Eight Locations.

Variety	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	15.30	100.31	89.40	99.69	31.99	113.44	12.61	99.92	8069.30	113.40	30.96	99.86	$990.43	113.37
HM 2463	15.20	99.69	89.76	100.10	27.90	98.94	12.60	99.81	7029.63	98.79	30.89	99.65	$862.03	98.67
ACH 352	15.16	99.42	89.33	99.62	28.33	100.46	12.48	98.89	7071.80	99.38	30.39	98.02	$860.90	98.55
HM 2467	15.75	103.29	89.61	99.93	25.75	91.31	13.05	103.40	6721.89	94.46	32.88	106.05	$846.70	96.92
Beta 4811	15.08	98.88	89.71	100.04	27.93	99.02	12.48	98.87	6968.95	97.94	30.38	97.98	$848.24	97.10
VDH 47150	15.00	98.40	90.23	100.62	27.31	96.84	12.51	99.11	6833.00	96.03	30.51	98.42	$833.34	95.39
Average:	**15.25**		**89.67**		**28.20**		**12.62**		**7115.76**		**31.00**		**873.61**	

2005 SMBSC Northern Variety Strip Trial Data - Olympic Average.

Belgrade

Variety	Stand Count	% of Mean	Sucrose (%)	% of Mean	Purity (%)	% of Mean	Yield (Ton/A)	% of Mean	ES (%)	% of Mean	ESA (lbs/A)	% of Mean	$/Ton	% of Mean	$/Acre	% of Mean
HM 2467	16.50	101.20	15.97	100.45	91.54	100.40	28.14	105.92	13.62	100.99	7663.45	107.09	35.35	101.67	$994.76	107.91
HM 2463	15.75	96.60	15.69	98.69	90.81	99.60	29.31	110.32	13.23	98.10	7753.87	108.36	33.65	96.78	$986.27	106.99
HM 2467 Prime	18.00	110.40	16.13	101.46	91.06	99.87	27.63	104.00	13.67	101.37	7553.47	105.56	35.58	102.33	$983.05	106.64
ACH 826	16.00	98.13	15.71	98.82	91.28	100.11	27.77	104.53	13.33	98.89	7405.40	103.49	34.11	98.11	$947.33	102.76
VDH 47150	15.63	95.86	15.47	97.31	91.10	99.91	28.61	107.69	13.08	97.04	7486.89	104.63	33.03	94.98	$944.85	102.49
Beta 4811	15.75	96.60	15.49	97.43	90.58	99.34	27.58	103.81	13.01	96.46	7173.96	100.25	32.68	93.99	$901.35	97.77
HM 2411	17.75	108.86	16.24	102.15	90.85	99.64	24.90	93.73	13.73	101.80	6835.91	95.53	35.83	103.05	$892.20	96.78
Beta 4901 Prime	17.13	105.06	16.31	102.59	91.65	100.52	23.54	88.61	13.94	103.42	6565.25	91.75	36.78	105.80	$865.91	93.93
Beta 1322	15.29	93.77	15.99	100.58	91.31	100.14	24.42	91.92	13.59	100.80	6637.88	92.76	35.24	101.35	$860.53	93.35
Beta 4901	15.25	93.53	15.98	100.52	91.60	100.46	23.77	89.47	13.64	101.14	6483.03	90.60	35.44	101.93	$842.40	91.38
Average:	**16.31**		**15.90**		**91.18**		**26.57**		**13.48**		**7155.91**		**34.77**		**921.87**	

2005 SMBSC Northern Variety Strip Trial Data - Olympic Average.

Starbuck

Variety	Stand Count	% of Mean	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 4811	15.50	94.24	16.07	102.36	90.90	99.63	27.84	102.84	13.58	102.02	7563.76	104.93	35.21	103.45	$980.23	106.41
Beta 4901 Prime	16.67	101.36	15.30	97.45	92.10	100.95	29.36	108.45	13.11	98.47	7699.46	106.81	33.15	97.39	$973.18	105.64
HM 2467 Prime	14.83	90.17	15.82	100.76	91.67	100.48	27.64	102.10	13.51	101.43	7465.83	103.57	34.86	102.44	$963.67	104.61
HM 2411	18.67	113.52	15.71	100.06	90.75	99.47	28.50	105.27	13.23	99.39	7543.32	104.64	33.68	98.96	$959.83	104.20
ACH 352	16.50	100.32	15.78	100.51	91.87	100.70	26.32	97.22	13.51	101.44	7109.79	98.63	34.87	102.45	$917.75	99.63
Beta 1322	16.00	97.28	15.65	99.68	91.06	99.81	27.00	99.73	13.24	99.42	7148.76	99.17	33.70	99.01	$909.85	98.77
ACH 826	17.14	104.21	15.97	101.72	91.37	100.15	25.62	94.64	13.58	102.02	6960.68	96.56	35.21	103.46	$902.08	97.93
HM 2463	16.50	100.32	15.69	99.94	91.33	100.11	25.96	95.89	13.32	100.07	6918.23	95.97	34.08	100.12	$884.60	96.03
Beta 4901	16.83	102.33	15.47	98.54	90.57	99.27	27.07	99.99	12.99	97.53	7030.65	97.53	32.60	95.77	$882.36	95.79
HM 2467	15.83	96.25	15.54	98.98	90.72	99.44	25.41	93.86	13.08	98.21	6645.47	92.19	32.99	96.93	$838.29	91.00
Average:	**16.45**		**15.70**		**91.23**		**27.07**		**13.32**		**7208.59**		**34.03**		**921.18**	

WHOLE ROTATION SOIL FERTILITY

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Sugar Beet – Corn Rotation

Introduction

New nitrogen fertilizer recommendations have been developed for sugar beet production in Minnesota and North Dakota. A study was established to confirm the recommendation and to determine the N contribution of sugar beet tops to a following corn crop. In the past soybean has been grown after sugar beet in the rotation. Since soybean is a legume, little attention was given the nitrogen that was released from sugar beet tops grown the previous year. In the future sugar beet producers will be encouraged to increase the length of their crop rotation from the common three year sugar beet – soybean – corn rotation practiced now. Information on nutrient issues for corn grown after sugar beet is needed. One of the issues is how much N credit should be given for sugar beet tops. Work in the Red River Valley indicates sugar beet tops can provide a varying amount of N for a wheat crop. The amount depends on the nitrogen status of the sugar beet crop at harvest. Green tops are credited up to 70 pounds of N per acre while yellow N deficient tops are given a 0 pound or N per acre credit. This article reports the results of the sugar beet crop grown under differing N rates in the first year of this two year study and the corn yields in the second year.

Materials and Methods

To accomplish the objective of this study, two sites were established in 2002, 2003, and 2004. Locations and year of study is listed in Table 1.

Table 1. Locations and year of study for sugar beet – corn rotation experiment.

Location	Sugar beet year	Corn year
Olivia	2002	2003
Maynard	2002	2003
Clara City	2003	2004
Hector	2003	2004
Raymond	2004	2005
Bird Island	2004	Abandoned

The first year treatments (sugar beet year) were five nitrogen fertilizer rates of 0, 40, 80, 120, and 160 pounds N per acre at all sites but the Maynard site where 0, 50, 100, 150, and 200 pounds N per acre were applied. The initial nitrate-N values to a four foot depth plus the N recommendations for each site are listed in Table 2.

Table 2. Initial soil nitrate-N and nitrogen fertilizer recommendations at the Maynard, Olivia, Clara City, Hector, Raymond, and Bird Island, Minnesota sites.

	Initial soil nitrate 0-4 ft. (lb nitrate-N/A)	N recommendation (lb N/A)
Maynard	49	81
Olivia	79	51
Clara City	104	26
Hector	54	76
Raymond	103	27
Bird Island	333	0

The fertilizer N treatments were applied early spring as urea to plots 44 ft X 44 ft in size before sugar beet was grown. The cooperators provided the planting, weed control, and fungicide applications to the sites. The studies were hand harvested early October. Root yield and quality determined at the Southern Minnesota Beet Sugar Cooperative tare laboratory. Also at harvest, sugar beet top yield was determined and sub-samples were taken and analyzed for total N. After harvest, soil samples were taken to a depth of four feet in each plot and analyzed for soil nitrate. In the fall after sugar beet harvest, the plots from the first year of the study were subdivided into 11 ft X 44 ft plots and nitrogen fertilizer as urea was applied at rates of 0, 40, 80, and 120 pounds N per acre. The fertilizer was incorporated after spreading. Corn was grown the second year and harvested for yield in September or October. Soil samples for nitrate-N were taken after corn harvest to a depth of four feet.

Results and Discussion

<u>Sugar Beet Yield and Quality in the First Year of the Rotation</u>

2002 Sites

Root yield was significantly increased with the first increment of fertilizer application (Table 3 and Table 4). The increase was 2.6 tons per acre with 50 pounds N per acre at the Maynard site (Table 3) and 5.4 tons per acre with 40 pounds N per acre at the Olivia site (Table 4). Root yields were not increased with additional N above the first increment of N application at either site.

Sucrose was reduced significantly by nitrogen fertilizer application at both sites. The average decrease was 0.38 % per 50 pounds of fertilizer N per acre at the Maynard site and 0.22 % per 50 pounds of fertilizer N per acre at the Olivia site. Purity was significantly decreased by nitrogen fertilizer application at both sites.

Table3. Root yield, root quality, and extractable sucrose for the Maynard site in 2002.

N rate	Root yield	Sucrose	Purity	Extractable sucrose	
pounds N/A	tons/A	-------- % --------		pounds/ton	pounds/A
0	26.7	18.4	92.6	320	8542
50	29.3	17.9	90.6	303	8873
100	30.8	17.3	90.4	291	8920
150	27.5	17.2	90.3	290	7955
200	31.3	16.9	89.7	282	8736
Statistics					
N rate	0.03	0.0002	0.04	0.001	0.23
C.V. (%)	8.2	2.4	1.5	4.0	8.1

Table 4. Root yield, root quality, and extractable sucrose for the Olivia site in 2002.

N rate	Root yield	Sucrose	Purity	Extractable sucrose	
pounds N/A	tons/A	-------- % --------		pounds/ton	pounds/A
0	23.1	17.4	92.2	301	6976
40	28.5	17.3	92.1	298	8475
80	28.3	16.7	90.7	282	7956
120	28.4	16.7	90.5	282	8005
160	26.7	16.7	90.4	281	7505
Statistics					
N rate	0.02	0.02	0.0001	0.01	0.03
C.V. (%)	9.3	2.4	0.7	2.9	8.5

At Maynard, the extractable sucrose per ton of sugar beet processed was reduced by 9.5 pounds per ton of processed sugar beet for every 50 pounds of N fertilizer applied per acre. The extractable sucrose per acre was not significantly affect by N fertilization.

Extractable sucrose per ton of processed sugar beet was reduced 5 pounds per ton for every 40 pounds of fertilizer N per acre applied at the Olivia site. The extractable sucrose per acre was increase by the first 40 pounds of fertilizer N per acre by 1500 pounds per acre. At both sites, the maximum recoverable sucrose per acre occurred at less amounts of soil nitrate-N plus fertilizer N than the current recommendations.

2003 Sites

Sugar beet was grown at the Hector and Clara City sites in 2003. Root yield, sucrose, extractable sucrose per ton, and extractable sucrose per ton were affected by N fertilizer application at the Hector site, Table 5. The root yield was increased to a economic maximum at 120 pounds of N per acre. This is 60 pounds N per acre greater than expected. The sucrose was decreased significantly at the 160 pounds of N per acre rate. Purity was not affected by N application. The extractable sucrose per ton decreased 3.75 pounds per ton for each 40 pounds of N applied. The optimum extractable sucrose per acre occurred at the 80 pounds N per acre N rate. This was 20 pounds more than the recommended rate.

Table 5. Root yield, root quality, and extractable sucrose for the Hector site in 2003.

N rate	Root yield	Sucrose	Purity	Extractable sucrose	
pounds N/A	tons/A	-------- % --------		pounds/ton	pounds/A
0	24.6	17.3	90.1	291	7143
40	25.0	17.5	89.9	293	7338
80	29.3	17.2	89.8	287	8381
120	29.7	17.3	89.7	288	8527
160	31.1	16.7	89.3	276	8578
Statistics					
N rate	0.03	0.05	0.45	0.06	0.07
C.V. (%)	11.9	2.2	0.8	2.9	11.8

There were not responses measured for any measured parameter at the Clara City site, Table 6. This site was severely affected by the lack of moisture in August and September of 2003. Some of the sugar beets at this location died from the drought. The drought occurred because of underlying sand lens at this site.

Table 6. Root yield, root quality, and extractable sucrose for the Clara City site in 2003.

N rate	Root yield	Sucrose	Purity	Extractable sucrose	
pounds N/A	tons/A	-------- % --------		pounds/ton	pounds/A
0	24.5	16.1	87.5	258	6422
40	24.7	15.6	87.1	248	6180
80	25.9	16.3	88.3	266	6937
120	24.1	15.9	86.9	253	6104
160	23.1	15.5	86.1	243	5649
Statistics					
N rate	0.97	0.19	0.71	0.40	0.86
C.V. (%)	29.7	2.5	2.1	5.4	23.0

2004 Sites

Sugar beet was grown at two locations in 2004. The locations were near Raymond and Bird Island, MN. The soil test nitrate-N to the four foot depth was marginal at the Raymond site and very high (333 pounds N per acre) at the Bird Island site. Sucrose and extractable sucrose per ton were significantly decreased with increasing N fertilizer application rates at the Raymond site, Table 7. Root yield, purity, and extractable sucrose per acre were not affected.

Table 7. Root yield, root quality, and extractable sucrose for the Raymond site in 2004.

N rate	Root yield	Sucrose	Purity	Extractable sucrose	
pounds N/A	tons/A	-------- % --------		pounds/ton	pounds/A
0	22.9	15.1	90.0	252	5761
40	20.3	15.2	89.4	250	5042
80	21.1	14.6	89.4	241	5094
120	21.8	14.6	89.1	239	5186
160	20.9	14.3	88.7	232	5042
Statistics					
N rate	0.47	0.005	0.24	0.009	0.21
C.V. (%)	9.6	2.4	1.0	3.4	9.8

Only purity was affected at the Bird Island site in 2004, Table 8. This decrease was 0.35 % per 40 pounds of N applied per acre. This decrease in purity did not reduce the extractable sucrose per ton or per acre. The sucrose and extractable sucrose per ton were extremely low. This was caused by the excessive amounts of residual nitrogen in the soil at this site.

Table 8. Root yield, root quality, and extractable sucrose for the Bird Island site in 2004.

N rate	Root yield	Sucrose	Purity	Extractable sucrose	
pounds N/A	tons/A	-------- % --------		pounds/ton	pounds/A
0	23.2	13.6	88.2	218	5045
40	24.2	13.9	87.5	221	5357
80	24.6	13.9	88.0	223	5473
120	26.4	13.6	86.9	214	5653
160	25.2	13.7	86.8	216	5432
Statistics					
N rate	0.44	0.36	0.03	0.35	0.58
C.V. (%)	11.0	2.3	0.9	3.4	10.8

Top Dry Matter, Top N Concentration, and Top N Content

2002 sites

The application of N fertilizer significantly increased top yield, N concentration, and N content at the Maynard site (Table 9). The top yield ranged from 4299 pounds per acre for the check sugar beet tops to 7104 pounds per acre for the 200 pounds N per acre treated sugar beets. The N concentrations ranged from 1.84 % for check sugar beet tops to 2.57 % for sugar beets grown with an extra 200 pounds N per acre. The resulting N contents of the sugar beet tops returned to the soil range from 79 pounds N per acre for the check beets to 184 pounds per acre for the beets grown with 200 pounds fertilizer N per acre.

Table 9. Top dry matter yield, nitrogen concentration, and nitrogen content for the Maynard site in 2002.

N rate	Top dry matter yield	N concentration	N content
pounds N/A	pounds dry matter/A	%	pounds N/A
0	4299	1.84	79
50	5046	2.05	104
100	5907	2.45	144
150	6410	2.43	154
200	7104	2.57	184
Statistics			
N rate	0.04	0.002	0.004
C.V. (%)	21.5	9.8	24.7

At Olivia, yield, N concentration, and N content of sugar beet tops were also increased by the addition of fertilizer N (Table 10). The top yield and N content at Olivia were considerably less than the top yield and N content at Maynard. The top yield increased from 2349 pounds per acre for the check sugar beet tops to 3205 pounds per acre for sugar beet tops treated with 160 pounds N per acre. The N content increased from 56 to 96 pounds N per acre from the check to 160 pound N treatments. The N concentrations at Olivia were greater than at Maynard. The N concentrations for the zero N plots were 2.37 % while the beets treated with 160 pounds N per acre had N concentrations of 3 %.

Table 10. Top dry matter yield, nitrogen concentration, and nitrogen content for the Olivia site in 2002.

N rate	Top dry matter yield	N concentration	N content
pounds N/A	pounds dry matter/A	%	pounds N/A
0	2349	2.37	56
40	2824	2.23	63
80	2754	2.61	72
120	3140	2.88	90
160	3205	3.00	96
Statistics			
N rate	0.07	0.002	0.002
C.V. (%)	15.2	8.2	16.2

2003 Sites

Nitrogen fertilizer application increased the amount of top yield and the N content in the tops at the Hector location is 2003, Table 11. Top yield was increased from 2639 pounds per acre to 3647 pounds per acre with the application of 120 pounds N per acre. The N content in the tops increased from 48 pounds with zero N application to 74 pound per acre with 160 pounds N per acre applied. The N concentration of the sugar beet tops were not significantly affected by the application of N fertilizer.

Table 11. Top dry matter yield, nitrogen concentration, and nitrogen content for the Hector site in 2003.

N rate	Top dry matter yield	N concentration	N content
pounds N/A	pounds dry matter/A	%	pounds N/A
0	2639	1.84	48
40	2458	1.72	43
80	3331	1.76	60
120	3647	1.75	64
160	3625	2.03	74
Statistics			
N rate	0.04	0.40	0.06
C.V. (%)	22.1	14.7	28.8

The use of N fertilizer did not affect the top yield, N concentration, or N content at Clara City in 2003, Table 12. As noted with the root yield and quality results, the droughty conditions affected these results.

Table 12. Top dry matter yield, nitrogen concentration, and nitrogen content for the Clara City site in 2003.

N rate	Top dry matter yield	N concentration	N content
pounds N/A	pounds dry matter/A	%	pounds N/A
0	3322	2.69	74
40	3494	2.78	95
80	3943	1.98	80
120	2782	2.49	65
160	2051	2.81	55
Statistics			
N rate	0.56	0.19	0.64
C.V. (%)	45.5	16.8	46.0

2004 Sites

The application of nitrogen in 2004 to the sugar beet crop did not significantly increase the amount of top growth at the Raymond site, Table 13. The N concentration and uptake in the tops was significantly increased with the increased application of nitrogen.

Table 13. Top dry matter yield, nitrogen concentration, and nitrogen content for the Raymond City site in 2004.

N rate	Top dry matter yield	N concentration	N content
pounds N/A	pounds dry matter/A	%	pounds N/A
0	5428	1.93	104
40	5013	2.09	106
80	6233	2.48	156
120	5384	2.40	131
160	6169	2.79	170
Statistics			
N rate	0.17	0.03	
C.V. (%)	15.5	17.0	25.3

<u>Residual nitrate-N</u>

Soil nitrate-N was measured from soil samples taken after sugar beet harvest at each site. At the Maynard, Olivia, Hector, and Raymond sites, there were no differences in residual soil nitrate caused by the fertilizer treatments applied in the spring, Table 14. At the Clara City the residual nitrate-N was elevated in the plots with the 120 and 160 pound N per acre treatments.

Table 14. Residual soil nitrate-N for the 0–4 ft. depth at the Maynard, Olivia, Hector, Clara City, and Raymond sites the fall after sugar beet production and before corn production.

N rate	Maynard*	Olivia	Hector	Clara City	Raymond
lb N/acre	---------------------- lb nitrate-N/acre 0-4 ft. ------------------------				
0	43	42	33	100	24
40	40	35	30	85	22
80	43	39	37	104	36
120	53	41	36	190	32
160	45	42	36	182	39

Whole Rotation Fertility Results for Corn Produced following Sugar Beet

Corn grain yields were increased from the top N and fertilizer N at the Olivia and Hector sites, Table 15. Corn yields were not affected by any treatments at the Maynard and Clara City. At the Olivia site, corn grain yields were increased by the year 1 treatment up to 80 pounds N per acre, Table 16. The residual nitrate-N was very small so the N came from the sugar beet tops. The optimum corn grain yield was at the 80 pounds N per acre from the year 2 treatment. At Hector, the greatest corn grain yield occurred with the year 1 treatment of 160 pounds N per acre and the year 2 treatment of 120 pounds per acre. This is considerably greater than the amount expected. The growing season of 2004 had conditions for N loses to denitrification in May. In 2005, the corn grain yield was only increased by the N fertilizer applied before the corn was grown. There was no effect from the nitrogen from the tops of the 2004 sugar beet crop.

Table 15. Statistical analysis for corn yield following sugar beet at Olivia and Maynard in 2003, Clara City and Hector in 2004, and Raymond in 2005.

	Olivia	Maynard	Hector	Clara City	Raymond
Factor	Probability of a greater F				
Yr1	0.0001	0.27	0.03	0.64	0.79
Yr2	0.0006	0.46	0.0001	0.13	0.0004
Yr1*Yr2	0.73	0.37	0.35	0.37	0.28
C.V. (%)	7.7	11.5	7.3	9.3	8.2

Table 15. Sugar beet top N content, corn grain yield for Olivia, Hector, and Raymond sites.

	Olivia 2002-2003		Hector 2003-2004		Raymond 2004-2005	
Year 1 treatment	Beet top N content	Corn grain yield	Beet top N content	Corn grain yield	Beet top N content	Corn grain yield
N rate (lb/acre)	lb N/acre	bu/acre	lb N/acre	bu/acre	lb N/acre	bu/acre
0	56	139	48	170	104	237
40	63	161	43	174	106	233
80	72	183	60	177	156	227
120	90	165	64	189	131	229
160	96	152	74	192	170	235
Year 2 treatment						
N rate (lb/acre)						
0		152		166		218
40		155		174		232
80		167		184		240
120		163		194		240

Summary

The results from four of the five sugar beet sites confirm the new N recommendations adopted in 2001. The Hector location required an additional 20 pounds N per acre more than the recommended amount for optimum extractable sucrose per acre. These sites have also set up conditions to test the effect of N credit from the sugar beet tops returned to the soil for the next corn crop. The fall soil nitrate-N test results indicate no differences in residual soil nitrate-N as a result of the previous N fertilizer treatment applications to the sugar beet crop. The increase at the Clara City site was a result of droughty conditions near the end sugar beet growing season.

Corn grain yields were affected by N treatments at three of the five sites. The corn grain yields at two of the three responsive sites were increased by N in the sugar beet tops and fertilizer N applied before corn production. At the Raymond in 2005, corn grain yield was only increase by the application N fertilizer before corn production. It can be concluded from this study that it is difficult to put a value on nitrogen contained in sugar beet tops from the previous crop for corn production in Southern Minnesota. This variability could be attributed to the amount of organic matter in the soils or the differences in climate during the study. In 2003, there were droughty conditions in August and September before harvest while in 2004 and 2005 there was significant rain in late May causing some N loses and better than normal growing conditions in September for corn growth.

Nitrogen Management with Sugar Beet Varieties as Influenced by Rhizomania

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Justification of Research:

The influence of nitrogen and rhizomania on sugar beet production throughout the sugar industry has been well documented. However, the interaction between nitrogen and rhizomania needs to be investigated. Varieties resistant to rhizomania tend to give low quality and high tonnage. The management of these varieties for increased quality giving greater sugar production per acre is essential to the survival of the sugar beet industry. To manage for maximum sugar production in the presence of rhizomania one needs to correctly apply the appropriate quantity of nitrogen, and understand the influence of the rhizomania complex and resistant cultivars on nitrogen uptake, and assimilation.

The lack of knowledge in reference to the adverse effect of the rhizomania disease complex on nitrogen management in sugar beets emphasizes the need for evaluation. Current nitrogen recommendations on sugar beet were made in the absence of both Rhizomania and rhizomania cultivars. Nitrogen studies conducted with cultivars of varying resistance and in the presence of the rhizomania complex could significantly add to the knowledge needed to manage nitrogen.

Nitrogen management with rhizomania resistant varieties in the presence of rhizomania has primarily occurred in light textured soils which characteristically give high quality sugar beet production. Recent, detection of the rhizomania disease has been in areas of soils with higher soil quality (higher organic matter and moisture) which adds some difficulty to nitrogen management. Producing sugar beets of high quality in the presence of rhizomania will be much more difficult in these areas. Therefore, to manage nitrogen in the presence of rhizomania, rhizomania resistant varieties, high organic matter, and high moisture, one needs to possess a greater understanding of the nitrogen/rhizomania complex interaction.

Objectives:

1. Determine correct nitrogen fertilizer management practices in the presences and absence of Rhizomania.
2. Determine nitrogen fertilizer management as influenced by varieties with varying degrees of Rhizomania resistance.
3. Determine nitrogen fertilizer management in relation to the degree of Rhizomania disease pressure.
4. Determine information necessary for diagnostic delineation between Rhizomania and nitrogen deficiencies via crop canopy reflectance.

Materials and Methods:

To meet above mentioned objectives, small plot studies were conducted in the Southern Minnesota Beet Sugar Cooperative growing area during the 2003, 2004, and 2005 growing seasons. The treatments included a factorial arrangement of three to six nitrogen fertility levels and three sugar beet varieties. The nitrogen levels were based on the soil test nitrate-N in the surface four feet plus fertilizer N applied. The residual soil nitrate-N level was 56 pounds per acre all three 2003 sites. The N levels at the three locations in 2003 were 56, 70, 90, 110, and 130 pounds N per acre. In 2004 the residual nitrate-N levels were different at each of the three sites. The residuals in 2004 were 90, 110, and 70 at the Maynard, Cosmos, and Raymond site, respectively. The N levels were 90, 110, 130, and 150 at Maynard, 110, 130, and 150 at

Cosmos, and 70, 90, 110, 130, and 150 at Raymond. In 2005, the residual soil nitrate-N was 54, 54, and 47 pounds N per acre at the Buffalo Lake, Clara City, and Raymond sites, respectively. The levels were 54, 70, 90, 110, 130, and 150 pounds of soil nitrate-N in the surface 4 feet plus fertilizer N applied at the Buffalo Lake and Clara City sites. The nitrogen levels at the Raymond site were 47, 90, 110, 130, and 150 pounds nitrate-N in the surface 4 feet plus fertilizer N. The nitrogen fertilizer source was urea (45-0-0). The varieties represented different resistance levels to rhizomania and relative quality. We used non-resistant-high quality, resistant-high quality, and resistant-low quality varieties. The treatments were applied in a split plot design with the N levels as the whole plots and varieties as the split plot with five replications. At harvest, sugar beet top samples were taken from each plot to determine the top yield and N uptake of the tops to evaluate the effect of N levels and varieties on plant nitrogen dynamics. The plots were harvested to determine root yield, sucrose concentration, and purity. To assess the N assimilation differences caused by rhizomania varieties, soil samples were taken to a depth of 4 feet and analyzed for nitrate-N after harvest.

Results and Discussion:

Root yield – The application of nitrogen fertilizer significantly increased root yield at six of the nine site-years in this study. At three of the six site years with a response, there was no interaction between the varieties and the response to N fertilizer application. The root yield responses at Prinsburg 03, Raymond 03 and Clara City 05 sites are shown in Figure 1. The optimum soil nitrate-N (0-4 ft.) plus fertilizer N for all three sites was at 120 lb N per acre.

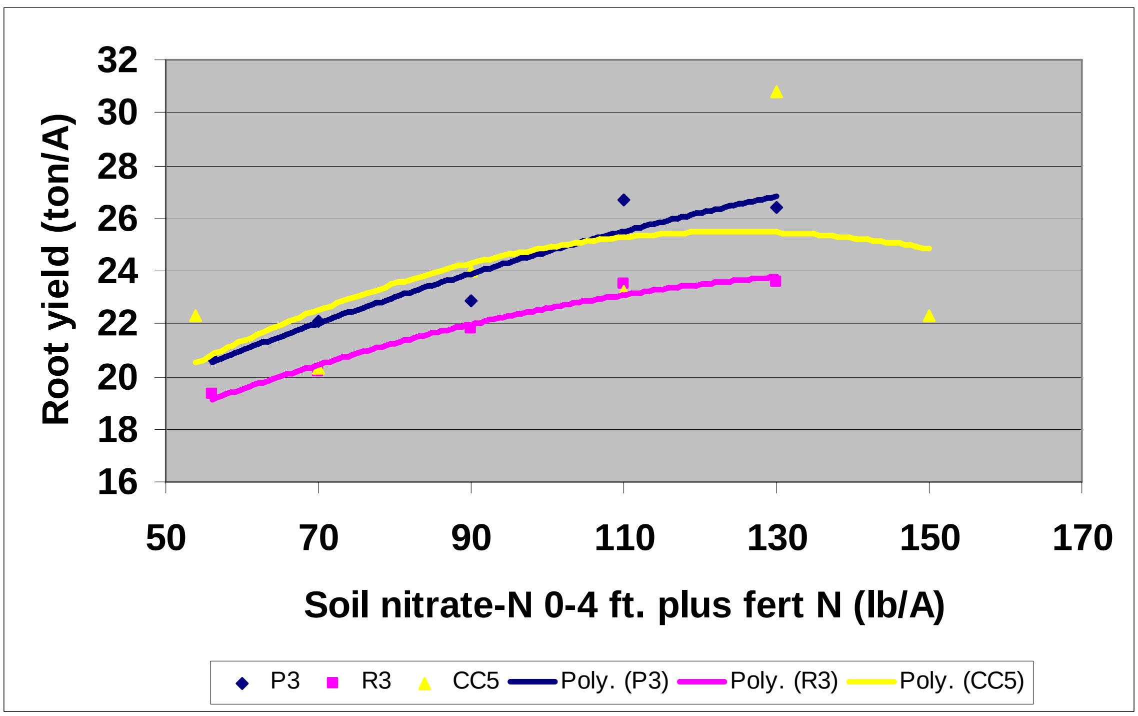


Figure 1. Root yield response to nitrogen at Prinsburg 03, Raymond 03, and Clara City 05.

The root yield response to nitrogen application at the Hector 03 site was affected by variety, Figure 2. The root yield for the non-resistant (NR) and resistant low quality (RLQ) varieties was increased by the application of nitrogen similarly. The maximum root yield occurred at 120 lb nitrate-N (0-4 ft.) plus fertilizer N per acre. This is similar to the sites that were not affected by a variety by N application interaction. The root yield of the resistant high quality (RHQ) variety was not increased by the application of nitrogen at this site.

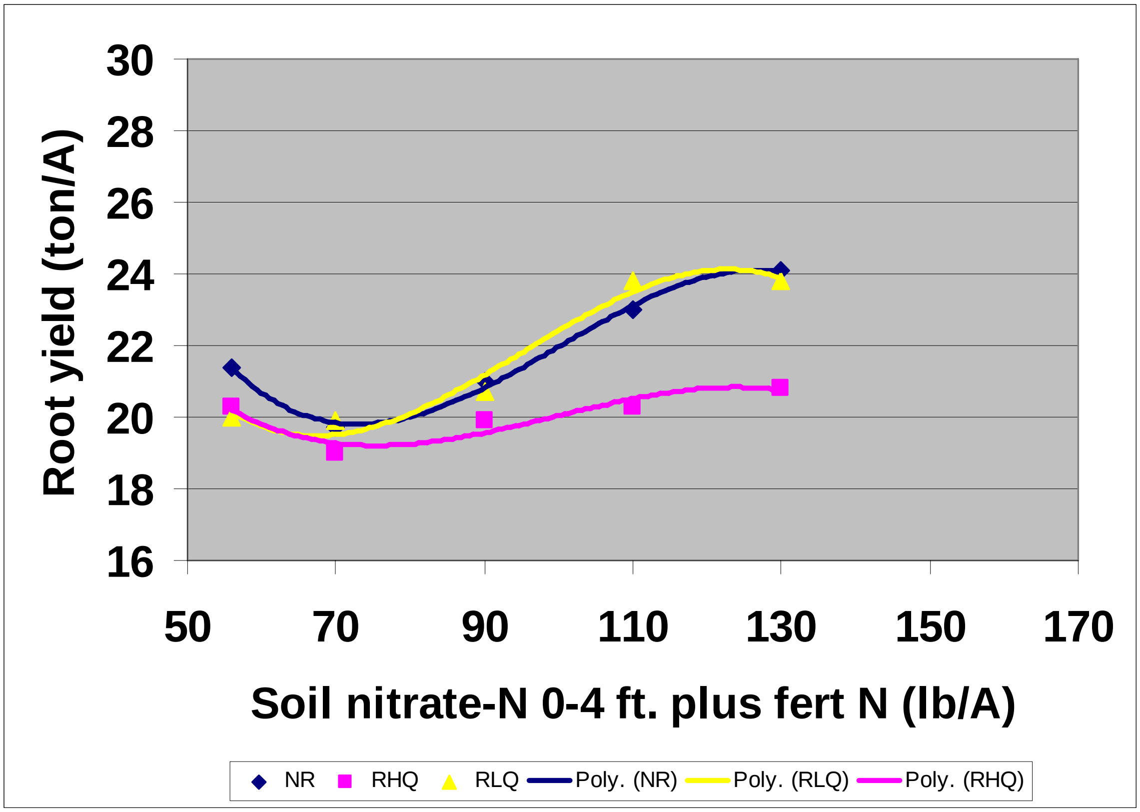


Figure 2. Root yield as affected by nitrogen and variety at the Hector 03 site.

Root yield at the Raymond 04 (Figure 3) and Raymond 05 (Figure 4) was increased by nitrogen application to all varieties. At both sites, the interaction between variety and N application was caused by maximum root yield being obtained at different nitrogen application amounts. The NR variety at both sites required less nitrogen for maximum root yield and had lower maximum root yields than the resistant varieties (RHQ and RLQ). The nitrogen application for maximum root yield for the NR variety was between 90 and 110 pounds soil nitrate-N (0-4 ft.) plus fertilizer per acre. At the Raymond 04 site (Figure 3), the two resistant varieties had a maximum root yield at 125 soil nitrate-N (0-4 ft.) plus fertilizer per acre. The RLQ variety required 130 soil nitrate-N (0-4 ft.) plus fertilizer per acre for maximum root yield while the RHQ require only 110 soil nitrate-N (0-4 ft.) plus fertilizer per acre at the Raymond 05 site, Figure 4.

Root sucrose - Root sucrose concentration was significantly affected at only two of the nine site years in this study. Variety did not affect the sucrose concentration response to the application of nitrogen at either site. Sucrose concentration was increased by the application of nitrogen at the Hector 03 site, while the sucrose concentration at the Buffalo Lake 05 site was decreased, Figure 5.

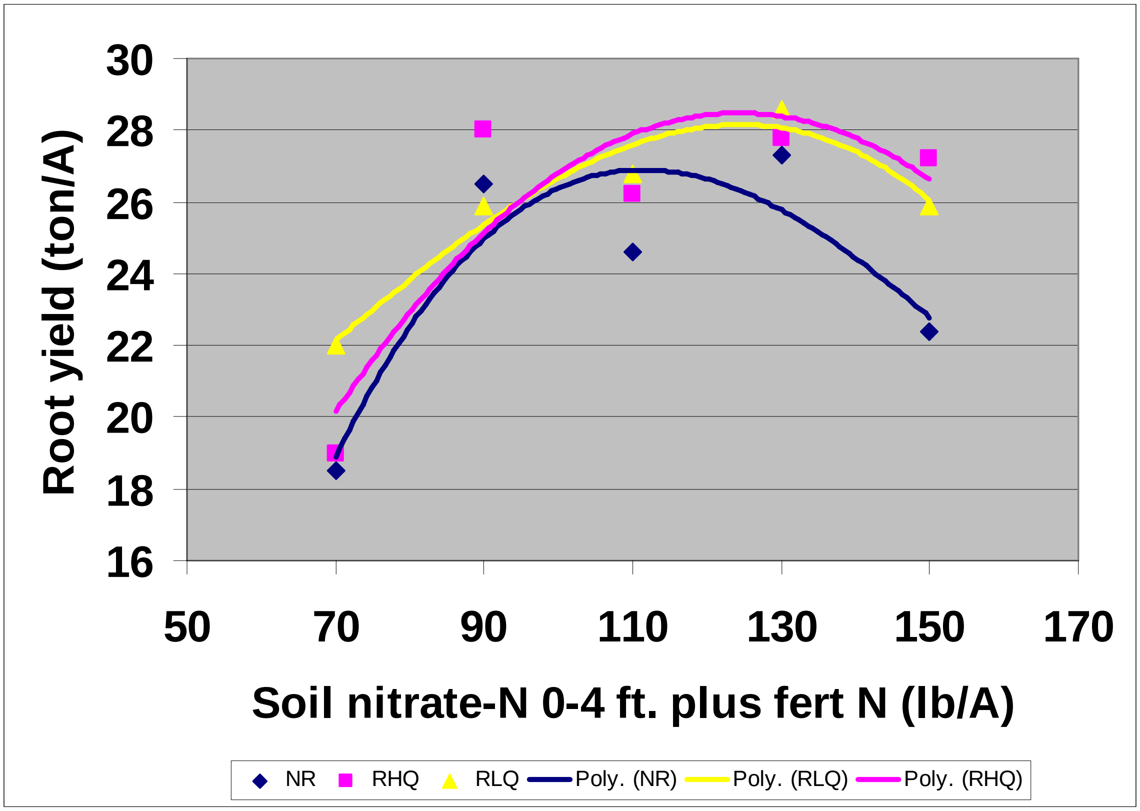


Figure 3. Root yield response to nitrogen application as affected by variety at the Raymond 04 site.

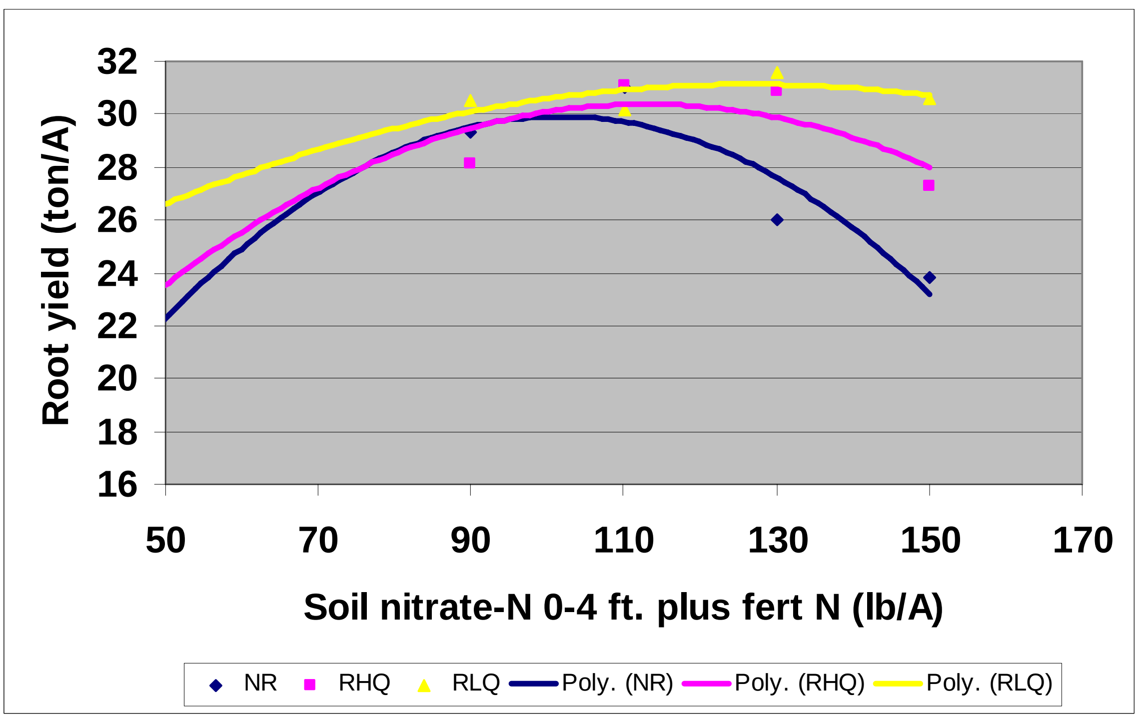


Figure 4. Root yield response to nitrogen application as affected by variety at the Raymond 05 site.

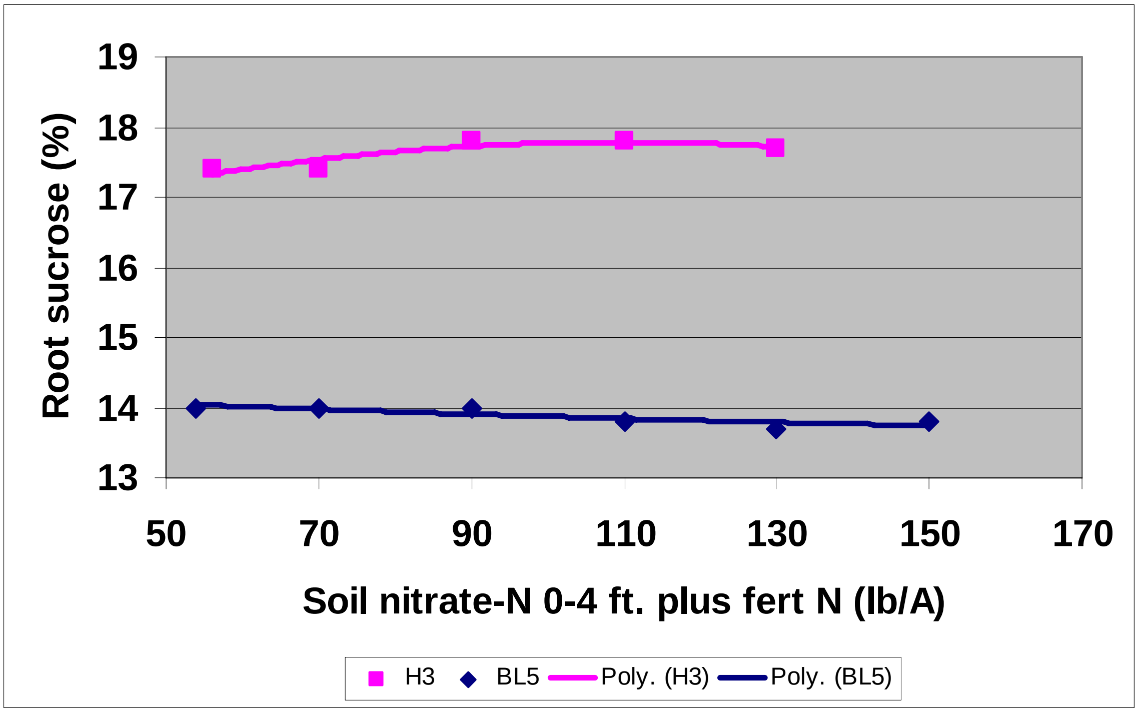


Figure 5. Root sucrose concentration as affected by nitrogen application at the Hector 03 and Buffalo Lake 05 sites.

Extractable sucrose - Extractable sucrose per acre was increase by nitrogen application at six of nine sites in this study. At two of the six N responsive sites, there was an interaction with the variety similar to the results reported for root yield. The four sites where there was no interaction with variety (Prinsburg 03, Hector 03, Raymond 03, and Clara City 05), extractable sucrose per acre was increased by the application of nitrogen, Figure 6. The maximum extractable sucrose per acre occurred at 120 soil nitrate-N (0-4 ft.) plus fertilizer per acre.

Extractable sucrose per acre response to nitrogen at the Raymond 04 (Figure 7) and Raymond 05 (Figure 8) sites were affected by variety. At both sites the NR variety had the maximum extractable sucrose at a less N application than the resistant varieties (RLQ and RHQ). At the Raymond 04 site the maximum N application for the NR variety was 105 soil nitrate-N (0-4 ft.) plus fertilizer per acre while at the Raymond 05 site the N level was 110 soil nitrate-N (0-4 ft.) plus fertilizer per acre. The RLQ required more N to maximize extractable sucrose than the RHQ variety at the Raymond site, 130 vs. 120 soil nitrate-N (0-4 ft.) plus fertilizer per acre (Figure 7). At the Raymond 05 site, Figure 8, the RLQ and RHQ varieties extractable sucrose responded similarly to N application with a maximum occurring at 110 soil nitrate-N (0-4 ft.) plus fertilizer per acre.

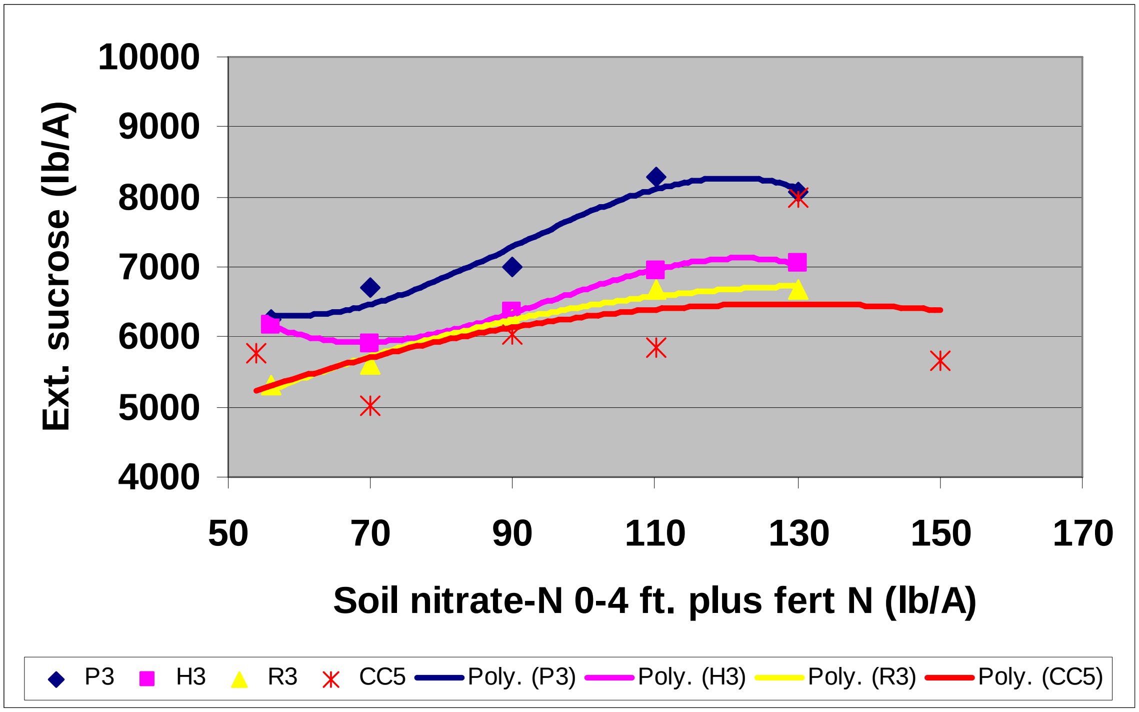


Figure 6. The effect of nitrogen application on extractable sucrose per acre at the Prinsburg 03, Hector 03, Raymond 03, and Clara City 05 sites.

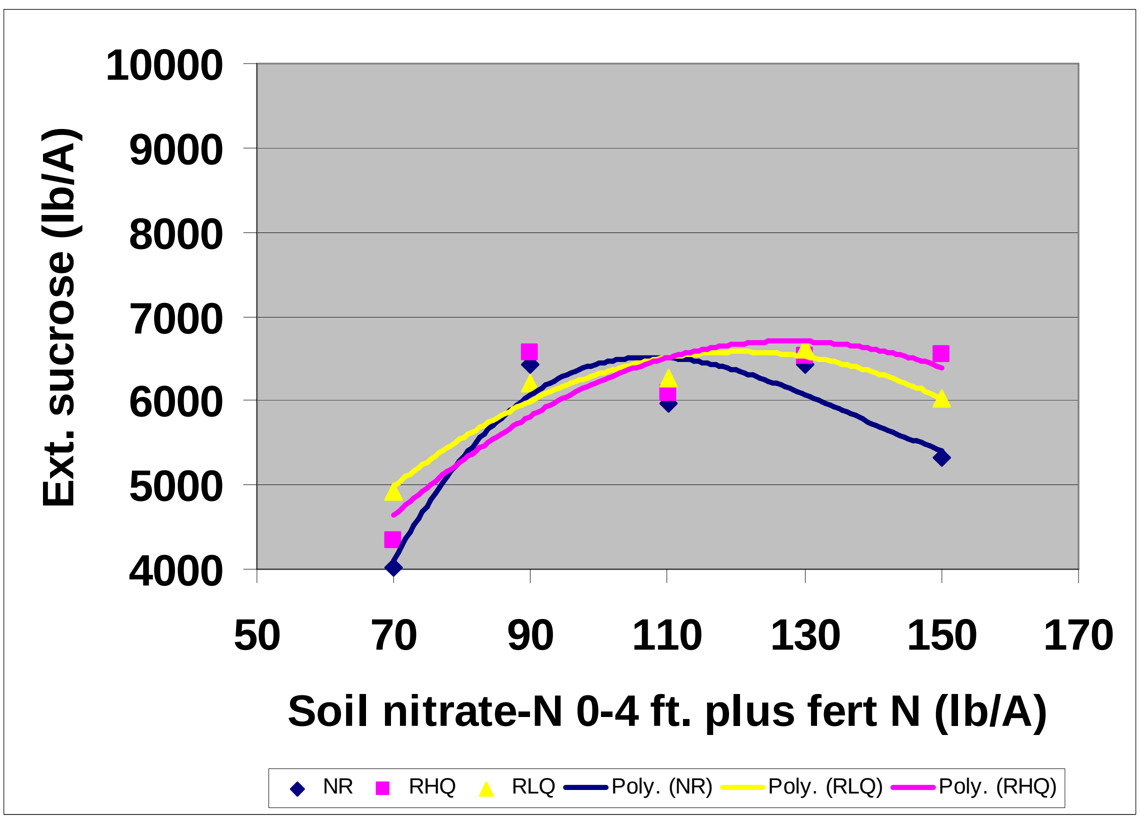


Figure 7. The effect of variety and N application on extractable sucrose per acre at the Raymond 04 site.

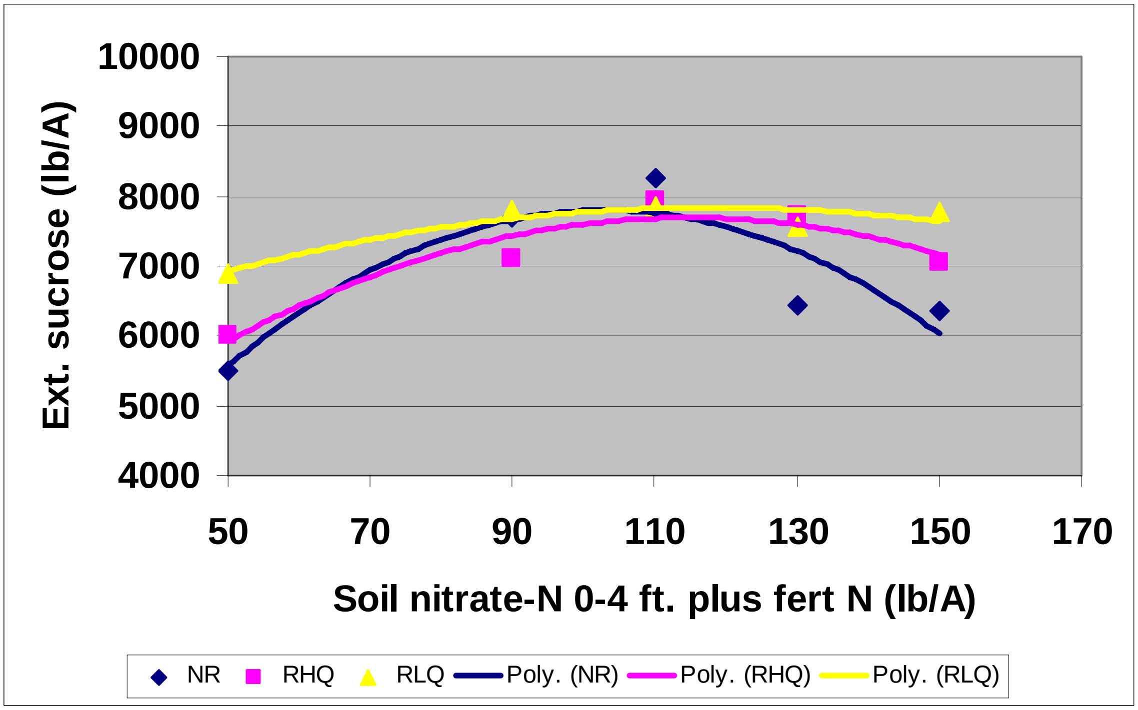


Figure 8. The effect of variety and N application on extractable sucrose per acre at the Raymond 05 site.

Residual soil nitrate-N – Soil nitrate-N was measured to a depth of four feet in one foot increments in this study. The results for each depth and the total amount of nitrate-N in the surface 4 feet were similar. Table 1 reports the amount of nitrate-N in the surface 4 feet. There was not difference in the amount of the soil nitrate-N after the sugar beet root was harvest between the different varieties. The amount of soil nitrate-N after harvest was not affected by application rate of nitrogen either.

Table 1. Soil nitrate-N in the surface 4 feet, 2003, 2004, and 2005.

	Soil nitrate-N plus fert. N	Prinsburg 2003	Hector 2003	Raymond 2003	Maynard 2004	Cosmos 2004	Raymond 2004	Buffalo Lake 2005	Clara City 2005	Raymond 2005
Variety	lb/A	---------------------------------- Soil nitrate-N in surface 4 feet (lb/A) --------------------------------								
	47									18
	56	54	45	45				18	12	
	70	43	48	48			19	17	14	
	90	40	44	47	19		18	16	12	16
	110	39	44	55	20	19	18	18	12	16
	130	45	36	44	20	20	17	17	12	18
	150				17	23	19	19	12	18
Nonresistant		46	44	47	18	20	18	17	13	18
Resistant high quality		39	42	47	19	20	18	18	12	17
Resistant low quality		47	43	50	19	20	18	18	12	17

<u>Summary</u>

The objective of this study was to determine if rhizomania resistant varieties required different nitrogen application recommendation than the non-resistant varieties that were used to develop the current nitrogen guidelines. Another goal was to conduct the study at sites that had either the presence or no presence of the disease. All locations had a medium to heavy occurrence of disease.

Root yield was increased at six of the nine sites in this study. At three of those sites the root response to nitrogen was not affected by the variety used. At the two of the three sites where the root yield response to nitrogen was different between the varieties, the non-resistant variety required less nitrogen for maximum root yield than the resistant varieties.   The maximum root yield at those two sites for the resistant varieties was greater than the non-resistant variety. For optimum root yield, there is reason to change the current N guidelines.

Root sucrose was only affected at two of the nine sites. The effect of N application was mixed with one site increasing sucrose concentration with N application to about 110 pounds of nitrate-N (0-4 ft.) plus fertilizer N and then decreasing. The sucrose concentration at the other site was reduced by increasing addition of fertilizer N.

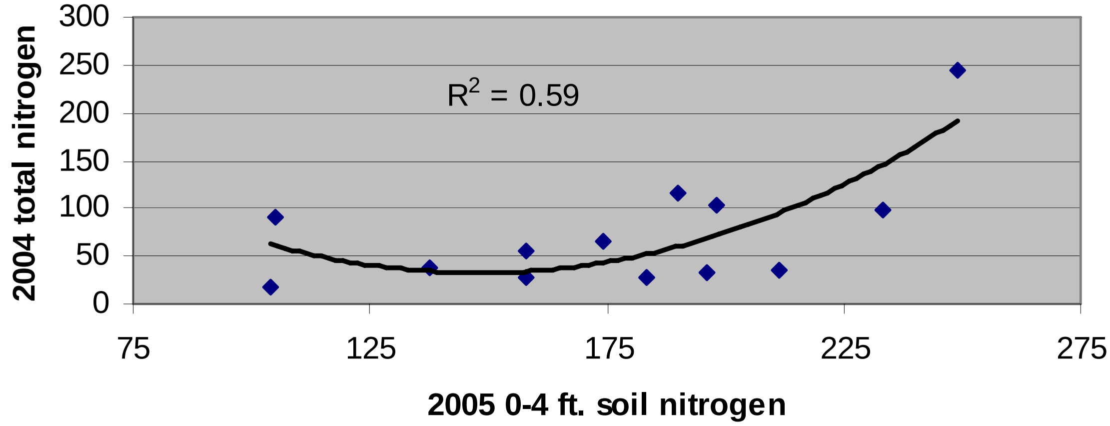
Extractable sucrose per acre was increased by N application at six of the nine sites. The extractable sucrose per acre response to N application was affected by variety at only two of those sites. The amount of soil nitrate-N (0-4 ft.) plus fertilizer N needed for maximum extractable sucrose per acre was 120 lb per acre at the four sites. At the two sites where the variety caused a difference in the extractable sucrose per acre response to nitrogen application, the non-resistant variety (NR) required less nitrogen for maximum extractable sucrose than the resistant varieties (RLQ and RHQ). The maximum amount of extractable sucrose was similar for the three varieties at the two sites.

Residual soil nitrate-N was not affect by variety or N application at any site in this study. This and N uptake in the plant tops (data not shown) indicates that under field conditions, there were no differences in use of nitrogen by the different varieties, resistant or non resistant. This information would indicate that there is no need to adjust nitrogen applications rates because of the variety, resistant or non-resistant.

Nitrogen management for sugar beets in a rotation with sweet corn and the influence of organic matter

In 2004 testing was initiated in three fields which had a cropping sequence of soybeans, sweet corn and sugar beets. This investigation was initiated after the soybean crop. The testing considered the influence of nitrogen management throughout the rotation on residual soil nitrogen and sugar beet production. The data presented in this discussion will be from all three sites combined. Figure 1 shows the influence of total nitrogen (residual soil nitrogen plus applied nitrogen) in the previous crop on 0-4 ft. soil nitrogen in the proceeding crop year. The graph shows an R^2 of .59 which indicates a relationship of nitrogen applied in the previous crop to residual soil nitrogen. Although this is not a strong relationship, the polynomial curve applied to the data shows a definite trend for higher applied nitrogen levels in the previous crop to increase the soil residual nitrogen in the proceeding crop.

Figure 1. 2005 0-4 ft. soil nitrogen as influenced by 2004 total nitrogen



In reviewing data, the one variable that showed a dynamic influence over time was organic matter. Organic matter reported was from the 0-.5 ft zone of the soil profile. In the first year of testing (2004 following soybeans) the relationship of organic matter to soil residual nitrogen was not strong (Figure 2). As with the total nitrogen in the previous crop there was a definite trend, showing the influence of higher organic matter giving higher residual nitrogen. The relationship of organic matter to residual soil nitrogen was much stronger in the 0-.5 ft zone of the soil profile (0.49 R^2) compared to the 0-2 ft. (Figure 3) zone of the soil profile (0.27 R^2) in the 2004 testing.

Figure 2. 2004 0-.5 ft. soil N as influenced by O.M.

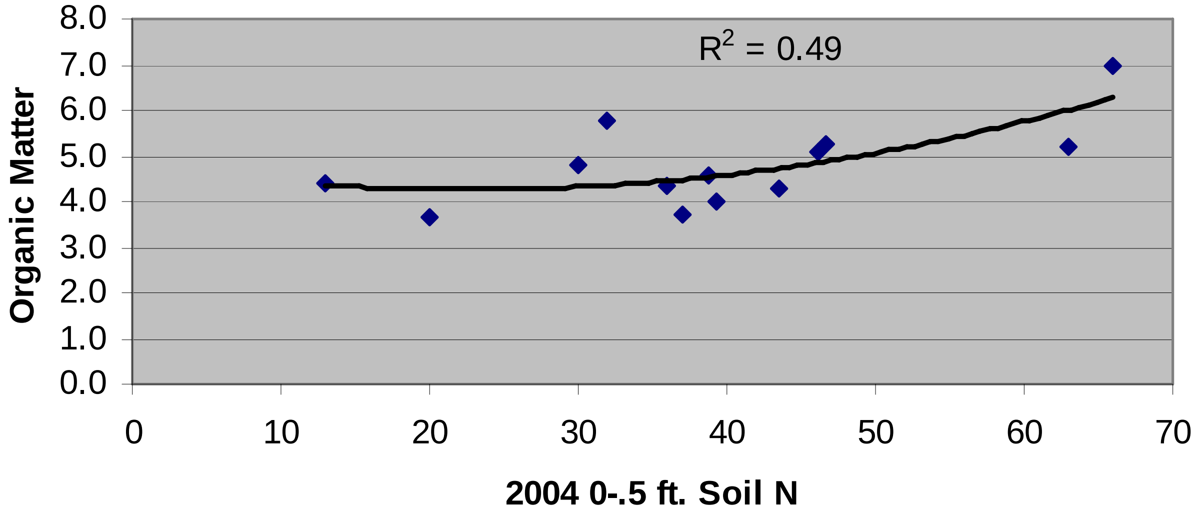
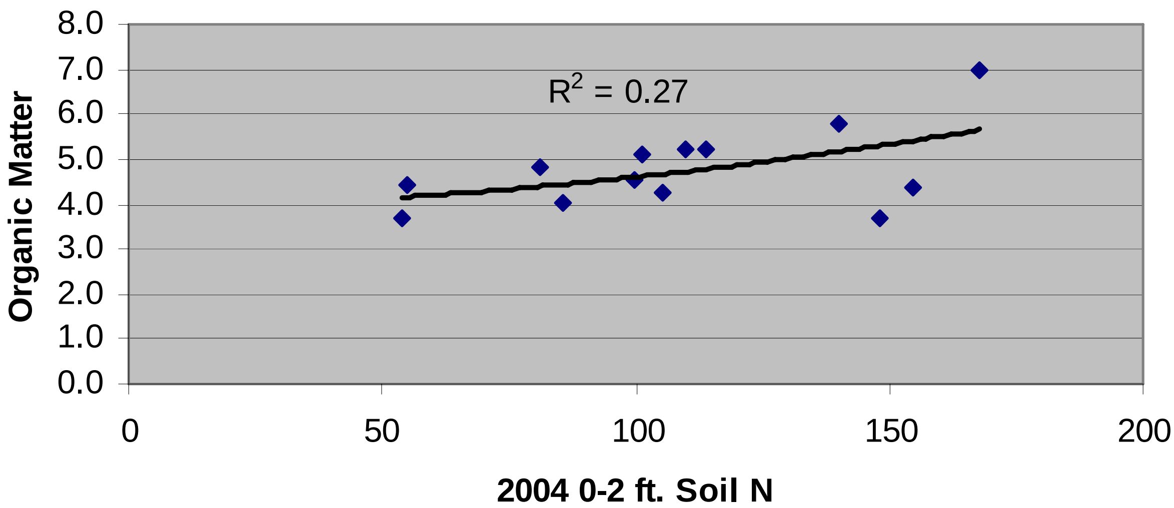


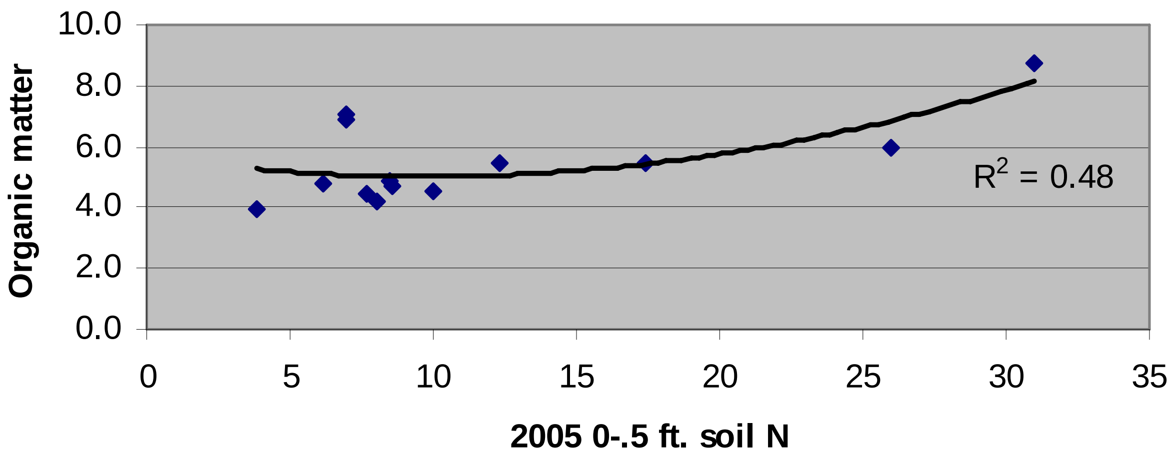
Figure 3. 2004 0-2 ft. soil N as influenced by O.M.

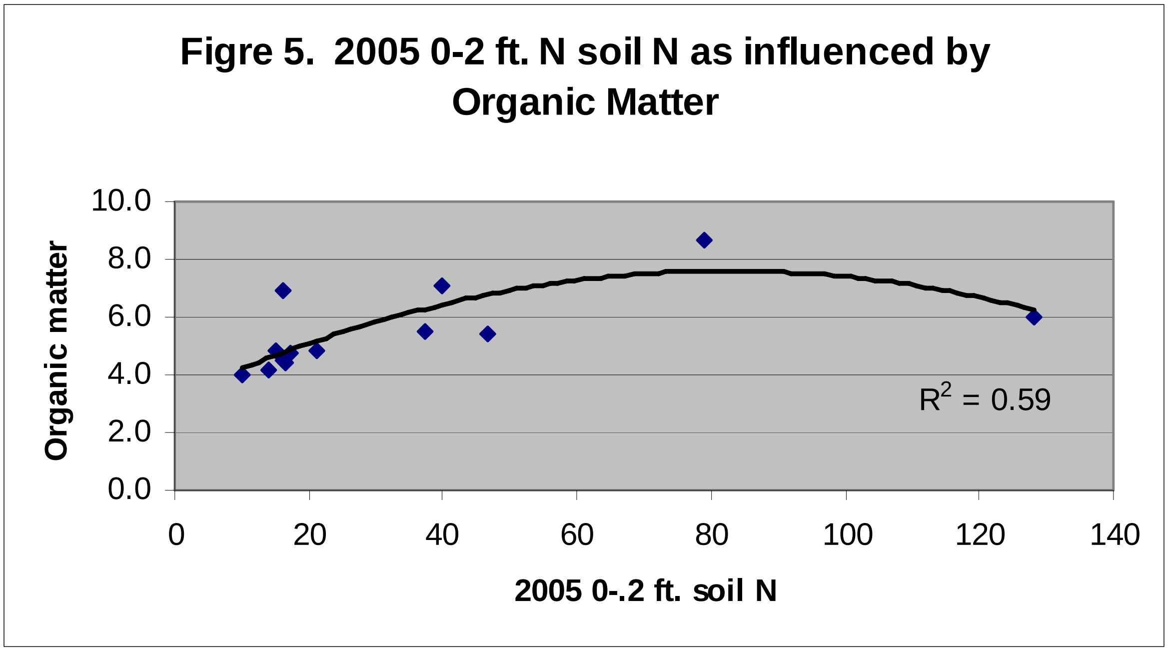


The relationship of organic matter to residual soil nitrogen changed dramatically (Figure 4-5) in the second year of testing (2005 following sweet corn). The soil nitrogen in the 0-.5 ft soil profile relationship to organic matter remained the same in the second year as it was in the first year; although, the relationship of soil nitrogen in the 0-2 ft soil profile to organic matter increased from R^2 0.27 to R^2 0.59. The relationship of soil nitrogen in the 0-4 ft profile to organic matter gave a relationship of 0.72 R^2 (Figure 6). This indicates that soil nitrogen, either applied or mineralized, moved into the deeper soil profile. One could also theorize that the organic matter in the deeper soil profile may have mineralized and mineralized nitrogen adhered to the soil parent material being a finer textured soil in the deeper soil profile.

The management of nitrogen has a significant influence on mineralization and diffusion of nitrogen throughout the profile. Mineralization is enhanced by various factors and one of the controllable factors is the availability of nitrogen. The availability of nitrogen is controllable by the management of commercial nitrogen applied. There are other variables that do influence the mineralization within soils but these are much less controllable than the influence of nitrogen.

Figure 4. 2005 0-.5 ft. soil N as influenced by Organic Matter




Figre 5. 2005 0-2 ft. N soil N as influenced by Organic Matter
Organic matter
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
140
R2 = 0.59
2005 0-.2 ft. soil N

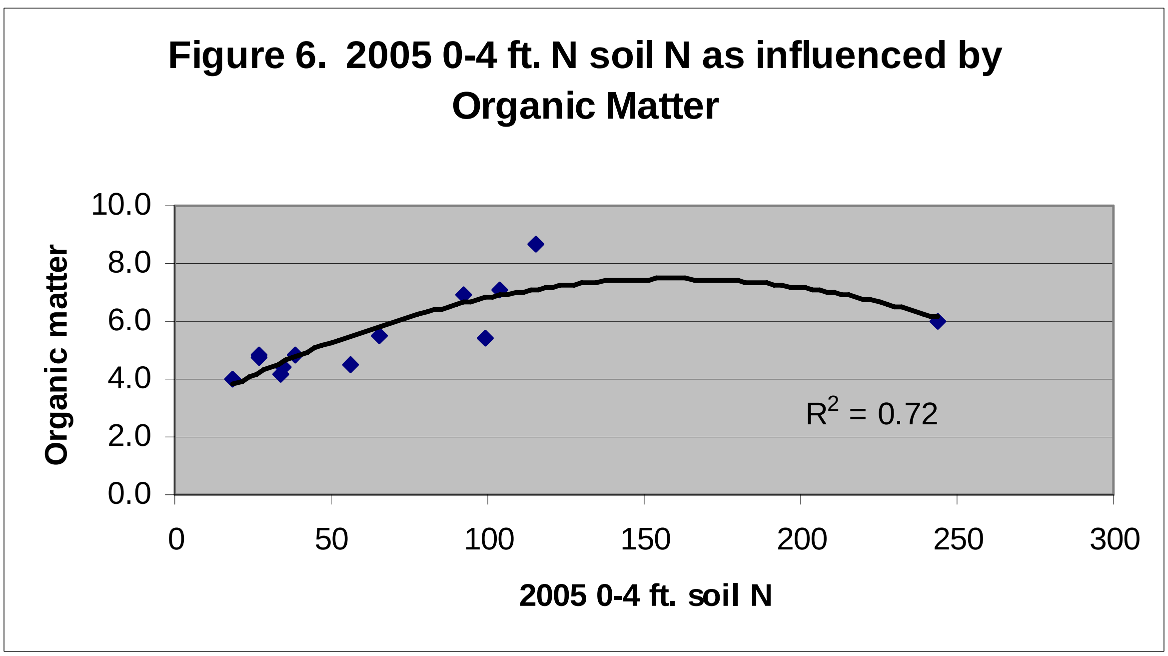
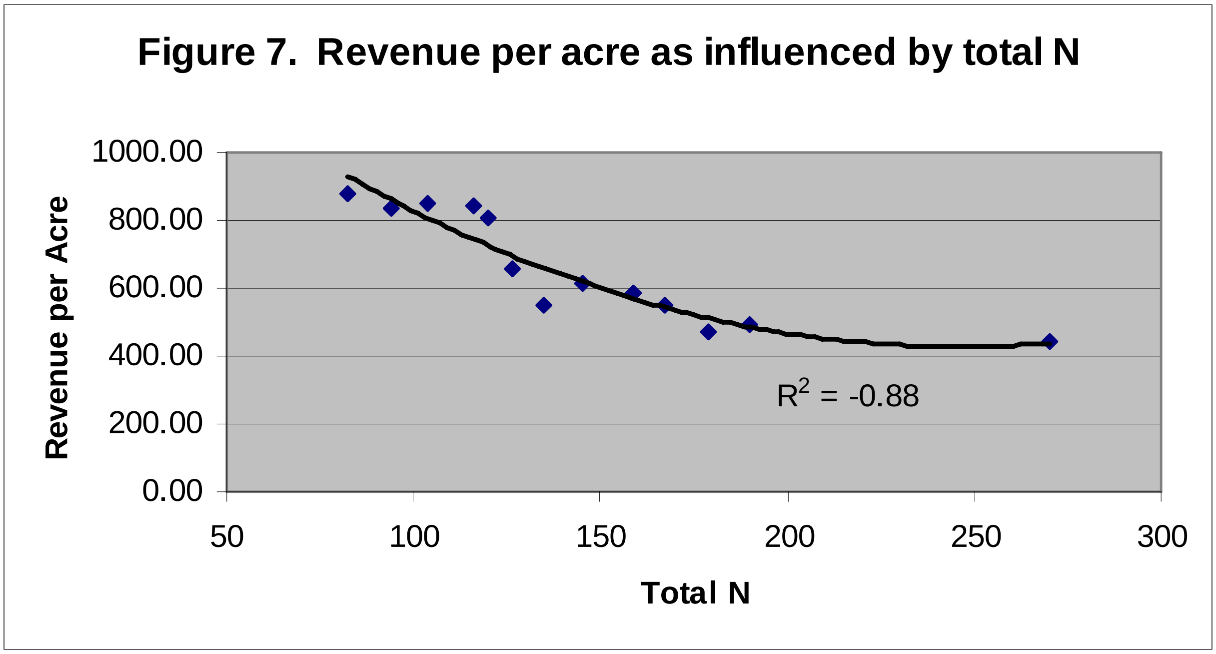
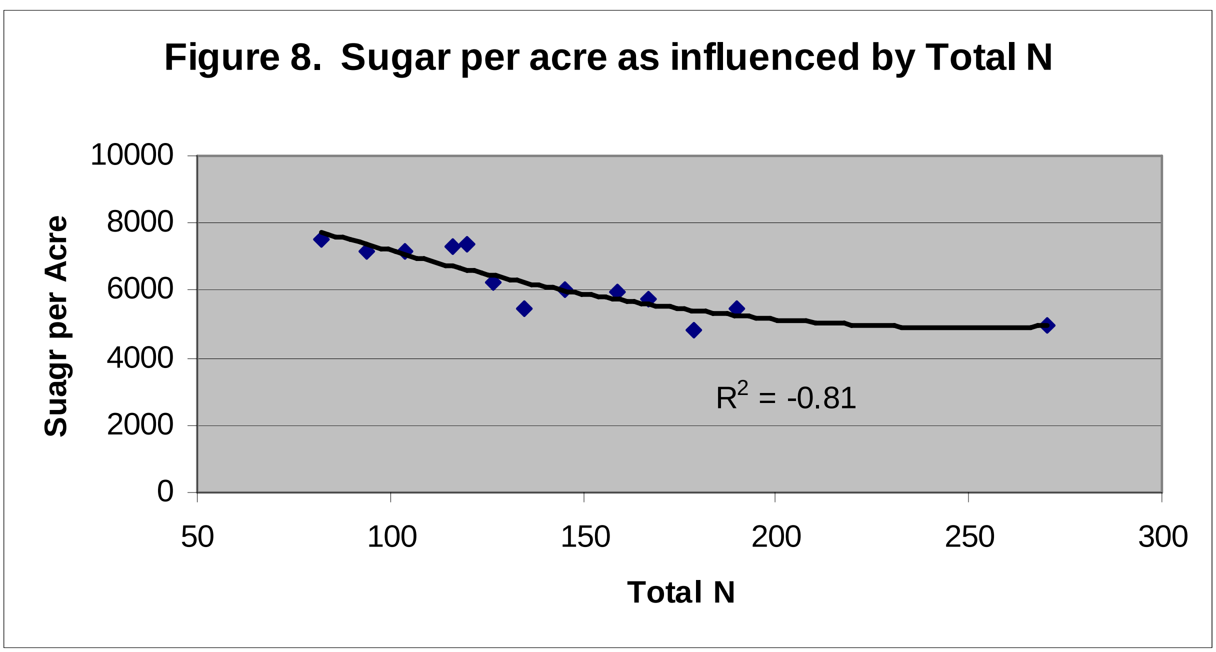


Figure 6. 2005 0-4 ft. N soil N as influenced by Organic Matter
Organic matter
10.0
8.0
6.0
4.0
2.0
0.0
0
50
100
150
200
250
300
R2 = 0.72
2005 0-4 ft. soil N

Sugar beet revenue per acre and sugar per acre (Figure 7-8) showed a strong relationship to total nitrogen (applied nitrogen plus soil nitrogen). This relationship was negative in that an increase in total nitrogen resulted in a decrease in sugar per acre and revenue per acre. The percent change in revenue per acre and sugar per acre that can be explained by total nitrogen is 88% and 81%, respectively. The results showing a strong relationship of total nitrogen to sugar per acre and revenue per acre coincides with previous results reported in the past years.





Summary

- The relationship of nitrogen applied in the previous crop to residual soil nitrogen in the proceeding crop is R^2 0.59. The polynomial curve applied to the data showed a trend toward the influence of higher nitrogen levels applied in the previous crop to increase the soil residual nitrogen tested in the proceeding crop.
- The variable that showed the most dynamic influence over time was organic matter.
- In the first year of testing, (following soybeans) the stronger relationship between organic matter and soil nitrogen was relative to the 0-.5 ft. soil profile.
- In the second year following sweet corn the relationship between organic matter and soil nitrogen changed in that the deeper soil profile produced a better relationship with organic matter.
- The theory to why this relationship changed the way it did is that the application of nitrogen in the sweet corn increased the diffusion of nitrogen to deeper zones of the soil profile and may have been higher in higher organic matter due to the higher levels of nitrogen in the 0-.5 ft soil profile in relation to level of organic in the previous year.
- The percent change in revenue per acre and sugar per acre that can be explained by total nitrogen is 88% and 81%, respectively.
- Results showing a strong relationship of total nitrogen to sugar per acre and revenue per acre coincide with previously reported results.
- The influence of organic matter on nitrogen management needs more research to determine the influence over time, nitrogen availability, soil profile zone and various other factors.

SEED-SAFE APPLICATION OF FLUIDS AT PLANTING

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ABSTRACT

For several reasons, interest in banded fertilizer placed close to the seed has expanded in recent years. The fluid fertilizers fit very well with the concept of placing fertilizer close to the seed at planting. There are also several serious questions associated with this concept. In order to provide an answer to some of these questions, this study was designed to evaluate the effect of placement (with seed, top of seed, below the seed) of three fluid grades (10-34-0, 4-10-10, 3-18-18) at two rates on emergence and yield of corn, soybeans, and sugarbeets.

Fertilizer placed near the seed had no effect on emergence and yield of corn and sugarbeets when the soil texture was a silty clay loam. When the soil texture was a loamy fine sand, corn emergence and subsequent yield were reduced by the use of the high rate (10 gallons per acre) of 10-34-0. The lower rate (5 gallons/acre) had no effect on these measurements. There was a minor reduction in stand when the high rate of 4-10-10 and 3-18-18 was placed close to the seed.

Rate of application was reduced for the soybean crop. However, placement of all grades in contact with the seed produced a substantial decrease in emergence that was not related to yield. The reduction in emergence was minimized when there was approximately ½ inch of soil between seed and fertilizer.

Treatment had no effect on sugarbeet emergence, yield, and sugar yield.

Soil texture is a major consideration when placement of fluid fertilizers near the seed is considered. There are several placement choices when corn and sugarbeets are planted on a soil with a silty clay loam texture. For sandy soils, fertilizer should not be placed close to the seed.

INTRODUCTION

Grower interest in use of banded fertilizer at planting is increasing. This renewed interest is due, in part to frequent observations that banded fertilizer increases crop growth and subsequent yield. Compared to the once popular 2x2 placement (commonly called starter fertilizer), there are now several inexpensive attachments that can be added to planters to place fertilizer in a band near the seed at the time of planting. These attachments provide an easy way for fluids to be placed close to the seed while allowing for some soil between the seed and fertilizer. A multi-row planter can easily be modified to apply banded fertilizer near the seed for a relatively low cost.

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 seed placed fertilizer. Recent research in Iowa has documented the positive benefits of several fluids placed near, but not in contact with, or very close to corn and soybean seed at planting.

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More recent research in northwestern Minnesota has shown that 10-34-0 applied at low rates in contact with seed has very positive effects on both 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 evaluate the effect of placement of fluid fertilizers near the seed on emergence, and yield of corn, soybeans, and sugarbeets.

EXPERIMENTAL PROCEDURE

This study was conducted in fields of four cooperating crop producers. 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 silt 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. Except for the corn (S) site (loamy fine sand texture), soil test values were high or very high. Therefore, if differences in yield were measured, they could be attributed to the treatment applied rather than a response to the rate of phosphate and potash applied in a band.

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

	Location			
Property	Corn (S)	Corn (B)	Soybean	Sugarbeet
pH	6.2	6.4	6.9	7.4
phosphorus, ppm	24	24	58	23 (Olsen)
potassium, ppm	78	157	352	201
texture	loamy fine sand	silty clay loam	silt loam	silty clay loam

All treatments at the corn (S) site, received a broadcast application of 150 lb. 21-0-0-24 and 200 lb 0-0-60 per acre. These materials were incorporated before planting. Adequate N as 46-0-0 was applied at the corn and sugarbeet sites at rates to support high yields. Preplant applications were used at sites with fine-textured soils. A split application of N (2 sidedress applications) was used at the corn (S) site.

All combinations of three fluid materials (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 varied with crop and the grade of fluid used and are listed in Table 2. The application of the 3-18-18 was reduced so that equal rates of K_2O would be applied with the 4-10-10 and 3-18-18.

Stand counts for the three crops were taken at approximately three 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%.

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.

Table 2. Rates of fluid used for corn, soybeans and sugarbeets.

Fluid Grade	Corn high	Corn low	Soybean high	Soybean low	Sugarbeets high	Sugarbeets low
	- - - - - - - - - - - -		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

RESULTS AND DISCUSSION

Corn Emergence:

Results varied with soil texture. The fluid material, rate of application, and placement had no significant effect on corn emergence at the site with the silty clay loam texture (Table 3). The soil at this site was moist at planting and fluid fertilizer placed near the seed had no effect on emergence.

Both fluid grade and rate applied had a highly significant effect on emergence at the site with the loamy fine sand texture. (Table 3). When averaged over rate and placement, use of 10-34-0 produced a substantial reduction in emergence. This is especially true when the 10-34-0 was placed with the seed at a rate of 10 gallons per acre. This treatment reduced emergence by about 33%. Emergence from the use of 4-10-10 and 3-18-18 was nearly equal when these fluids were placed close to the seed. However, both of these materials reduced emergence when placed close to the seed at the high rates.

Since smaller amounts of N were applied with the 4-10-10 and 3-18-18, the results of this trial indicate that high rates of N applied near the seed can cause a reduction emergence when corn is grown on a sandy soil. These observations are consistent with those recorded from a study with the same design conducted in 2004. The high rates of 4-10-10 and 3-18-18, regardless of placement, reduced emergence when the soil was sandy. The stand reductions were small, but consistent.

Soybean Emergence:

The measured emergence of the soybean crop as affected by treatment is summarized in Table 4. Emergence was significantly affected by the fluid material, rate of application, and placement.

When averaged over rate and placement, the largest reduction was associated with the use of 10-34-0 with the least reduction associated with the application of 3-18-18. As would be expected, the highest rate produced the largest stand reduction. When averaged over material and rate, placement with the seed produced the largest stand reduction. Comparing placement on top with placement below the seed, there was less damage when the fertilizer was placed on top of the seed. Compared to the control, a reduction of 37% was associated with placement of 10-34-0 with the seed.

As with corn, stand reduction appeared to be related to the added N in the 10-34-0. The rate of 6 gallons per acre would have supplied 7 lb. N per acre in contact with the seed. This rate was apparently high enough to reduce emergence.

Sugarbeet Emergence:

Sugarbeet emergence was not significantly affected by treatment (Table 5). There are two possible explanations for this observation. First, lower rates of application were used.

Table 3. Corn emergence as affected by fluid material, rate, and placement in soils with two contrasting soil textures. 2005.

	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	
Material	high	low	high	low	high	low	high	low	high	low	high	low
	plants per acre											
10-34-0	32,017	32,670	31,145	31,799	32,017	30,710	20,691	28,532	21,127	28,967	20,909	26,136
4-10-10	32,581	30,492	31,363	30,274	32,017	32,452	28,532	32,234	27,661	31,581	28,314	31,363
3-18-18	32,670	31,581	33,541	32,452	31,794	30,274	29,185	32,670	31,363	32,888	27,878	32,017

control (no fluid applied) = 33,106 and 30,710 for silty clay loam and loamy fine sand sites

Table 6. Corn yield as affected by fluid material, rate, and placement in soils with two contrasting soil textures. 2005.

	Texture, Placement, Rate											
	silty clay loam						loamy fine sand					
	with seed		top of seed		below seed		with seed		top of seed		below seed	
Material	high	low	high	low	high	low	high	low	high	low	high	low
	bu./acre											
10-34-0	211.6	203.6	213.8	208.9	213.6	209.6	154.9	176.8	170.5	190.6	151.7	199.3
4-10-10	204.7	196.9	210.3	208.4	203.0	210.3	192.8	203.7	188.4	208.7	201.3	190.9
3-18-18	201.0	212.2	215.3	209.3	211.0	206.7	189.3	207.8	205.7	203.5	201.1	204.4

control (no fluid fertilizer) = 208.7 and 185.5 bu./acre for the silty clay loam and loamy fine sand sites respectively.

Secondly, the sugarbeet seed was coated and this coating may have protected the seed from fertilizer damage.

Table 4. Soybean emergence as affected by fluid material, rate, and placement when grown in a silt loam soil. 2005.

	Placement and Rate					
	with seed		top of seed		below seed	
Material	high	low	high	low	high	low
	- - - - - - - - - - - plants/acre - - - - - - - - - - - -					
10-34-0	106,721	156,816	118,483	164,657	154,202	164,221
4-10-10	150,717	171,626	164,656	181,209	169,012	172,062
3-18-18	125,452	162,914	128,937	160,300	167,706	164,221

control (no fluid fertilizer) = 168,577

Table 5. Sugarbeet emergence as affected by fluid material, rate, and placement. 2005.

	Placement and Rate					
	with seed		top of seed		below seed	
Material	high	low	high	low	high	low
	- - - - - - - - - - - plants/acre - - - - - - - - - - - -					
10-34-0	43,124	43,718	45,144	43,480	44,312	46,332
4-10-10	43,599	45,144	43,362	44,787	43,362	42,174
3-18-18	42,886	42,837	43,243	44,906	45,025	45,738

control (no fluid fertilizer) = 46,450

Corn Yield:

The impact of treatment on corn yield varied with soil texture (Table 6). Treatment had no significant effect on yield at the site with the silty clay loam texture.

Yield was affected by both material and rate at the site with the loamy fine sand texture. This is consistent with the effect of these factors on emergence. Compared to the control, both rates of 10-34-0 applied in contact with the seed reduced yield. This is attributed to a reduction in stand associated with the corresponding treatments. Use of 10-34-0 at the low rate improved yield when the band was placed so that there was some soil between seed and fertilizer. In general, application of 4-10-10 and 3-18-18 either in contact with or near the seed improved yield when both rates were applied. The yields were equivalent for both rates applied. There was no significant interaction between fluid grade and rate of application.

Soybean Yield:

Although all factors included in the study had a significant effect on emergence, there was no effect on yield (Table 7). There is general agreement that reductions in soybean stands do not necessarily correspond to reductions in yield. With fewer plants, each plant produces more branches and, subsequently, more pods per plant.

Sugarbeet Yield:

Fluid grade had a significant effect on sugarbeet yield (Table 8). When averaged over rate and placement, yield was highest when 10-34-0 was used. Application of 4-10-10 and 3-18-18, regardless of rate and placement, had no positive effect on yield. Compared to the control

(28.9 ton/acre), average yield were lower when the 4-10-10 and 3-18-18 were applied. These lower yields cannot be attributed to a reduction in emergence. The data do not provide an exact explanation.

Table 7. Soybean yield as affected by fluid material, rate, and placement. 2005.

	Placement and Rate					
	with seed		top of seed		below seed	
Material	high	low	high	low	high	low
	- - - - - - - - - -	- bu./acre -	- - - - - -	- - - - -		
10-34-0	61.9	65.0	63.3	64.5	62.3	64.2
4-10-10	65.3	65.1	63.4	64.9	65.6	62.5
3-18-18	62.7	68.1	66.7	64.4	63.4	64.2

control (no fluid fertilizer) = 63.1 bu./acre

Table 8. Sugarbeet yield as affected by fluid material, rate, and placement in soil with a silty clay loam texture.

	Placement and Rate					
	with seed		top of seed		below seed	
Material	high	low	high	low	high	low
	- - - - - - - - - -	- tons/acre -	- - - - - -	- - - - -		
10-34-0	28.1	29.1	27.2	29.4	29.1	30.2
4-10-10	24.3	27.4	28.8	26.8	29.8	27.8
3-18-18	23.0	29.9	26.7	28.0	25.9	23.8

control (no fluid fertilizer) = 28.9 tons/acre

Table 9. Sugar yield as affected by fluid material, rate, and placement in soil with a silty clay loam texture.

	Placement and Rate					
	with seed		top of seed		below seed	
Material	high	low	high	low	high	low
	- - - - - - - - - -	- lb. sugar/acre -	- - - - - -	- - - - -		
10-34-0	7227	7297	6966	7350	7323	8397
4-10-10	6197	6794	7299	7188	7220	7111
3-18-18	5952	7668	7331	7265	6501	6299

control (no fluid fertilizer) = 7599 lb./acre

Sugar Yield:

Payment to the sugarbeet producer is based on the amount of sugar produced per acre rather than tons of sugarbeets grown. Therefore, the impact of treatment on sugar yield is of interest. That effect is summarized in Table 9.

In this trial, none of the factors included in the study had a significant effect on sugar yield. Compared to the control, all factors studied had an equal effect on the amount of sugar produced per acre.

Nitrogen Management and Postharvest Quality

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Justification of Research:

Extensive research has documented the importance of proper soil nitrogen management in providing a high yielding, high quality sugarbeet crop. Deficient soil N is associated with a reduction in root yield, where excess soil N may yield large roots that have decreased sucrose concentration and poor quality. Much of the research has examined the impact of soil N on recoverable sucrose yields at harvest, and little information is available on the importance of soil N and quality during postharvest storage.

Respiration is the metabolic process that utilizes sugarbeet's sucrose reserves to provide energy and carbon substrates for maintaining healthy tissue, healing wounds from harvest and piling, and defending against various storage pathogens. Postharvest respiration may account for 60-80% of sucrose loss during sugarbeet storage, and the impact of soil N on postharvest respiration is unclear.

Objective:

The objective of this study was to evaluate the impact of soil N on postharvest respiration and carbohydrate impurity formation during storage.

Materials and Methods:

Sugarbeet roots were kindly provided by Dr. John Lamb, and Mark Bredehoeft from an ongoing whole rotation nitrogen management study in the Southern Minnesota Beet Sugar Cooperative growing area. The previous crop in the rotation was corn, and the residual soil nitrate-N level in the surface four feet was 50 pounds per acre. In this experiment, roots from three soil nitrogen levels were harvested. The nitrogen levels were based on the soil test nitrate-N in the surface four feet plus the fertilizer N applied. The three N levels were: 50, 130, and 250 pounds N per acre, and the nitrogen fertilizer source was urea (45-0-0). Roots were hand harvested from a Maynard, MN field location 29 Oct. 2004. Roots were gently washed by hand, placed in perforated plastic bags, and stored at 6ºC (43ºF) and 95 % relative humidity. Respiration rates were measured at 30, 60, 105, and 135 days after harvest. At each time point, roots were placed in sealed buckets with a regulated flow of ambient air. After 24 hours, the CO_2 concentration of air from the exit tube was determined with an infrared gas analyzer, and respiration rate is expressed as mg CO_2 kg roots^{-1} hour^{-1}. Respiration data is the average of three replicate buckets filled with 10 roots per bucket. Root carbohydrate concentrations were determined at field harvest, and after 30, 60, and 135 days in storage. Sucrose, invert sugar (glucose and fructose), and raffinose concentrations were determined using established high performance liquid chromatography methods. Carbohydrate concentrations are the mean ± SE of three replicates (10 roots/rep).

Results and Discussion:

To evaluate the impact of soil N on sugarbeet respiration, beets were stored for 30 days prior to respiration measurement to allow for wound healing from harvest. Respiration was determined at 30, 60, 105, and 135 days after harvest. Respiration was affected by time in storage, but soil N level did not impact postharvest respiration rates (Fig. 1). When averaged across the three soil N treatments, there was a 20% increase in respiration between 30 and 60 days after harvest. Similar respiration rates were observed at 60, 105, and 135 days after harvest. At each storage duration, soil N level did not significantly impact root respiration rate.

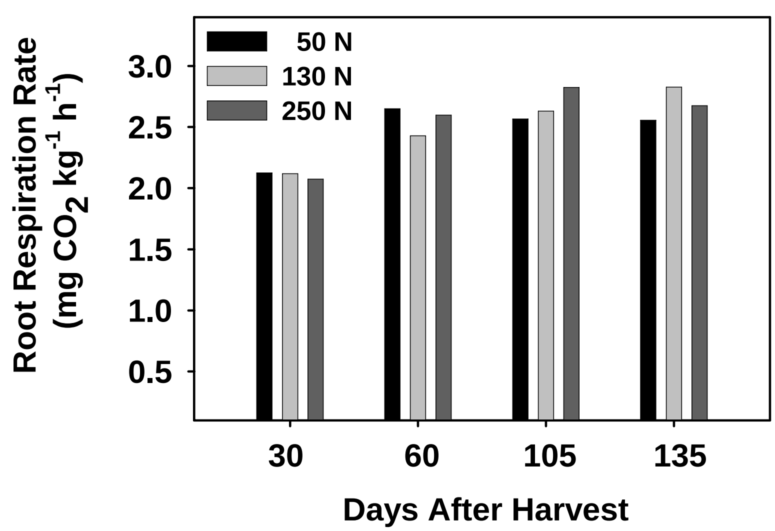

Figure 1. Effect of soil N on root respiration in storage. The three soil N levels: 50, 130, and 250 N (lb/A) equal the soil nitrate-N at the surface four feet plus the total fertilizer N applied.

Although there was no significant difference in respiration attributed to soil N levels, the impact of soil N on sucrose, invert sugar, and raffinose concentrations was also evaluated throughout storage. To evaluate the impact of soil N on root carbohydrate concentrations, sugars were quantified at harvest, and after 30, 60 and 135 days in storage.

At 60 and 135 days after harvest, root sucrose concentrations from the 130 and 250 N levels were decreased by 10% when compared with roots from the 50 N treatment, however, differences in sucrose content were not statistically significant (Fig. 2A.)

Soil N level and time in storage had a significant impact on invert sugar concentrations (Fig. 2B). When averaged across soil N treatments, invert sugar concentrations at harvest and at 135 days in storage were significantly greater than invert concentrations at 30 and 60 days after harvest. Soil N did not impact invert sugar concentration until 135 days after harvest. At 135 days, roots from the 250 lb/A soil nitrate (0-4 ft) plus fertilizer treatment had a 45% increase in invert sugars when compared to roots from the 50 and 130 (lb/A) soil N levels.

Raffinose concentrations increased during storage and with increased N application (Fig. 2C). Raffinose concentrations 135 days after harvest were 3 fold greater than at harvest. There was no significant impact of soil N until 135 days after harvest, where roots from the 250 (lb/A) treatment had a 30% increase in raffinose when compared to roots from the 50 and 130 (lb/A) treatments.

Conclusions:

The first year of this study indicates that soil N level did not significantly impact postharvest respiration or root sucrose concentrations. Excess soil N (250 lb/A), however, was associated with increased invert sugar and raffinose concentrations 135 days after harvest.

The response of soil N on postharvest respiration and sugarbeet quality is currently being evaluated from roots harvested October, 2005 from a Hector, MN field location.

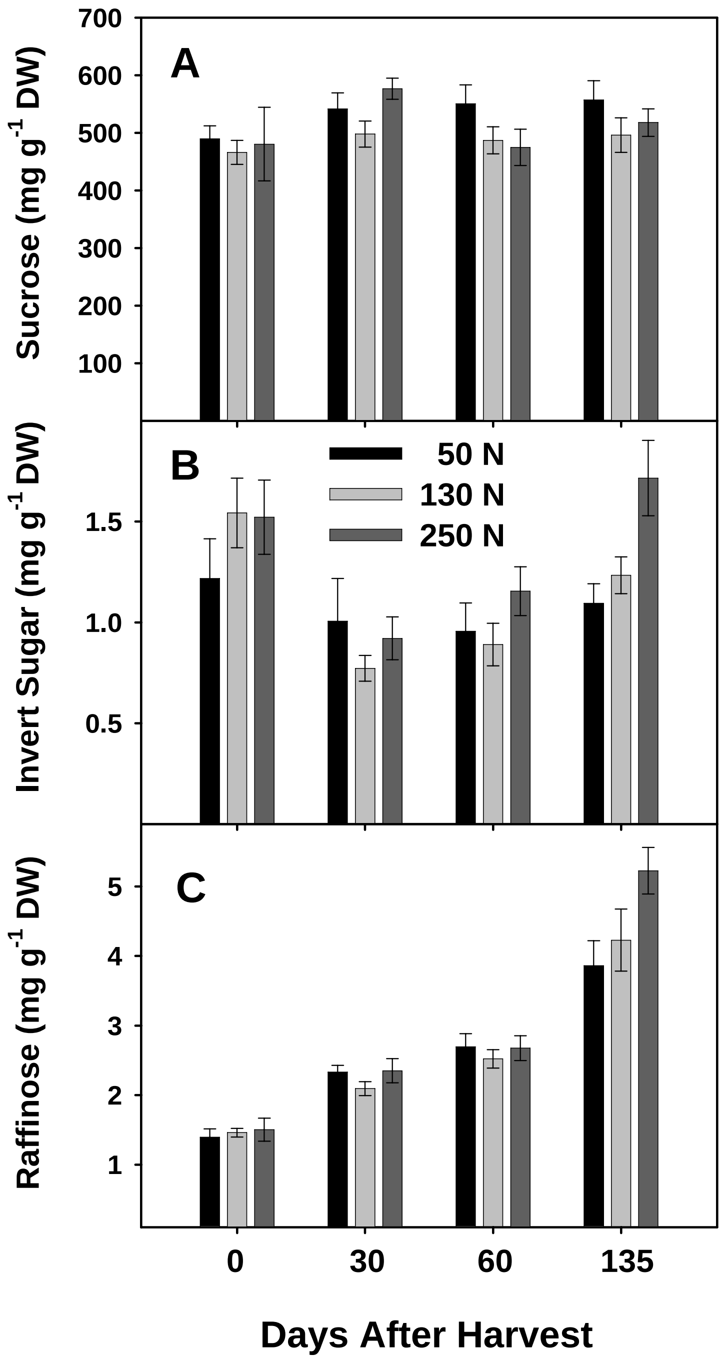

Figure 2. Effect of soil N on root sucrose (A), invert (B), and raffinose (C) concentrations in storage. The three soil N levels: 50, 130, and 250 (lb/A) equal the soil nitrate-N at the surface four feet plus the total fertilizer N applied. Data is the mean ± SE of three replicates (10 roots/replicate).

Modeling Field Quality Using Landsat Images and a Field GIS Database

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Progress report for 2005

A large GIS database was used to locate field boundaries in 1202 sugarbeet fields from the 2004 growing season in Southern Minnesota. Canopy pixel data were identified as regions of interest within each field and extracted from four Landsat images (bands 1,2,3,4,5, 7) and converted to reflectance values. The database included seed variety, harvest sucrose concentration, and harvest date for each field. Harvest date and a sugar accrual model were used to estimate sucrose concentration on a common date of October 1. In addition field variables of planting date, weed pressure rating, population uniformity rating, plus ratings for two fungal diseases, and the viral disease rhizomania were added to the database for 2004. Fields were grouped by variety and multiple linear regression models were used to test for correlation between harvest sucrose concentration and canopy and field condition variables. A Green NDVI index was used as the canopy variable on individual image dates. Change in canopy index between dates was also tested as the canopy variable in models. Most models were significant ($P<0.01$) in correlating sucrose to canopy and field condition. However, some varieties (ACH826, HM2411, VDH46177) produced models that did not retain a canopy variable, indicating these varieties may be poor candidates for this approach to predicting field sucrose concentration. In models developed for individual dates the R2 value increased from Aug. 5 to Aug. 21, and again in the Sept. 6 data. Models utilizing a temporal change in canopy index between two image dates were significant ($P<0.01$) but generally did not produce higher correlations than single date models. While models were statistically valid, the R2 values were low (0.17-0.4). Field status variables for disease, planting date, and stand were inconsistently retained in the MLR models. High quality estimates of these variables would be expected to reduce scatter in models relating canopy spectra to sucrose concentration due to management variation among fields. Fields with heavy weed pressure, or pronounced disease would be expected to have differing relationships of canopy spectra and sucrose concentration. Additional analysis will be conducted to determine if these variables can be used to improve predictive ability of canopy models. Models developed with sufficient correlation could be used in optimizing harvest strategies to maximize sucrose extraction and overall value across the cooperative. Models from the 2003 crop similar to those reported here were used in a first attempt to predict relative quality of fields in an image of the 2005 crop. The modeling process also produces an estimate of the accrual rate of sucrose during the harvest period for different varieties. This also will be useful in planning the harvest to maximize sucrose production.

Scalping sugar beet influence on Quality and Economic Returns

Work at Southern Minnesota Beet Sugar Cooperative has attempted to consider methods of managing the sugar beet for increased extraction of white sugar. This can be done through management of nutrients, various cultural production practices, variety selection, pest management, and finally harvest and storage management.

Harvesting of sugar beets for efficient processing into sugar and long-term storage needs has been a quest of the sugar industry for years. Sugar industry personnel have developed many theories regarding best management practices for production, harvest and storage of a high quality sugar beet. One fact that remains constant is that sugar beets of high quality process more efficiently than sugar beets with lower quality. There are significant economic gains to be made by correctly managing harvest and storage of sugar beets. This is a review of research conducted in 2002 - 2005 to evaluate the delivery of a highly extractable sugar beet. This was done by removing the crown of the sugar beet which has low quality.

Methods

2003-2005

Sugar beets were collected by having the cooperating grower defoliate but not scalp sugar beets. The sugar beets were harvested with the grower's harvester and unloaded onto a flat bed trailer with panel sides. The sugar beets were harvest on October 17, 18 and 12 of 2003, 2004 and 2005, respectively. The sugar beets were randomly separated into groups for sampling. The treatment and number of sugar beets for each treatment are as described in Table 1. The crown of each sugar beet was scalped to the specific depth for each treatment by physically measuring the depth of cut. Main portion of sugar beet from which the portion of the sugar beet was removed (scalped) is called the whole beet portion for samples analyzed prior to storage and stored portion for samples analyzed after storage. The scalped portion is the part of the sugar beet which was removed (scalped) from the stored portion of the sugar beet. The stored portion of the sugar beet was put into tare lab bags with an identification bar code for tare lab analysis. Scalped portion of sugar beets were put into small plastic bags and coded to matching stored sugar beet sample. The stored portion was placed in a unventilated sugar beet pile at Renville, Mn.. Each scalping treatment had 20 samples placed in steel cages which were 6 ft high 8 feet long and 4 ft wide. Sugar beets were placed in the bottom 4 ft. of the steel cages, the scalping treatment samples were placed on top of the sugar beets and more sugar beets were placed on top of the scalping treatment samples to fill the steel cages. The steel cages were placed in a sugar beet pile at the SMBSC Renville piling site (pile #3 in all years). The position of the steel cages in the sugar beet pile were 75 ft. toward the center of the sugar beet pile from the outer tow of the sugar beet pile and at the mid point of the sugar beet pile from beginning to end of harvest. The sugar beet pile was split, positioning the steel cage in the middle of a shoulder of the pile. The sugar beet samples were stored in the sugar beet pile until approximately March 1 or 140 days in all years. The tare lab at SMBSC analyzed the stored and scalped portion of sugar beets for quality and weight.

Table 1. Treatments for 2003 sugar beet scalping study

Sugar beet Portion	* Scalp description (depth of scalp)	**Diameter in inches of scalp on top of average beet
Stored	**unscalped**	**0**
Stored	**scalped .25 inch**	**2.5**
Scalp	**scalped .25 inch**	**N/A**
Stored	**scalped .5 inch**	**3.5**
Scalp	**scalped .5 inch**	**N/A**
Stored	**scalped 1 inch**	**5**
Scalp	**scalped 1 inch**	**N/A**
Stored	**scalped 2 inch**	**6**
Scalp	**scalped 2 inch**	**N/A**

* Scalped description is based on a depth from the top or crown of sugar beet

** Diameter is considering an average sized sugar beet

Discussion

Prior to storage

Scalped portion of the sugar beet increased in weight as depth of scalp increased (Table 2). Percent of scalped portion was 2.09, 4.00, and 6.75 for scalped depth of .25, .5, and 1 inch, respectively. Scalping the sugar beet to depths of .25, .5, and 1 inches decreased tons per acre by .45, .92, and 1.55, respectively.

Table 2. Scalping study base data
prior to storage
2003-2005 combined data

Sugar beet Portion	Scalped description	Tons per acre	Percent of total
Whole beet	**unscalped**	22.00	100.00
Whole beet	**scalped .25 inch**	21.55	97.96
Scalped	**scalped .25 inch**	0.48	2.09
Whole beet	**scalped .5 inch**	21.12	95.99
Scalped	**scalped .5 inch**	0.92	4.00
Whole beet	**scalped 1 inch**	20.52	93.29
Scalped	**scalped 1 inch**	1.55	6.75

Sugar quality was increased as scalp depth increases (Table 3). All scalped sugar beet treatments gave higher quality than unscalped sugar beet treatments. Sugar percent and purity was higher in scalped sugar beets, which lends to higher extractable sugar per acre. Sugar percent and purity increased .61 and .84, respectively in whole beet portion when scalped portion of sugar beet increased from .25 to 1 inch. Quality of the scalped sugar beet portion was the lowest in the .25 inch scalped sugar beet portion. Sugar percent and purity of scalped portion continued to increase as scalped depth increased. Increased depth of sugar beet scalp tended to decrease brie nitrate in the whole beet portion of the sugar beet.

Table 3. Scalping influence on sugar beet quality prior to storage
2003-2005 combined data

Sugar beet Portion	Scalped description	Nitrate	Sugar %	PURITY	Extraction Sug./ton	Extraction Sug./acre
Whole beet	**unscalped**	91	16.38	89.55	272	5984
Whole beet	**scalped .25 inch**	55	16.99	90.57	287	6175
Scalped	**scalped .25 inch**	83	7.66	60.45	79	35
Whole beet	**scalped .5 inch**	57	17.11	90.96	290	6136
Scalped	**scalped .5 inch**	85	9.72	70.49	117	99
Whole beet	**scalped 1 inch**	56	17.22	91.20	293	6024
Scalped	**scalped 1 inch**	91	11.47	76.60	150	247

The scalping of sugar beets (Table 4) can enhance revenue per ton from sugar beets due to increased quality. Revenue per acre is a result of both quality and tons harvested. Revenue was the highest when sugar beets were scalped to .5 inch depth. Sugar beets scalped to .25, .5 and 1 inch depth gave $52.94, $55.44 and $ 46.33 per acre revenue greater than unscalped sugar beets.

Table 4. Scalping influence on sugar revenue prior to storage

2003-2005 combined data

Sugar beet Portion	Scalped description	Revenue per ton	per acre	variance*
Whole beet	**unscalped**	33.55	738.02	0
Whole beet	**scalped .25 inch**	36.70	790.96	52.94
Scalped	**scalped .25 inch**	-8.26	-4.05	
Whole beet	**scalped .5 inch**	37.56	793.46	55.44
Scalped	**scalped .5 inch**	-0.12	-1.77	
Whole beet	**scalped 1 inch**	38.21	784.35	46.34
Scalped	**scalped 1 inch**	7.16	9.64	

* **Revenue variance** = The revenue per acre variance of the scalped treatment over the unscalped treatment

Sugar beets stored showed similar trends as sugar beets analyzed prior to storage (table 5-6). Sugar percent and purity was increased by each incremental scalping depth. This translated into increases in the sugar per ton and sugar per acre. This data disproved previous theories that losses would be incurred in storage which would offset any pre-storage advantages when scalping the sugar beet. Sugar beets scalped to .25, .5 and 1 inch depth gave $33.94, $36.87 and $22.36 per acre revenue greater than unscalped sugar beets.

Table 5. Scaling influence on sugar beets quality, post storage
2003-2005 combined data

Sugar beet Portion	Scalped description	Nitrate	Sugar %	PURITY	Extractable Sugar/ton	Extractable Sugar/acre
Stored	unscalped	101	16.46	89.10	272	5974
Stored	scalped .25 inch	77	16.83	90.03	282	6100
Stored	scalped .5 inch	85	17.03	90.28	286	6149
Stored	scalped 1 inch	96	17.10	90.47	288	6074

Table 6. Scalping influence on sugar beets revenue, post harvest
2003-2005 combined data

Sugar beet Portion	Scalped description	Revenue per ton	Revenue per acre	Revenue variance
Stored	unscalped	31.16	685.43	0
Stored	scalped .25 inch	33.29	720.67	35.24
Stored	scalped .5 inch	34.28	735.86	50.43
Stored	scalped 1 inch	34.73	730.56	45.13

* **Revenue variance** = The revenue per acre variance of the scalped treatment over the unscalped treatment

<u>*Summary*</u>

1. Quality was increased by scalping sugar beets, regardless of the depth.

2. Revenue was highest on sugar beets scalped at .25 or .5 inches deep from the crown of sugar beet.
3. Sugar beets stored showed similar trends as sugar beets analyzed prior to storage.
4. Revenue per acre was increased $52.94, $55.44 and $46.33 for sugar beets scalped to .25, .5 and 1 inch, respectively. This translates into a $6,352,800.00, $6,652,800.00 and $5,559,600 increase for sugar beets scalped at .25, .5 and 1 inches based on 120,000 acres considering prior to storage data.
5. Post storage data gave a $35.24, $50.43 and $45.13 increase per acre return at sugar beets scalped to .25, .5 and 1 inch depth, respectively.

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 (i.e., impurities that interfere with processing) are concentrated in the upper crown (Jaggard et al., 1999; Mahn et al., 2002). The incidence and severity of storage rots, however, is reported to increase in roots defoliated by scalping or topping since injury is required for infection by *Botrytis cinerea* and *Penicillium* spp., two common storage rots (Akeson et al., 1974; Mumford and Wyse, 1976; Wyse, 1978). Leaf regrowth, which is associated with increased respiration rate and invert sugar accumulation during storage, is affected by the number of intact vegetative buds on the root crown and decreases as more of the crown is removed (Wyse and Dexter, 1971; Steensen and Augustinussen, 2003). Root respiration rate also is affected by defoliation method since crown tissue respires at a faster rate than tissue in the true root (Wyse, 1978; Wyse and Peterson, 1979; Steensen and Augustinussen, 2003). Root respiration rate, therefore, is generally lower in topped than in lightly scalped or flailed roots. Because defoliation method affects post-storage sucrose yield and root quality through its effect on initial root quality, the incidence of storage diseases, leaf regrowth, and respiration rate, the impact of defoliation method on extractable sucrose yield is likely to be dependent on sugarbeet variety, storage temperature, storage duration and level of disease inoculum present in soil adhering to roots and in piles. Since these factors can vary between storage seasons and storage piles, the impact of defoliation method on postharvest losses can be variable.

Experimental Design

A small study was conducted to determine the effect of crown tissue removal during defoliation on root respiration rate during storage. Roots of Beta 4901 were mechanically defoliated on 16 Oct. 2006. Four defoliation treatments were used which removed approximately 0, 0.6, 1.3, and 2.5 cm (0, 0.25, 0.5, and 1 inch) of the root apex measured along the root longitudinal axis. Prior to storage at 6^oC 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, and 89 days in storage, and will be measured after approximately 150 days in storage. For each treatment at each time point, respiration was measured on three replicate samples, each of which comprised ten roots. A brei sample was collected from each replicate, frozen and stored at -20^oC. After all samples have been collected, brei samples will be analyzed by HPLC to determine sucrose, glucose and fructose concentrations.

Results

The amount of crown tissue removed during defoliation had no statistically significant effect on respiration rate of roots stored for 13, 32 or 89 days at 6^oC and 95% relative humidity (Fig. 1). Across all treatments, respiration rate was similar after 13 and 32 days in storage, but was approximately 25% lower after 89 days in storage. No statistically significant interaction between defoliation treatment and time in storage was observed.

The experiment is ongoing at the time of this report. Future research will determine the respiration rate of roots after approximately 150 days in storage and the concentrations of sucrose, glucose and fructose in roots of all treatments after 13, 32, 89 and 150 days in storage.

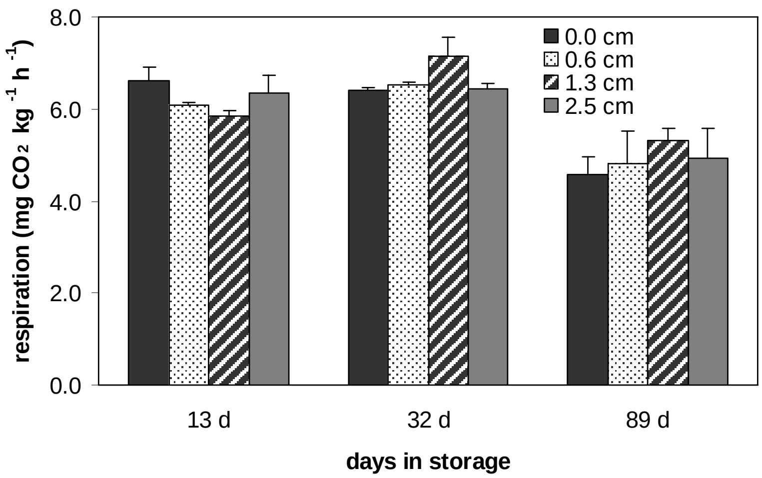

Fig. 1: Respiration rate of roots with 0, 0.6, 1.3 and 2.5 cm of the root apex removed during mechanical defoliation after 13, 32 and 89 days in storage at 6°C and 95% relative humidity.

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Sucrose Synthase Activity in Relation to Soil Type

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Sucrose synthase is a sucrose degrading enzyme that is abundant in sugarbeet roots and has been implicated as a biochemical factor that may influence root yield and storage losses. Studies in many plant species have demonstrated a relationship between sucrose synthase activity and size of storage organs, and in sugarbeet root, sucrose synthase activity is closely associated with root growth. In addition, a growing body of evidence indicates that sucrose synthase has a major role in sucrose degradation during storage. Determination of factors that influence sucrose synthase activity in roots, therefore, is a high priority, since manipulation of these factors may influence root yield and storage loss.

In 2001, an experiment was conducted to determine varietal differences and the influence of rhizomania on sucrose synthase activity. Roots of six varieties, ACH 952, Beta 3945, Beta 4600, Beta 4811, Hilleshog 7083 and Van Der Have 46109 were produced at three field locations. Sugarbeets were grown in fields outside of St. Thomas, ND by Larry Campbell, USDA-ARS, and by Southern Minnesota agricultural staff in fields near Clara City, MN and De Graff, MN. Rhizomania was present at the Clara City location, while fields near St. Thomas and De Graff were free of disease. Sucrose synthase activity was determined on root samples (n = 4) collected from these fields at harvest.

Results of the experiment described above showed that differences in sucrose synthase activity were observed that were related to variety, disease, and field location (Fig. 1). While varietal and disease-associated differences were not surprising, the large location differences in sucrose synthase activity between roots grown in the Southern Minnesota growing region (Clara City and De Graff) and St. Thomas were unexpected.

The cause of the location differences in this experiment is unknown. Many cultural and environmental factors were likely to differ between locations, and these factors, either individually or in combination, may have been responsible for the location effects observed. In work described in this report, we examined one possible factor, soil type, for its effect on sucrose synthase activity.

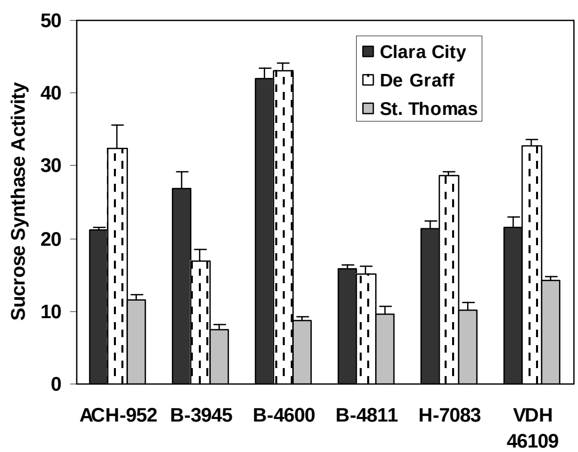


Fig. 1: Sucrose synthase activity in roots of six commercial varieties grown at three field locations, Clara City, MN, De Graff, MN and St. Thomas, ND. Activity is expressed as mmole sucrose cleaved per hour per gram protein. Data is the mean ± SE of four replicate roots.

Experimental Design

Roots of Beta 4901 were produced at three field locations with different soil types. Roots were produced on fields located near Belgrade, MN on Esterville coarse sandy loam, near Clara City, MN on Doland silt loam, and near Hector, MN on Canisteo-Glencoe complex, a clay loam. Roots were harvested on 16 Oct. 2005. Representative longitudinal sections containing crown and root tissue were taken from ten taproots from each site. Tissue was rapidly frozen in liquid nitrogen, lyophilized, ground to a fine powder and stored at -80^{o}C until assayed. Sucrose synthase activity assays were conducted in duplicate with control reactions for each sample.

Results

Sucrose synthase activity was not significantly different in roots produced at the three locations with different soil types (Fig. 2). Although the experiment was limited in size and evaluated the influence of only three soil types on sucrose synthase activity at harvest, the data suggests that soil type does not significantly influence sucrose synthase activity.

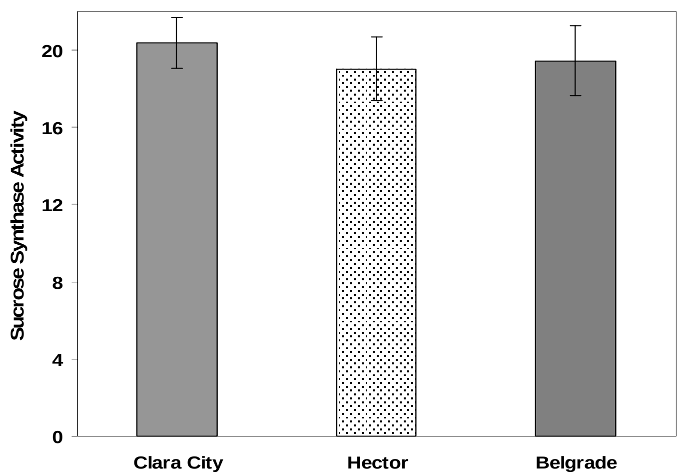


Fig. 2: Sucrose synthase activity in roots of Beta 4901 produced at three field locations, Clara City, MN, Hector, MN and Belgrade, MN. Activity is expressed as mmole sucrose cleaved per hour per gram protein. Data is the mean ± SE of ten replicate roots.

A report on the influence of frost damaged sugar beets in 2002 on Economic Return

Methods

2002

Sugar beets were harvested on October 23, 2002, immediately after a freezing temperature of 25^{o} F. Harvested sugar beets were stored in mesh bags buried five feet deep in the shoulder of a sugar beet pile. Mesh bag samples were extracted from the sugar beet pile and analyzed by the SMBSC lab at 0, 15 and 32 days after freezing temperature for lactic acid and glucose.

Table 7. Sugar beet post frost deterioration study

Sample Date	Lactic mg/L	Glucose mg/L
October 23, 2002	9.40	55.26
November 7, 2002	7.80	68.54
November 25, 2002	0.99	154.12

The lost revenue can be calculated as follows:

1. Multiply 2002 harvested sugar beet tons (2,216,401) by the average sugar of 15.7, this equals the tons of sugar (347,970) from harvested sugar beets.
2. Tons sliced (2,007,286) multiplied by the percent sliced sugar (15.96), which equals the ton of sugar in beets harvested (320,363).
3. Therefore, there were 27,612 tons or 55,224,223 pounds sugar lost in a normal storage situation.
4. There was 184 days of slice which translates into a .15 average pounds of sugar lost per ton of beets per day.
5. A review of percent glucose level in cassettes across the belt (% on dry Substance) for the months of October thru December which was 0.196 % and comparing the equivalents measurement on frost damaged sugar beets of 0.612%, indicates that there was a 3.12 fold increase in sugar loss.
6. The 3.12 fold sugar loss in the frost damaged sugar beets would translate into 0.47 (0.15 x 3.12) pounds of sugar lost per ton of sugar beets per day from the frost damaged sugar beets or 0.32 extra pounds of sugar lost per ton per day compared to the normal storage situation.
7. This calculates into a 20,949.55 ton sugar loss due to frost damaged sugar beets, if you consider this loss through December 1, 2002.

8. Considering a 75% percent recovery of sugar through processing, one could realize a $6,913,351.00 revenue loss at $.22 per cwt.
9. This translates into a 57.61 per acre based on 120,000 acres.

The economic value of the sugar loss from frost damaged sugar beets needs to be compared to the economic value of the loss in harvestable tons per acre from scalping of sugar beets. Sugar beets analyzed by SMBSC in 2002 were frost damaged to a consistent depth of one inch. Scalping the sugar beets to remove frost damaged sugar beet tissue is advantageous since loss of revenue due to frost damage was $192.04 per acre compared to $35.47 per acre for scalping to a one inch depth. The differential in revenue would render a $5,636,520.00 increase in revenue considering one third of the crop or 36,000 acres is processed during late October to early December and $156.57 per acre increase in revenue by removing the frost damaged portion of the sugar beet.

Summary

1. Revenue lost due to frost damaged sugar beets was calculated at $6,913,352.00 after approximately 37 days of storage.
2. Revenue would be increased $5,636,520.00 by removing the frost damaged sugar beet tissue to a one inch depth compared to the loss in tons/acre by scalping to a one inch depth.

SMBSC weed control program, 2005

Weed control continues to be one of the most significant production issues to challenge sugar beet growers. Testing of weed control programs continues to be a priority of SMBSC Agricultural Research. The products for weed control in sugar beets have not changed, but the strategies for a successful weed control program are dynamic. Prominent weed pests continue to change. Smartweed has become one of the most common weeds in sugar beet fields. Velvetleaf and smartweed were two of the targeted weeds in 2005 herbicide testing along with the traditional common lambsquarters and amaranth species.

Methods

Weed control trials were established at three locations; Gluek, Maynard and Buffalo Lake. Treatments were applied to the middle four rows of six row, 35 foot long plots which were replicated four times. Herbicide treatments at Gluek, Maynard and Buffalo Lake were evaluated for weed control efficacy. The Gluek location was harvested in order to evaluate herbicide treatment effect on yield. Herbicide treatments were applied at 17 gal/acre and 40 psi.

Results

Buffalo Lake (table 1)

Weed intensity was high at the Buffalo lake location. Weeds present at the Buffalo Lake location were velvetleaf, smartweed, lambsquarters, black nightshade and amaranth species (redroot pigweed, water hemp and Powell amaranth).

Velvetleaf was best controlled when Upbeet was in the spray mix. Upbeet applied with methylated seed oil (MSO) was more consistent. Herbicide combinations including Progress, Upbeet and Stinger without MSO required elevated rates of Progress and Upbeet for adequate velvetleaf control. Herbicides with soil activity were advantageous in the control of velvetleaf. The highest velvetleaf control (93%, trt. 15) was achieved by applying Outlook in the third application (4-6 leaf sugar beet stage) of the microrate applied four times. The second highest level of velvetleaf control (91%, trt. 12) was achieved with Nortron applied preplant incorporated plus elevated rates of Progress, Upbeet and Stinger applied postemergence. The data shows that to maximize velvetleaf control a soil applied herbicide should be applied in the spray program along with a microrate containing methylated seed oil or elevated rates of the microrate components in the absence of methylated seed oil. One problem with achieving control with elevated rates, of the microrate without methylated seed oil, is the rates of the microrate components need to be elevated early in the growth stage of the sugar beet, which may result in sugar beet injury under certain situations. The best application method would be to first apply Nortron PPI or PRE. Another choice is Dual Magnum or Outlook applied at or after the four leaf stage of the sugar beet. Also, the microrate should be applied at the highest rates the label would allow while taking precaution to minimize sugar beet injury.

Smartweed control above 90% was achieved with one or both of the following variables in the spray program: 1) Preplant (PPI), preemergence (PRE) or lay-by application of soil applied herbicides and 2) Progress rate of 17.9 oz. per acre as early in the sugar beet growth stage as possible and higher rates of Progress thereafter. If no PPI, PRE or lay-by application of soil applied herbicide was made, increased rates of Upbeet and Stinger need to be applied with the higher rates of Progress. When traditional microrate rates were applied in the first two applications, increased rates of Progress up to 35.5 oz. per acre were needed to obtain smartweed control higher than 90%. If Nortron was applied PPI or PRE at 7.5 pt. per acre, traditional microrate rates or elevated microrate rates achieved approximately 90% or greater smartweed control. Dual Magnum or Outlook applied lay-by in combination with the microrate at the standard microrate rates gave smartweed control greater than 90%.

Black nightshade control was good with all treatments. These results agree with past conclusions in that black nightshade is not difficult to control with Progress, Upbeet, Nortron, Dual Magnum or Outlook in the spray program.

Amaranthus species and Lambsquarters weed control discussion will encompass results from all three locations since both weeds were present at all locations and results were generally similar (Table 1, 2 and 3).

Amaranthus species and lambsquarters
Amaranthus species and lambs quarter control was enhanced by increasing the Progress rate in the spray program. The application of a soil applied herbicide generally gave the best control of amaranth species regardless of the postemergence applications.

Gluek yield results (table 3)

Tons per acre were directly related to level of weed control. Sugar percent and purity did not relate to weed control level. Treatments with Nortron generally gave higher extractable sugar per acre.

Summary of results

1. Velvetleaf control was best with Upbeet plus methylated seed oil and control was enhanced by soil applied herbicides.
2. Soil applied herbicides were advantageous in the control of velvetleaf.
3. To maximize velvetleaf control the spray program, one should include a soil applied herbicide and microrate with methylated seed oil or elevated rates of the microrate components without methylated seed oil.
4. Smartweed control was best achieved by: 1) applying preplant (PPI), preemergence (PRE) or lay-by application of soil applied herbicide and 2) applying Progress rate of 17.9 oz. per acre as early in the sugar beet growth stage as possible and higher rates of Progress thereafter.
5. If no PPI, PRE or lay-by application of soil active herbicide was made, increased rates of Upbeet and Stinger need to be applied with the higher rates of Progress.
6. When traditional microrate rates were applied in the first two applications, increased rates of Progress up to 35.5 oz. per acre were needed to obtain smartweed control higher than 90%.
7. If Nortron was applied PPI or PRE at 7.5 pt. per acre, traditional microrate rates or elevated microrate rates achieved approximately 90% or greater smartweed control.
8. Dual Magnum or Outlook applied lay-by with the microrate at the standard rates gave smartweed control greater than 90%.
9. The data supports past conclusions. Black nightshade is not difficult to control with Progress, Upbeet, Nortron, Dual Magnum or Outlook in the spray program.
10. Amaranthus species and lambsquarters control was enhanced by increasing the Progress rate in the spray program.
11. The application of a soil applied herbicide generally gave the best control of amaranth species regardless of the postemergence applications.
12. Tons per acre were directly related to weed control level, while sugar percent and purity did not relate to weed control level. Treatments, with Nortron, generally gave higher extractable sugar per acre.

Table 1. 2005 SMBSC herbicide program weed control evaluation, Buffalo Lake location

Trt	Herbicide	Herbicide Rate	Velvet leaf	Amaranth species	Smart Weed	Lambs Quarter	Black night shade
					(% control)		
1	No ppi/pre		76	79	68	76	86
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
2	No ppi/pre		78	86	80	91	92
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	15.7 oz+1/8 oz+1.3oz+2oz+1.5%					
3	No ppi/pre		73	82	74	89	92
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%					
4	No ppi/pre		66	85	75	93	94
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	15.7oz+1/8 oz+1.3oz+2oz+1.5%					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	15.7oz+1/8 oz+1.3oz+2oz+1.5%					
5	No ppi/pre		83	97	91	98	97
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	17.9oz+1/4oz+2.5oz+3oz+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	35.5oz+1/4oz+2.5oz+3oz+1.5%					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	35.5oz+1/4oz+2.5oz+3oz+1.5%					
6	No ppi/pre		78	96	90	98	99
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	17.9oz+1/4oz+2.5oz+3oz+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%					
7	No ppi/pre		0	89	72	94	97
cot -2lf	Progress	17.9 oz.					
2lf-4lf	Progress	23.6 oz.					
4lf-6lf	Progress	35.5 oz.					
6lf-8lf	Progress	35.5 oz.					
8	No ppi/pre		76	79	74	90	95
cot -2lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz					
9	No ppi/pre		89	97	95	97	98
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3oz+2oz+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3oz+2oz+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select	35.5oz+1/4oz+2.5oz+3oz					
6lf-8lf	Progess+Upbeet+Stinger+Select	35.5oz+1/4oz+2.5oz+3oz					
10	Nortron (Pre)	7.5 pt	84	95	89	95	95
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
		LSD (.05)	***15***	***11***	***12***	***8***	***7***

Table 1. 2005 SMBSC herbicide program weed control evaluation, Buffalo Lake location (continued)

Trt	Herbicide	Herbicide Rate	Velvet leaf	Amaranth species	Smart Weed	Lambs Quarters	Black night shade
					(% control)		
11	Nortron (PPI)	7.5 pt	85	97	91	98	98
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
12	Nortron (PPI)	7.5 pt	91	96	94	98	98
cot -2lf	Progess+Upbeet+Stinger+Select	17.9oz+1/4oz+2.5oz+3oz					
2lf-4lf	Progess+Upbeet+Stinger+Select	23.6oz+1/4oz+2.5oz+3oz					
4lf-6lf	Progess+Upbeet+Stinger+Select	23.6oz+1/4oz+2.5oz+3oz					
6lf-8lf	Progess+Upbeet+Stinger+Select	23.6oz+1/4oz+2.5oz+3oz					
13	Nortron (PPI)	7.5 pt	89	96	95	98	98
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	15.7 oz+1/8 oz+1.3oz+2oz+1.5%					
14	No ppi/pre		73	92	91	95	98
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO+Dual Mag.	5.7 oz+1/8 oz+1.3+2+1.5%+28oz					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
15	No ppi/pre		93	99	99	99	99
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO+Outlook	5.7 oz+1/8 oz+1.3+2+1.5%+21oz					
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%					
16	Nortron (ppi)	7.5 pt	43	96	92	98	98
cot -2lf	Progess	15.7oz					
2lf-4lf	Progess	20oz					
4lf-6lf	Progess	23.5oz					
17	Dual Magnum(ppi)	32oz	40	99	84	99	99
cot -2lf	Progess	.15.6oz					
2lf-4lf	Progess	20oz					
4lf-6lf	Progess	23.5oz					
6lf-8lf	Progess	23.5oz					
18	Nortron (ppi)	7.5 pt	35	91	74	95	98
cot -2lf	Progress+Nortron	15.6oz+3oz					
2lf-4lf	Progress+Nortron	20oz+3oz					
4lf-6lf	Progress+Nortron	20oz+3oz					
19	Nortron (ppi)	7.5 pt	25	94	89	95	99
cot -2lf	Progress+Nortron	15.6oz+3oz					
2lf-4lf	Progress+Upbeet+Stinger+Nortron	20oz+1/4oz+2.5oz+3oz					
4lf-6lf	Progress+Nortron	20oz+3oz					
20	Dual Magnum(ppi)	32 oz.	58	96	80	98	99
cot -2lf	Progress	15.6oz					
2lf-4lf	Progress+Upbeet+Stinger+Nortron	20oz+1/4oz+2.5oz+3oz					
4lf-6lf	Progress+Dual Magnum	20oz+28oz					
		LSD (.05)	***15***	***11***	***12***	***8***	***7***

Table 2. 2005 SMBSC weed control program evaluation, Maynard location

Trt	*Herbicide*	*Herbicide Rate*	*S. beet injury*	*Lambs quarters*	*Amaranth species*
				(%)	
1	No ppi/pre		0	81	58
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
2	No ppi/pre		0	96	86
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	15.7 oz+1/8 oz+1.3oz+2oz+1.5%			
3	No ppi/pre		0	98	95
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%			
4	No ppi/pre		0	96	87
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	15.7oz+1/8 oz+1.3oz+2oz+1.5%			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	15.7oz+1/8 oz+1.3oz+2oz+1.5%			
5	No ppi/pre		0	99	98
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	17.9oz+1/4oz+2.5oz+3oz+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	35.5oz+1/4oz+2.5oz+3oz+1.5%			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	35.5oz+1/4oz+2.5oz+3oz+1.5%			
6	No ppi/pre		1	99	98
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	17.9oz+1/4oz+2.5oz+3oz+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%			
7	No ppi/pre		1	98	90
cot -2lf	Progress	17.9 oz.			
2lf-4lf	Progress	23.6 oz.			
4lf-6lf	Progress	35.5 oz.			
6lf-8lf	Progress	35.5 oz.			
8	No ppi/pre		1	99	98
cot -2lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz			
9	No ppi/pre		1	99	97
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3oz+2oz+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3oz+2oz+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select	35.5oz+1/4oz+2.5oz+3oz			
6lf-8lf	Progess+Upbeet+Stinger+Select	35.5oz+1/4oz+2.5oz+3oz			
10	Nortron (Pre)	7.5 pt	0	99	99
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
		LSD (0.05)	***1***	***6***	***12***

Table 2. 2005 SMBSC weed control program evaluation, Maynard location (continued)

Trt	Herbicide	Herbicide Rate	S. beet injury	Lambs quarters	Amaranth species
				(%)	
11	Nortron (PPI)	7.5 pt	0	97	94
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
12	Nortron (PPI)	7.5 pt	0	99	99
cot -2lf	Progess+Upbeet+Stinger+Select	17.9oz+1/4oz+2.5oz+3oz			
2lf-4lf	Progess+Upbeet+Stinger+Select	23.6oz+1/4oz+2.5oz+3oz			
4lf-6lf	Progess+Upbeet+Stinger+Select	23.6oz+1/4oz+2.5oz+3oz			
6lf-8lf	Progess+Upbeet+Stinger+Select	23.6oz+1/4oz+2.5oz+3oz			
13	Nortron (PPI)	7.5 pt	0	99	98
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	15.7 oz+1/8 oz+1.3oz+2oz+1.5%			
14	No ppi/pre		0	90	73
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO+Dual Magnum	5.7 oz+1/8 oz+1.3+2+1.5%+28oz			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
15	No ppi/pre		0	99	98
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO+Outlook	5.7 oz+1/8 oz+1.3+2+1.5%+21oz			
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%			
16	Nortron (ppi)	7.5 pt	0	98	98
cot -2lf	Progess	15.7oz			
2lf-4lf	Progess	20oz			
4lf-6lf	Progess	23.5oz			
17	Dual Magnum(ppi)	32oz	0	99	99
cot -2lf	Progess	.15.6oz			
2lf-4lf	Progess	20oz			
4lf-6lf	Progess	23.5oz			
6lf-8lf	Progess	23.5oz			
18	Nortron (ppi)	7.5 pt	0	98	99
cot -2lf	Progress+Nortron	15.6oz+3oz			
2lf-4lf	Progress+Nortron	20oz+3oz			
4lf-6lf	Progress+Nortron	20oz+3oz			
19	Nortron (ppi)	7.5 pt	0	98	96
cot -2lf	Progress+Nortron	15.6oz+3oz			
2lf-4lf	Progress+Upbeet+Stinger+Nortron	20oz+1/4oz+2.5oz+3oz			
4lf-6lf	Progress+Nortron	20oz+3oz			
20	Dual Magnum(ppi)	32 oz.	0	99	99
cot -2lf	Progress	15.6oz			
2lf-4lf	Progress+Upbeet+Stinger+Nortron	20oz+1/4oz+2.5oz+3oz			
4lf-6lf	Progress+Dual Magnum	20oz+28oz			
		LSD (0.05)	**1**	**6**	**12**

Table 3. 2005 SMBSC weed control program evaluation, Gluek location

Trt	*Herbicide*	*Herbicide Rate*	Lambs quarters	Amaranth species	Wild mustard	Tons/ Acre	Sugar (%)	Purity	Extractable Sugar /Ton	Extractable Sugar /Acre
1	No ppi/pre		65	68	99	15.57	15.90	90.89	269	4167
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
2	No ppi/pre		88	79	99	16.15	16.74	91.18	285	4631
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	15.7 oz+1/8 oz+1.3oz+2oz+1.5%								
3	No ppi/pre		90	88	99	16.73	15.92	91.21	270	4510
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%								
4	No ppi/pre		96	88	99	17.42	16.28	90.93	276	4793
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	15.7oz+1/8 oz+1.3oz+2oz+1.5%								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	15.7oz+1/8 oz+1.3oz+2oz+1.5%								
5	No ppi/pre		97	89	99	17.34	15.95	90.93	270	4613
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	17.9oz+1/4oz+2.5oz+3oz+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	35.5oz+1/4oz+2.5oz+3oz+1.5%								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	35.5oz+1/4oz+2.5oz+3oz+1.5%								
6	No ppi/pre		96	90	99	16.87	15.29	91.51	260	4376
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	17.9oz+1/4oz+2.5oz+3oz+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	23.6oz+1/4oz+2.5oz+3oz+1.5%								
7	No ppi/pre		94	88	99	15.41	16.48	91.88	283	4337
cot -2lf	Progress	17.9 oz.								
2lf-4lf	Progress	23.6 oz.								
4lf-6lf	Progress	35.5 oz.								
6lf-8lf	Progress	35.5 oz.								
8	No ppi/pre		96	90	99	15.40	16.14	91.36	275	4261
cot -2lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO+Nortron	5.7 oz+1/8 oz+1.3oz+2oz+1.5%+3oz								
9	No ppi/pre		97	91	99	15.24	16.85	90.88	285	4334
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3oz+2oz+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3oz+2oz+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select	35.5oz+1/4oz+2.5oz+3oz								
6lf-8lf	Progess+Upbeet+Stinger+Select	35.5oz+1/4oz+2.5oz+3oz								
10	Nortron (Pre)	7.5 pt	99	99	99	18.02	15.92	91.22	270	4876
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
		LSD (0.05)	***4***	***4***	***NS***	***4.57***	***1.06***	***1.12***	***21***	***1239***

Table 3. 2005 SMBSC weed control program evaluation, Gluek location (continue)

Trt	*Herbicide*	*Herbicide Rate*	Lambs quarters	Amaranth species	Wild mustard	Tons/ Acre	Sugar (%)	Purity	Extractable Sugar /Ton	Extractable Sugar /Acre
11	Nortron (PPI)	7.5 pt	99	99	99	17.00	15.55	90.52	261	4439
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
12	Nortron (PPI)	7.5 pt	99	99	99	17.70	16.35	91.17	278	4916
cot -2lf	Progess+Upbeet+Stinger+Select	17.9oz+1/4oz+2.5oz+3oz								
2lf-4lf	Progess+Upbeet+Stinger+Select	23.6oz+1/4oz+2.5oz+3oz								
4lf-6lf	Progess+Upbeet+Stinger+Select	23.6oz+1/4oz+2.5oz+3oz								
6lf-8lf	Progess+Upbeet+Stinger+Select	23.6oz+1/4oz+2.5oz+3oz								
13	Nortron (PPI)	7.5 pt	99	99	99	17.19	16.98	90.90	288	4950
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	8.7 oz+1/8 oz+1.3oz+2oz+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO	11.4oz+1/8 oz+1.3oz+2oz+1.5%								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	15.7 oz+1/8 oz+1.3oz+2oz+1.5%								
14	No ppi/pre		85	76	99	14.38	15.55	91.28	264	3773
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO+Dual Mag.	5.7 oz+1/8 oz+1.3+2+1.5%+28oz								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
15	No ppi/pre		91	86	99	15.63	15.54	91.29	264	4116
cot -2lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
2lf-4lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
4lf-6lf	Progess+Upbeet+Stinger+Select+MSO+Outlook	5.7 oz+1/8 oz+1.3+2+1.5%+21oz								
6lf-8lf	Progess+Upbeet+Stinger+Select+MSO	5.7 oz+1/8 oz+1.3+2+1.5%								
16	Nortron (ppi)	7.5 pt	93	95	99	16.30	16.01	90.96	271	4413
cot -2lf	Progess	15.7oz								
2lf-4lf	Progess	20oz								
4lf-6lf	Progess	23.5oz								
17	Dual Magnum(ppi)	32oz	78	74	99	13.44	16.47	91.41	281	3764
cot -2lf	Progess	.15.6oz								
2lf-4lf	Progess	20oz								
4lf-6lf	Progess	23.5oz								
6lf-8lf	Progess	23.5oz								
18	Nortron (ppi)	7.5 pt	99	99	99	17.05	16.24	91.07	276	4678
cot -2lf	Progress+Nortron	15.6oz+3oz								
2lf-4lf	Progress+Nortron	20oz+3oz								
4lf-6lf	Progress+Nortron	20oz+3oz								
19	Nortron (ppi)	7.5 pt	99	99	99	17.34	16.21	91.70	277	4811
cot -2lf	Progress+Nortron	15.6oz+3oz								
2lf-4lf	Progress+Upbeet+Stinger+Nortron	20oz+1/4oz+2.5oz+3oz								
4lf-6lf	Progress+Nortron	20oz+3oz								
20	Dual Magnum(ppi)	32 oz.	89	84	99	16.25	16.55	90.97	280	4558
cot -2lf	Progress	15.6oz								
2lf-4lf	Progress+Upbeet+Stinger+Nortron	20oz+1/4oz+2.5oz+3oz								
4lf-6lf	Progress+Dual Magnum	20oz+28oz								
		LSD (0.05)	***4***	***4***	***NS***	***4.57***	***1.06***	***1.12***	***21***	***1239***

SMBSC soil applied herbicide weed control evaluations and influence on sugar beet production, 2004-2005

Testing of soil applied herbicides was conducted at two locations in 2004 and 2005. The trials were initiated in the fall of 2003 and 2004 for fall applications of Dual Magnum and Nortron. Spring application were made immediately prior to planting and incorporated to a 4 inch depth. In the tables presenting the data, Nortron is used as an interchangeable term for products containing Ethofumesate such as (Nortron and Etho-Tron). Various treatments were evaluated and these treatments are listed in data Tables 1-4. All treatments had Progress applied at 14 and 17 oz. per acre in the first and second postemergence applications, respectively. Stinger was also applied in the first and second postemergence applications at 1.5 oz. per acre. The first and second postemergence applications were made at the cotyledon and 2-4 leaf stage respectively, or approximately one week apart. Postemergence applications of Dual Magnum and Outlook were made at the second postemergence application timing. The results and data for the four testing sites are presented below. Sugar beet injury was very low and was not recorded at all sites, thus sugar beet injury will not be discussed.

Results – Raymond 2004 site (Table 1)

- Lambsquarters, Amaranth species (red root, water hemp, and palmer amaranth) and eastern black nightshade pressure was moderately heavy.
- Nortron, applied at seven pints per acre, resulted in higher weed control than five pts. per acre and tended to give higher weed control than six pts. per acre.
- Two pints of Dual Magnum gave significantly higher weed control compared to lower rates of Dual Magnum.
- Nortron, applied at 5 pt. /acre, gave similar weed control as 2 pt. /acre of Dual Magnum.
- Five pints of Nortron, applied spring preplant incorporated plus, 1.67 pt. Dual Magnum or 21 oz. of Outlook applied postemergence gave similar control compared to 7 pt. Nortron applied alone.

Results - Buffalo Lake 2004 site (Table 2)

- Lambsquarters, Amaranth species (red root, water hemp, and palmer amaranth) and giant ragweed pressure was heavy.
- Weed control was generally increased as the rate of soil applied herbicide was increased.
- Dual Magnum applied in the spring tended to give higher weed control than similar Dual Magnum rates applied in the fall.
- Dual magnum, applied in the fall and supplemented with 1 pt in the spring, gave the highest weed control of treatments where Dual Magnum was the only soil applied herbicide.
- Nortron, applied at 7 pt per acre in the fall, did give higher weed control than all treatments with Dual Magnum applied alone in the spring or fall.
- Nortron, applied at 7 pt per acre, did not give statistically different weed control in the fall compared to the spring.
- Adding a post application of Dual Magnum to Nortron treatments, did not significantly increase weed control or tons per acre.
- The addition of Outlook, at 21 oz. per acre to Nortron at 5 and 6 pt per, gave higher weed control and tons per acre compared to treatments with Nortron alone at similar rates.
- Lay-by treatment of Outlook, applied at 21 oz. per acre and Dual Magnum applied at 2 pt. per acre, gave similar weed control.

- Supplementing one pint of Dual Magnum applied postemergence to 1.67 pts. per acre of Dual Magnum applied at the fall or spring preemergence timing increased weed control.

Results – Maynard 2005 site (Table 3)

- Lambsquarters, Amaranth species (red root, water hemp, and palmer amaranth) pressure was moderately heavy.
- Dual Magnum applied at 2 pt. per acre tended to give higher weed control compared to 1.67 pt per acre, regardless of time of application.
- Dual Magnum applied at the same rate tended to give higher amaranth species control when applied n the spring compared to fall applications
- Dual Magnum applied in the spring gave significantly higher velvet leaf and smart weed control compared to fall applications
- Weed control by Dual Magnum applied in the fall at 1.67 and 2 pt per acre, tended to be increased by applying 1 pt of Dual Magnum postemergence
- Nortron applied at 7 pt per acre tended to give higher amaranth species control than 5 or 6 pt per acre. However, all rates gave greater than 90% control of amaranth species
- Nortron applied in the spring gave control of velvet leaf and smart weed that was significantly higher at 7 pt per acre compared to 5 or 6 pt per acre
- Nortron applied in the spring at 7 pt per acre tended to give higher weed control compared to Nortron applied in the fall at 7 pt per acre

Results – Buffalo Lake 2005 site (Table 4)

- Velvetleaf, Amaranthus species (red root, water hemp, and palmer amaranth) and smartweed pressure was heavy.
- Control of velvetleaf, amaranthus species and smartweed tended to be better when Dual Magnum was applied in the spring or fall at 2 pt. per acre compared to 1.67 pt per acre.
- Fall and spring application of Dual Magnum gave similar control of Amaranthus species when comparing similar rate.
- Dual Magnum applied in the spring gave significantly higher velvetleaf control and smartweed control compared to fall application regardless of the rate.
- Amaranthus species control with Dual Magnum at 1.67 and 2 pt per acre was increased by 13 percent by applying 1 pt of Dual Magnum postememergence.
- Smartweed control with fall applied Dual Magnum at 1.67 and 2 pt per acre was increased by 43 (58%) and 18 (51%) percent respectively by applying 1 pt of Dual Magnum postememergence.
- Smartweed control was 18 and 20 percent higher respectively, with Dual Magnum applied in the spring at 1.67 and 2 pt per acre compared to similar rates of Dual Magnum applied in the fall with 1 pt of Dual Magnum applied lay-by.
- Nortron gave Amaranthus species control greater than 90 percent at all rates of 5pt.or greater.
- The highest velvetleaf and smartweed control with Nortron was at 7 pt per acre giving 40 and 82 percent control, respectively
- Applying Dual Magnum postemergence at 1.67 pt. per acre, negatively influenced Nortron weed control, regardless of the Nortron rate.

- Outlook applied at 21 oz. per acre provided control of Amaranthus species that was similar to Dual Magnum applied at 2 pt per acre but tended to be less than Nortron applied at 7 pt. per acre

Summary of two years weed control testing

- Dual Magnum applied at 2 pt. per acre gave better weed control and sugar beet production than 1.67 pt. per acre of Dual Magnum, regardless if fall or spring applied.
- Weed control was more consistent with Nortron at 7 pt per acre than 5 or 6 pt. per acre.
- Dual Magnum and Nortron applied in the spring generally gave better weed control than fall applications.
- Dual Magnum applied in the fall at 2 or 1.67 pt. per acre followed by a lay-by application of 1 pt. per acre gave weed control similar to equal rates applied in spring.
- Nortron applied at 6 pt plus Outlook applied lay-by at 21 oz. gave the highest sugar per acre in the trials that were harvested (Buffalo Lake 2005 not harvested).
- The best sugar production with Dual Magnum treatments was fall applications followed by a lay by application of 1.67 pt per acre
- The highest sugar per acre was achieved with the herbicide treatment of either Nortron applied in the spring at 6 pt. per acre and a lay by application of Outlook at 21 oz. per acre or Nortron applied in the spring at 7 pt. per acre
- Treatments with Nortron generally gave higher yield and sugar per acre than all other treatments

Table 1. 2004 SMBSC soil applied herbicide evaluation - Raymond site

Herbicide	Herbicide Rate	Application timing	Oats	Lambs quarters	Amaranth species	Night shade
				(% control)		
Dual Magnum	1.67 pt.	spring	28	37	33	40
Dual Magnum	2.00 pt	spring	40	77	68	67
Dual Magnum	1.67 pt.	fall	20	65	55	30
Dual Magnum	2.00 pt.	fall	33	60	45	50
Dual Mag./Dual Mag.	1.67/1.00 pt.	fall/post	95	90	80	85
Dual Mag./Dual Mag.	2.00/1.00 pt.	fall/post	79	85	81	80
Nortron	7 pt	fall	60	70	73	73
Nortron	5 pt	spring	45	50	55	47
Nortron	6 pt	spring	50	70	60	65
Nortron	7 pt	spring	75	80	85	80
Nortron/Dual Mag.	5/1.67 pt	spring/post	75	85	85	85
Nortron/Dual Mag.	6/1.67 pt	spring/post	95	95	97	97
Nortron/Outlook	5 pt/21 oz	spring/post	87	75	75	74
Nortron/Outlook	6 pt/21 oz	spring/post	97	99	98	98
Outlook	21 oz	Post	67	78	75	75
		LSD (0.05)	**16**	**19**	**17**	**16**

Table 2. 2004 SMBSC soil applied herbicide testing - Buffalo Lake site

Trt #	Herbicide	Herbicide Rate	Application Timing	Lambs quarters	Amaranth species	Giant ragweed
					(% control)	
1	Dual Magnum	1.67 pt.	Spring	9	43	41
2	Dual Magnum	2.00 pt	Spring	53	50	58
4	Dual Magnum	1.67 pt.	Fall	40	44	53
5	Dual Magnum	2.00 pt.	Fall	43	45	50
6	Dual Mag./Dual Mag.	1.67/1.00 pt.	Fall/post	70	68	58
7	Dual Mag./Dual Mag.	2.00/1.00 pt.	Fall/post	70	73	63
8	Nortron	7 pt	Fall	84	85	74
9	Nortron	5 pt	spring	51	65	58
10	Nortron	6 pt	spring	71	75	65
11	Nortron	7 pt	spring	83	81	73
13	Nortron/Dual Mag.	5 pt/1.67 pt	Spring/post	49	62	55
14	Nortron/Dual Mag.	6 pt/1.67 pt	Spring/post	70	74	64
15	Nortron/Outlook	5 pt/21 oz	Spring	86	93	63
16	Nortron/Outlook	6 pt/21 oz	Spring	90	91	66
			LSD (0.05)	13	11	11

Table 3. 2005 SMBSC soil applied herbicides evaluation
Guek location

Herbicide	*Herbicide Rate*	*Application Timing*	*Amaranth species*	*Lambs quarter*
			(% control)	
Dual Magnum	1.67 pt.	Spring	60	43
Dual Magnum	2.00 pt	Spring	74	64
Dual Magnum	1.67 pt.	Fall	65	54
Dual Magnum	2.00 pt.	Fall	71	63
Dual Magnum/Dual Mag.	1.67/1.00 pt.	Fall/post	80	75
Dual Magnum/Dual Mag.	2.00/1.00 pt.	Fall/post	82	76
Nortron	7.0	fall	80	72
Nortron	5.0	spring pre	87	86
Nortron	6.0	spring pre	91	86
Nortron	7.0	spring pre	99	99
Nortron/Dual Mag.	5/1.67 pt	Spring/post	84	79
Nortron/Dual Mag.	6/1.67 pt	Spring/post	92	83
Nortron/Outlook	5/1.67 pt	Spring	84	82
Nortron/Outlook	6/1.67 pt	Spring	95	88
Outlook	21 oz.	post	84	81
		LSD (0.05)	***11***	***11***

Table 4. 2005 SMBSC soil applied herbides evaluation, Buffalo Lake location

Trt #	*Herbicide*	*Herbicide Rate*	**Application Timing**	**S. Beet injury**	**Velvet leaf**	**Amarnath species**	**Smart weed**
				(%)	(% control)		
1	Dual Magnum	1.67 pt.	Spring	3	55	67	73
2	Dual Magnum	2.00 pt	Spring	3	61	74	84
4	Dual Magnum	1.67 pt.	Fall	0	5	69	15
5	Dual Magnum	2.00 pt.	Fall	0	15	73	33
6	Dual Magnum/Dual Mag.	1.67/1.00 pt.	Fall/post	0	18	82	58
7	Dual Magnum/Dual Mag.	2.00/1.00 pt.	Fall/post	0	20	85	51
8	Nortron	7.0	fall	4	32	93	73
9	Nortron	5.0	spring	0	20	96	54
10	Nortron	6.0	spring	0	18	91	53
11	Nortron	7.0	spring	5	40	99	82
13	Nortron/Dual Mag.	5/1.67 pt	Spring/post	3	30	90	75
14	Nortron/Dual Mag.	6/1.67 pt	Spring/post	3	28	76	46
15	Nortron/Outlook	5/1.67 pt	Spring	0	25	80	38
16	Nortron/Outlook	6/1.67 pt	Spring	0	18	86	45
17	Outlook	21 oz.	post	1	21	78	43
			LSD (0.05)	*5*	*15*	*20*	*20*

Table 5. Sugar beet yield and quality as influenced by soil applied herbicide treatment, combined data (Buffalo Lake and Raymond, MN 2004, Buffalo Lake, MN 2005)

Herbicide	Herbicide Rate	Application timing	Sugar	PURITY	Yield	Extractable Sug./ton	Extractable Sug./acre
			(tons)	(%)	(%)	(lbs)	(lbs)
Dual Magnum	1.67 pt.	spring	14.69	90.81	14.24	247	3518
Dual Magnum	2.00 pt	spring	15.24	89.43	16.19	252	4086
Dual Magnum	1.67 pt.	fall	15.10	90.10	14.99	252	3764
Dual Magnum	2.00 pt.	fall	15.37	90.17	16.34	257	4182
Dual Mag./Dual Mag.	1.67/1.00 pt.	fall/post	14.81	90.42	18.26	247	4520
Dual Mag./Dual Mag.	2.00/1.00 pt.	fall/post	15.28	89.91	19.02	254	4829
Nortron	7 pt	fall	15.28	90.04	19.32	288	4913
Nortron	5 pt	spring	14.95	89.57	16.96	253	4289
Nortron	6 pt	spring	15.30	89.75	19.43	257	4974
Nortron	7 pt	spring	15.61	90.70	21.02	261	5507
Nortron/Dual Mag.	5/1.67 pt	spring/post	15.61	89.34	18.18	257	4676
Nortron/Dual Mag.	6/1.67 pt	spring/post	15.59	88.68	20.43	252	5174
Nortron/Outlook	5 pt/21 oz	spring/post	15.63	90.89	19.45	264	5147
Nortron/Outlook	6 pt/21 oz	spring/post	15.58	91.02	22.02	263	5812
Outlook	21 oz	Post	15.56	90.31	18.11	260	4711
		LSD (0.05)	**0.50**	**0.97**	**1.39**	**13**	**462**

SMBSC evaluation of fungicides for cercospora leaf spot control

Justification

Sugar beet production can be significantly influenced by foliar disease, such as cercospora leaf spot. The control of cercospora leaf spot has been a challenge for sugar beet growers for many years. Efficacy of disease control is one of the factors considered in selection and sequence of fungicides for cercospora leaf spot control programs. The testing presented in this report considers the efficacy of fungicides for control of cercospora leaf spot.

Results

In 2005 fungicides were evaluated for cercospora leaf spot control at two locations. One location (South CLS) was two miles south of the SMBSC processing facilities and the other (North CLS) was five miles north of the SMBSC processing facilities. A test for homogeneity between sites was conducted. The test for homogeneity showed that the two sites (North CLS and South CLS) could be combined. The discussion of the results will consider the combined data (Table 1). Table 2 shows the application information for the two locations.

Cercospora leaf spot control was statistically similar for all treatments with an equal number of applications when considering either three or four applications. Cercospora leaf spot control, with treatments having only two applications, was generally unacceptable. Eminent followed by Headline gave the highest control with a CLS rating of 4.8.

At these locations, four applications tended to give a higher control of cercospora leaf spot but gave significantly less extractable sugar per acre than most of the treatments having three applications. Given that control of cercospora leaf spot tended to be better with four applications compared to three applications, one can conclude that cercospora leaf spot was not the variable that caused this phenomenon.

Three fungicide applications gave the highest extractable sugar per acre. The two best treatments were fungicides applied in a fourteen day spray interval. One sequence was Eminent, Triphenyl Tin Hydroxide and Headline and the other was Headline, Triphenyl Tin Hydroxide and Eminent. There was only 149 pounds of sugar per acre separating the performance of these two treatments. Thus, whether Eminent or Headline was applied first or last was not important when considering extractable sugar per acre. More important than the application sequence is the inclusion of three separate modes of action.

Treatments with two fungicide applications only tended to give less sugar production per acre compared to treatments with three applications. There were only small differences between treatments with the same number of applications. When comparing the average of treatments with the same number of application, treatments with two applications gave 671 pounds of extractable sugar per acre less than treatments with three applications. Considering that the cercospora leaf spot control was significantly better with treatments having three applications compared to treatments with two applications, one can conclude that the difference in sugar per acre can be attributed to control of cercospora leaf spot. This difference in extractable sugar per acre supports a conclusion that three applications is better than two applications for production of sugar from sugar beets.

Extractable sugar per acre was statistically similar whether Headline or Gem was applied in the fungicide application sequence. These results agree with previous conclusions that there is not a yield difference whether Headline or Gem is included in the fungicide spray program as the Strobilurin mode of action component.
In summary:

1. Three applications gave the highest extractable sugar per acre.
2. Whether Eminent or Headline was applied first or last in a three spray program, cercospora leaf spot control and sugar production per acre was statistically similar.
3. Cercospora leaf spot control and sugar production per acre was statistically similar whether Gem or Headline was used in the spray program.
4. To effectively practice disease resistance management, the suggested sequence for a three spray cercospora leaf spot control program is Eminent, Tryphenyl Tin Hydroxide and Strobilurin (Gem or Headline).

Table 1. SMBSC 2005 Cercospora leaf spot fungicide screening
Combined locations

Treatment	Interval days	Rate Oz./Acre	CLS rating	Tons /acre	Sugar %	Purity	Nitrate ppm	Extractable Sugar %	Extractable Sugar/ton	Extractable Sugar/acre
Untreated Check			**6.9**	**18.43**	**13.36**	**87.18**	**154**	**10.56**	**211**	**3894**
Eminent TPTH Gem TPTH	14 14 14 14	13 5 3.37 5	**1.9**	**22.73**	**14.01**	**88.87**	**97**	**11.39**	**228**	**5179**
Eminent TPTH Gem	14 14 14	13 5 3.37	**2.7**	**24.79**	**15.08**	**89.87**	**50**	**12.51**	**250**	**6203**
Eminent Gem TPTH Headline	14 14 14 14	13 3.37 5 9	**1.9**	**23.09**	**14.25**	**88.99**	**80**	**11.62**	**232**	**5378**
Eminent TPTH Headline	14 14 14	13 5 9	**2.8**	**27.15**	**14.55**	**89.25**	**86**	**11.94**	**239**	**6479**
Headline TPTH Eminent	14 14 14	9 5 13	**3.0**	**26.03**	**15.24**	**90.44**	**47**	**12.75**	**255**	**6618**
TPTH Headline Eminent TPTH	14 14 14 14	5 9 13 5	**1.9**	**21.82**	**14.93**	**89.43**	**88**	**12.31**	**246**	**5390**
Eminent TPTH	14 14	13 5	**5.4**	**23.37**	**15.08**	**89.48**	**62**	**12.45**	**249**	**5795**
Eminent Headline	14 14	13 9	**4.8**	**22.93**	**15.39**	**89.80**	**55**	**12.78**	**256**	**5849**
TPTH Eminent	14 14	5 13	**5.9**	**24.40**	**14.50**	**88.91**	**89**	**11.84**	**237**	**5779**
TPTH Headline	14 14	5 13	**5.3**	**23.09**	**15.30**	**89.67**	**39**	**12.67**	**253**	**5858**
TPTH Gem	14 14	5 3.37	**5.5**	**23.23**	**14.51**	**89.18**	**94**	**11.90**	**238**	**5530**
		LSD (0.05)	***0.9***	***3.70***	***1.16***	***1.56***	***65***	***1.24***	***25***	***927***

Table 2. Cercospora leaf spot fungicde screening site Application specifics

	CLS North site specifics					***CLS South site specifics***				
Previous crop	Field corn					Field corn				
%O.M.	5.1					4.8				
pH	7.5					7.3				
Sugar Beet Variety	Beta 4930					Beta 4930				
Application Info.	start	14 day	21 day	14 day	14,21 day	start	14 day	21 day	14 day	14,21 day
date	14-Jul	28-Jul	2-Aug	13-Aug	26-Aug	13-Jul	27-Jan	1-Aug	11-Aug	24-Aug
Time of application	9-4:00	9-5:00	11-4:00	9-5:00	9-3:00	10-3:00	9-4:00	12-4:00	10-5:00	9-5:00
%RH	82	70	80	80	85	75	70	80	72	85
air temp	85	75	88	78	79	83	69	85	80	73
soil temp	80	70	80	75	77	80	72	79	70	78
% cloud cover	30	40	10	30	30	50	75	20	50	30
wind speed and direction	5	15	5	10	10	10	5	10	5	0
soil moisture	mod.	mod.	mod.	mod.	mod.	mod.	mod.	mod.	mod.	mod.
crop stage	closure					closure				
pest stage	spores					spores				
Applicator ground speed	5					5				
carrier	water					water				
pressure	120					120				
volume	20					20				
nozzle type	XR 8002 VS					XR 8002 VS				
nozzle spacing	20 inch					20 inch				

SMBSC Non-subjective evaluation of cercospora leaf spot in sugar beets using light band reflectance

Justification

Researchers have for many years evaluated fungicide effectiveness and variety tolerance by using the KWS scale for cercospora leaf spot visual ratings. The KWS scale is a rating from 1-9 indicating incidence of cercospora leaf spot. The visual evaluation procedure is subjective in that the KWS rating given to a specific treatment for cercospora leaf spot is dependant on the evaluator. The rationale for using light band reflectance for evaluating cercospora leaf spot, is that the light and reflectance readings are not subjective, while the visual ratings are subjective.

Method

The research trial area was established as a Randomized Complete Block Design (RCBD) with four replications. Experimental units were 35 ft. long and 11ft (6 rows) wide. Sugar beets were planted in 22 inch wide rows with seed at 1.25 inches deep and 5.5 inches apart. Fungicide treatments were applied and resulted in varying degrees of cercospora leaf spot control. Fungicide treatments were evaluated visually using the KWS scale and will be referred to as cercospora leaf spot rating. A hand held optical sensor was used to measure Normalized Difference Vegetative Index (NDVI) and Red to Near Infrared Ratio (R-NIR ratio) of plant material. These measurements can indicate plant health.

An N-tech model 505 GreenSeeker Hand Held Optical sensor unit was used to scan sugar beet foliage for light reflectance measurements. The GreenSeeker was operated 36 inches above the sugar beet canopy. Measurements were initiated and concluded 2 ft. from each end of the plot area. Light reflectance measurements were taken in each experimental unit in all replications. The GreenSeeker unit was held over the middle two rows of each experimental unit.

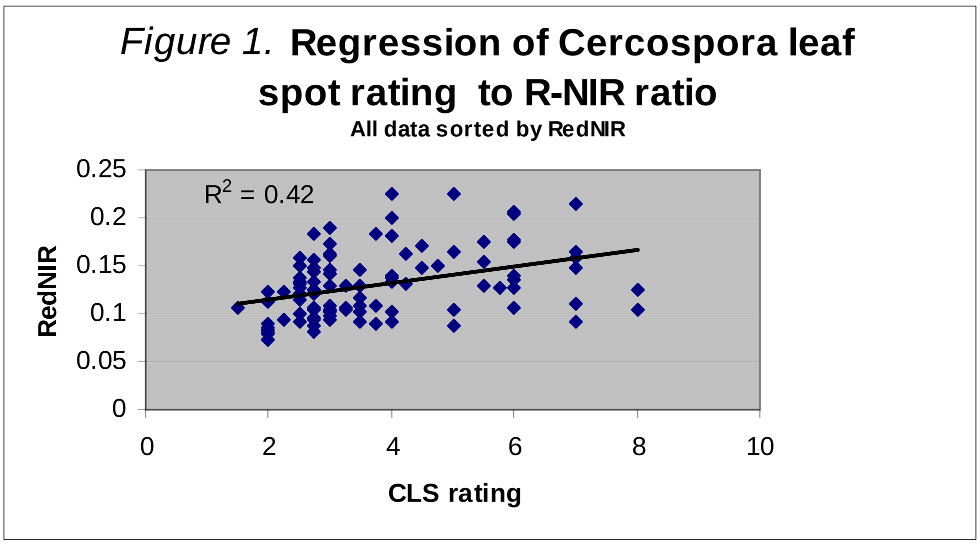
Results

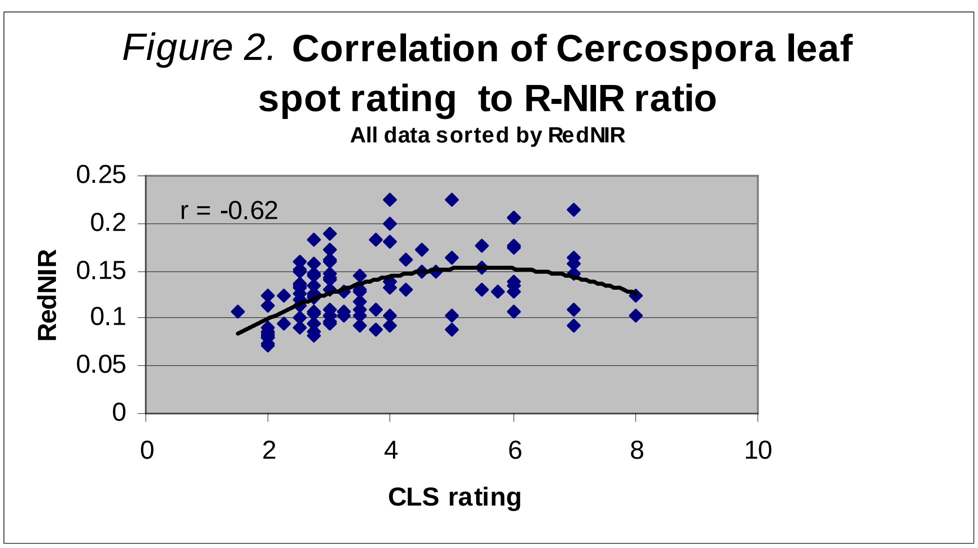
A multiple linear regression analysis was conducted and indicated a better relationship of R-NIR ratio to cercospora leaf spot rating and other sugar beet production variables, when compared to NDVI . Therefore, all further comparisons will refer to R-NIR ratio. R-NIR ratio wave band showed a weak relationship to cercospora leaf spot incidence when analyzing the data using simple linear regression (figure 1). The R^2 for R-NIR ratio accuracy in estimating cercospora leaf spot rating was 0.423. The relationship, considering the data as a linear relationship, was directly positive. However, when considering the data, the best fit line was quadratic which requires a correlation analysis.

The correlation analysis in reference to R-NIR ratio relationship to cercospora leaf spot rating was moderate giving an r of -0.62 (figure2). This relationship does not indicate an adequate relationship to consider using R-NIR ratio to measure the level of cercospora leaf spot . The relationship would indicate a change in the model would be needed for the R-NIR ratio to be applicable for this use.

However, the ultimate indicator of a disease impact is the effect it has on sugar per acre. In this case there was not a good relationship of cercospora leaf spot effect on sugar per acre, as indicated by cercospora leaf spot rating to sugar per acre correlation r = -.4053 (figure 3) although, the correlation coefficient was statistically significant. The question of whether or not the R-NIR ratio is a good indicator of the cercospora leaf spot rating can be answered by considering whether or not both variables have a similar influence on estimating sugar per acre.

The correlation coefficient for R-NIR ratio to sugar per acre was -.4134 (figure 4). This indicates that both cercospora leaf spot rating and R-NIR ratio similarily measure the influence of cercospora leaf spot on sugar per acre. Further testing should be conducted to try to improve the model for predicting the influence of cercospora on sugar per acre.





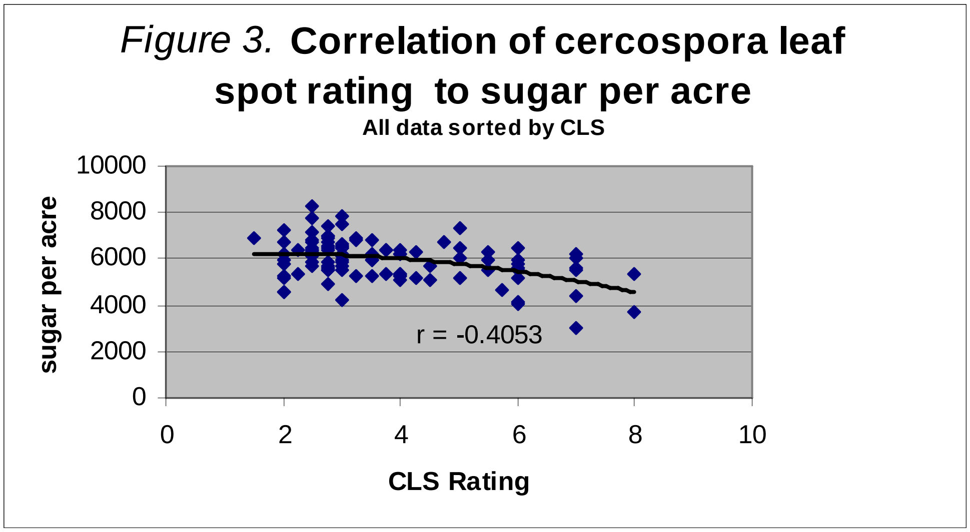


Figure 3. **Correlation of cercospora leaf spot rating to sugar per acre**
All data sorted by CLS
sugar per acre
10000
8000
6000
4000
2000
0
r = -0.4053
0
2
4
6
8
10
CLS Rating

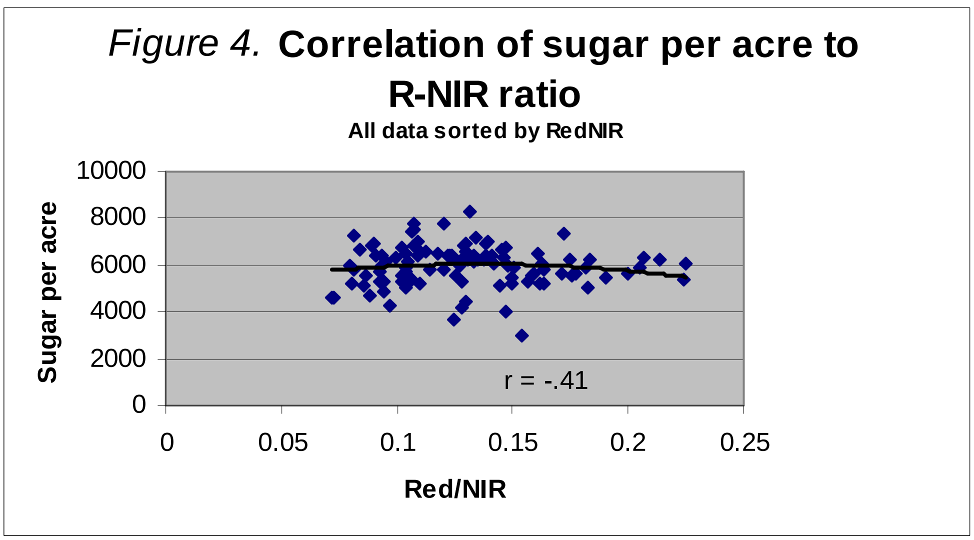


Figure 4. **Correlation of sugar per acre to R-NIR ratio**
All data sorted by RedNIR
Sugar per acre
10000
8000
6000
4000
2000
0
r = -.41
0
0.05
0.1
0.15
0.2
0.25
Red/NIR

SENSITIVITY OF *CERCOSPORA BETICOLA* TO FOLIAR FUNGICIDES IN 2005.

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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. The 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. The terms sensitive, reduced sensitivity, insensitive, tolerant and resistant are often used to describe the reactions of fungal populations to fungicides.

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. Sensitivity testing of *C. beticola* isolates collected from throughout the sugarbeet growing region of ND/MN to Tin, Topsin and Eminent.was conducted in cooperation with Dr. John Weiland. Fungicide sensitivity testing of *C. beticola* to the five commonly used fungicides in our area was continued in 2003, 2004 and 2005.

OBJECTIVES

The 2005 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 2005, 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 2005.

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 consisting of 3-5 leaves, *C. beticola* spores were collected from a minimum of five spots/leaf from each leaf of each sample. The spores were mixed, and composite of 200 µl of spores transferred to each of three Petri plates containing water agar amended with

Tin at 1 ppm or non-amended (water agar alone). Germination of 100 random spores on tin amended water agar was counted 16 hrs after plating and percent germination calculated. The colony on non-amended media was used as a source of single spore sub cultures for subsequent Eminent, Headline and Gem sensitivity testing.

The fungicide sensitivity testing for Eminent used a standard radial growth procedure developed in our lab for *C. beticola*. A subculture from the original non-amended media was grown on water agar medium amended with serial ten-fold dilutions of Eminent from 0.001 – 1.0 ppm. After 15 days, inhibition of 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 developed in our lab by Rivera et al for efficient spore production and sensitivity testing. A subculture from the original non-amended medium was grown on modified V-8 medium and induced to sporulate abundantly. The spores were collected and transferred to water agar amended with serial ten fold dilutions of Headline or Gem from 0.001 – 1.0 ppm. Studies in our lab in 2003 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 2005 season and the majority of the CLS samples were delivered to our lab in late August or early September. Due to the diligent collection efforts of the grower cooperative agronomists, approximately 1319 individual isolates of *C. beticola* representing all production areas and factory districts were tested. This number includes isolates collected from the field fungicide trials of Dr. Mohamed Khan, Dr. Larry Smith and SMSBC Renville. A few samples that were submitted for testing were not done, because the spores did not germinate despite repeated attempts. 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 observed 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 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% and in 2005 was 0.97% (Fig. 1). 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 to 0.46 over the period from 1998-2005.

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 is 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 and from 2005 was 0.29. In 2002, 1.2 % of the isolates tested had an EC_{50} value of >1 compared to 6.0% of the isolates in 2003, 10.8% of the isolates in 2004 and 12.4% in 2005 (Fig 3). Sensitivity to tetraconazole 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). It is evident that both the average tetraconazole sensitivity as measured by EC50, and the incidence of isolates with EC_{50} values >1 ppm have slowly increased over the past three years. This indicates a potential for increased resistance to tetraconazole, and that practices must be implemented to slow this trend.

A limited 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. Sensitivity of C. *beticola* to these fungicides has remained stable since these fungicides have been used commercially (Headline three years, Gem two years) compared to the baseline, but there appears to be a slight shift toward increased sensitivity (Figs. 6 and 7) 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 noted that we have found isolates in the population that have an EC_{50} value >1.0 ppm for both Headline and Gem.

Fungicide sensitivity monitoring is not only important for control of sugarbeet diseases, but is also an important issue in potatoes, particularly for the strobilurin (QoI) fungicides. There are five QoI products registered for potatoes: Quadris, Headline, Gem, Reason and Tanos. Decreased sensitivity to Quadris and Headline has been documented in the early blight pathogen, *Alternaria solani* after only two years of use. Because *C. beticola* has a history of developing tolerance or insensitivity to fungicides, and insensitivity to at least one, and probably other, strobilurin fungicides has developed in another adaptable pathogen in the potato pathosystem, it is important to monitor population sensitivity to Headline and Gem. It is also important to monitor sensitivity to Eminent, since this is the alternating fungicide partner for managing reduced sensitivity in Headline and Gem.

SUMMARY

1. Tin tolerance at 1.0 ppm is declining, probably due to the use of alternate fungicides that has resulted in the reduction in the number of tin applications from 2.4 to 0.46 from 1998 to 2005..

2. Resistance to Topsin at 5.0 ppm is widespread across all production areas of the state, and is not declining. Topsin sensitivity was not tested in 2005.

3. Sensitivity to Eminent is relatively stable, but there is 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. The increase was smaller in 2005 than in either 2003 or 2004.

4. Sensitivity to Headline and Gem remains relatively stable, but there are rare isolates identified with a thousand-fold decrease in sensitivity.

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

6. Disease control recommendations include

- Fungicide rotation
- Eminent first, once, or not at all
- Only one strobilurin per season
- A good three spray program is Eminent, tin, strobilurin
- Scout at end of the season to decide the necessity of a late application; CLS developed late in 2005
- Use NDAWN DIV's as fungicide application guide or first application at row closure
- Use fungicide resistance maps for fungicide selection
- Use a variety with resistance to CLS
- Spray intervals of 14 days
- Use15-20 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 2005 at 1.0 ppm as measured by bulk spore germination

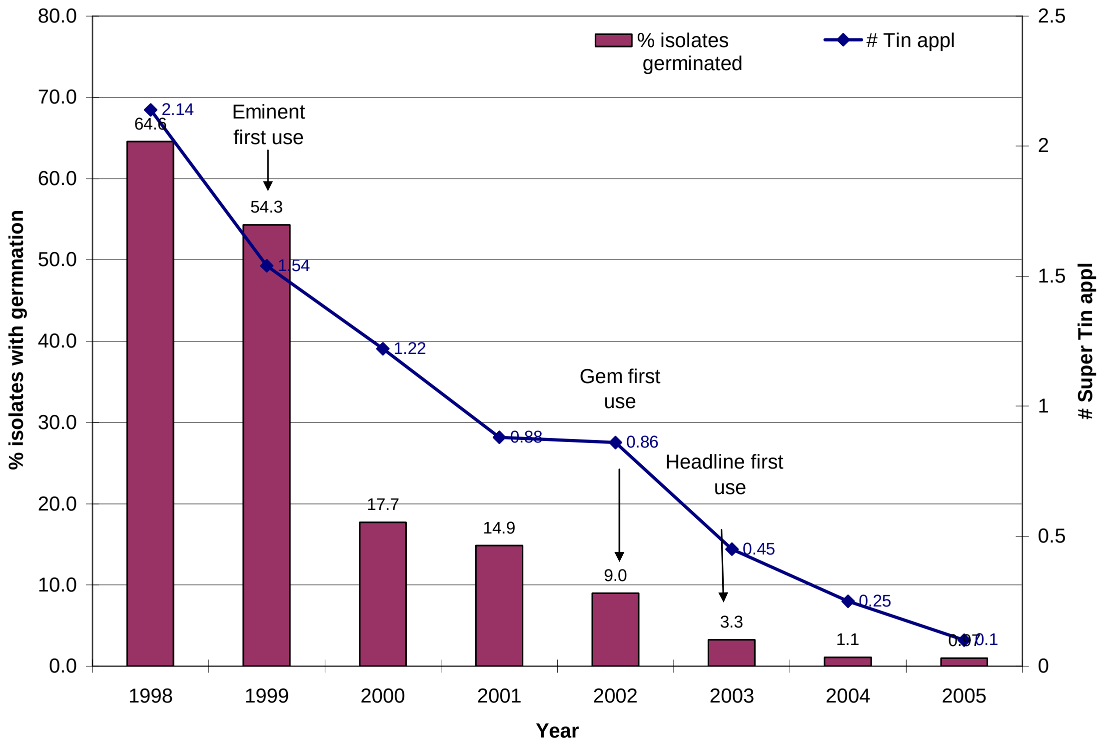


Fig 2. Average EC-50 value of Cercospora beticola isolates collected from 1997-2005 to tetraconazole

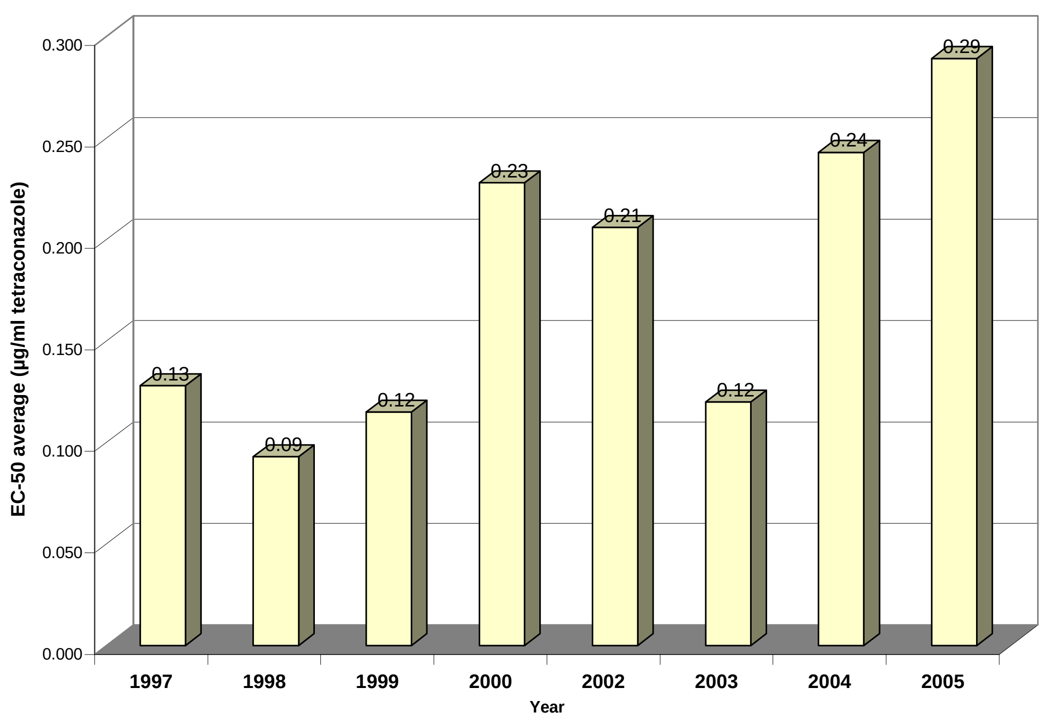


Fig. 3 Sensitivity of C. beticola isolates collected in ND and MN from 1997-2005 to tetraconazole

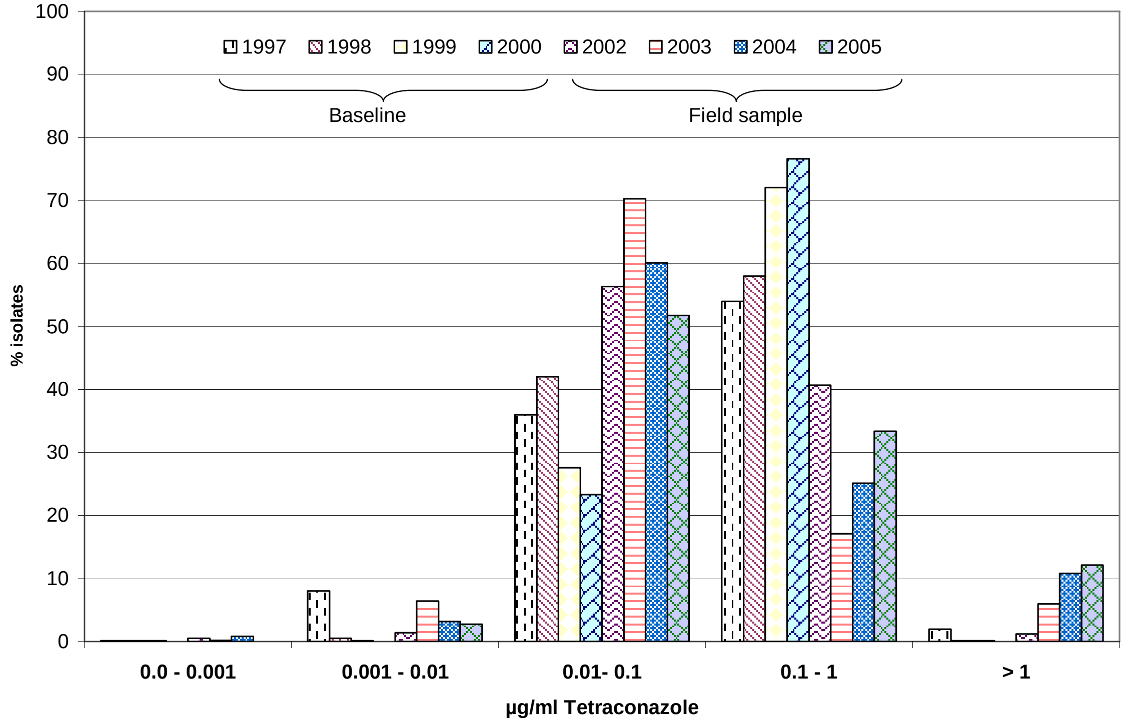


Fig 4. Sensitivity of *C. beticola* to tetraconazole by factory district 2005

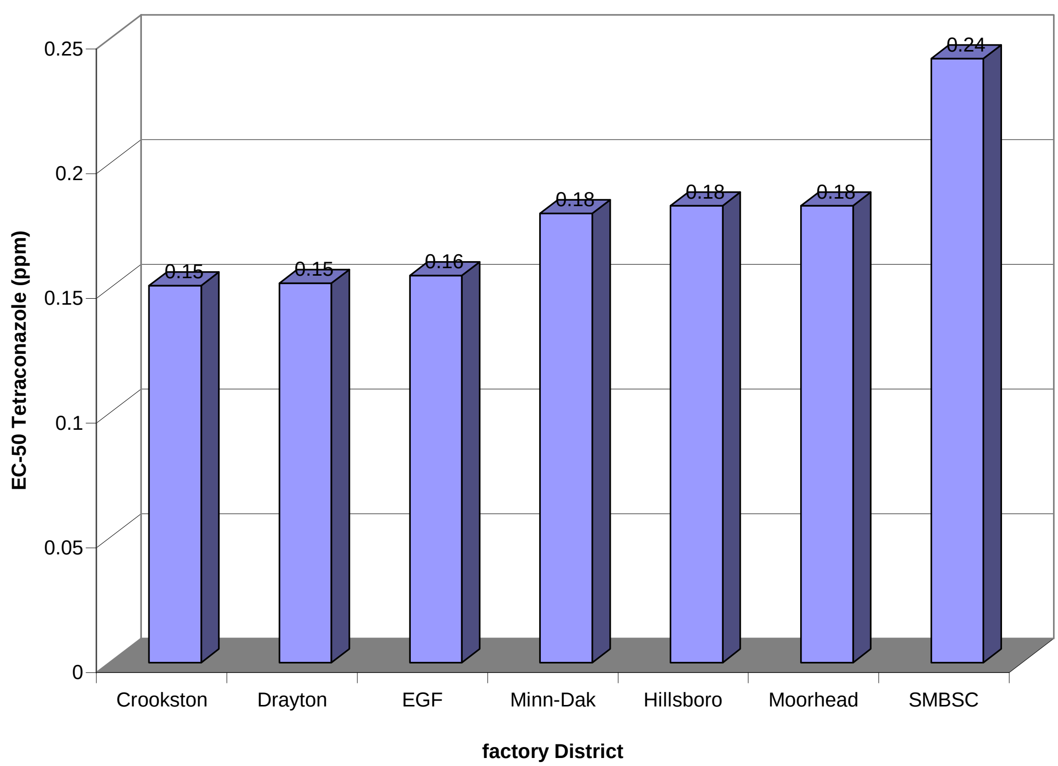


Fig 5. Percent of *C. beticola* isolates with EC-50 > 1 µg/ml of tetraconazole collected in 2005 by factory district

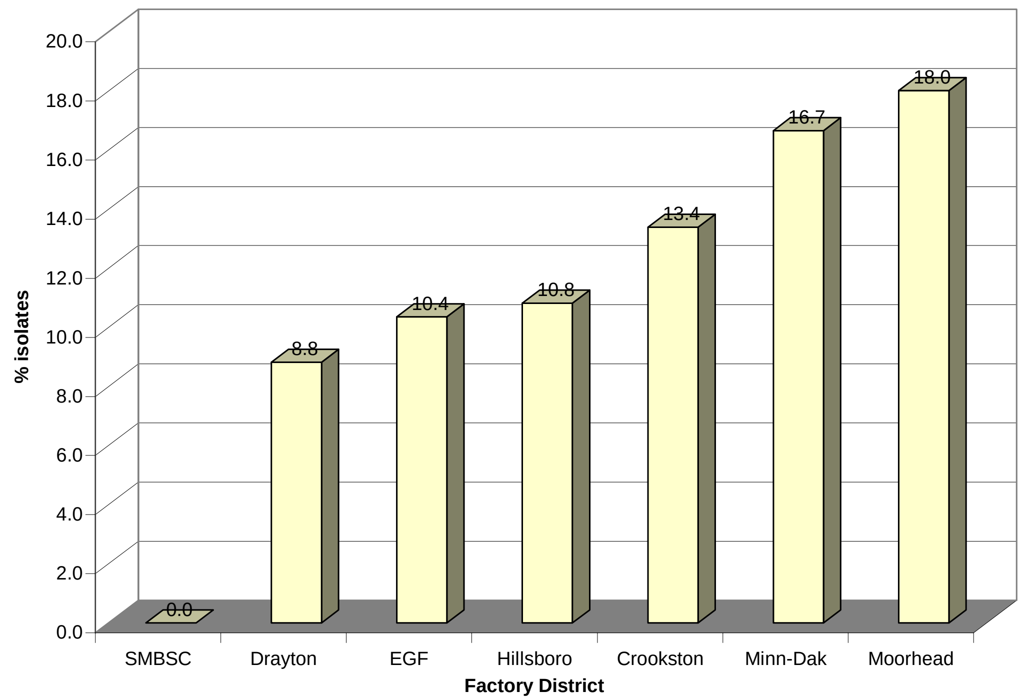


Fig 6. Sensitivity of *C. beticola* isolates to pyraclostrobin (Headline) collected from 2003-2005

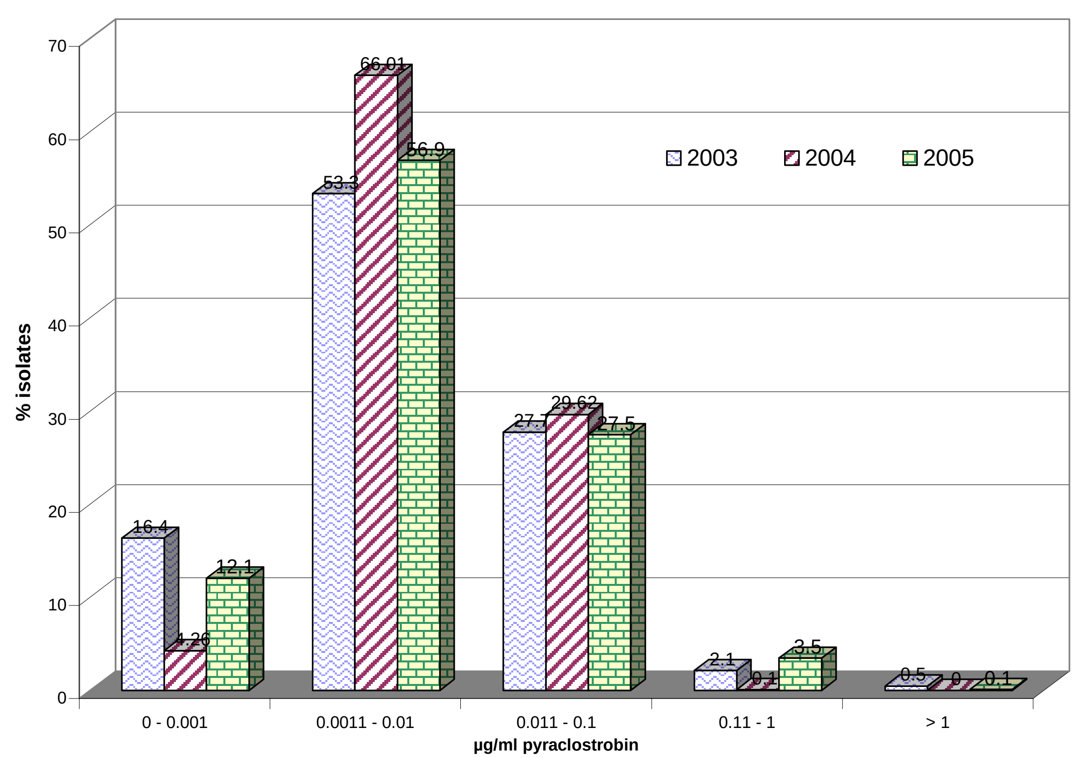
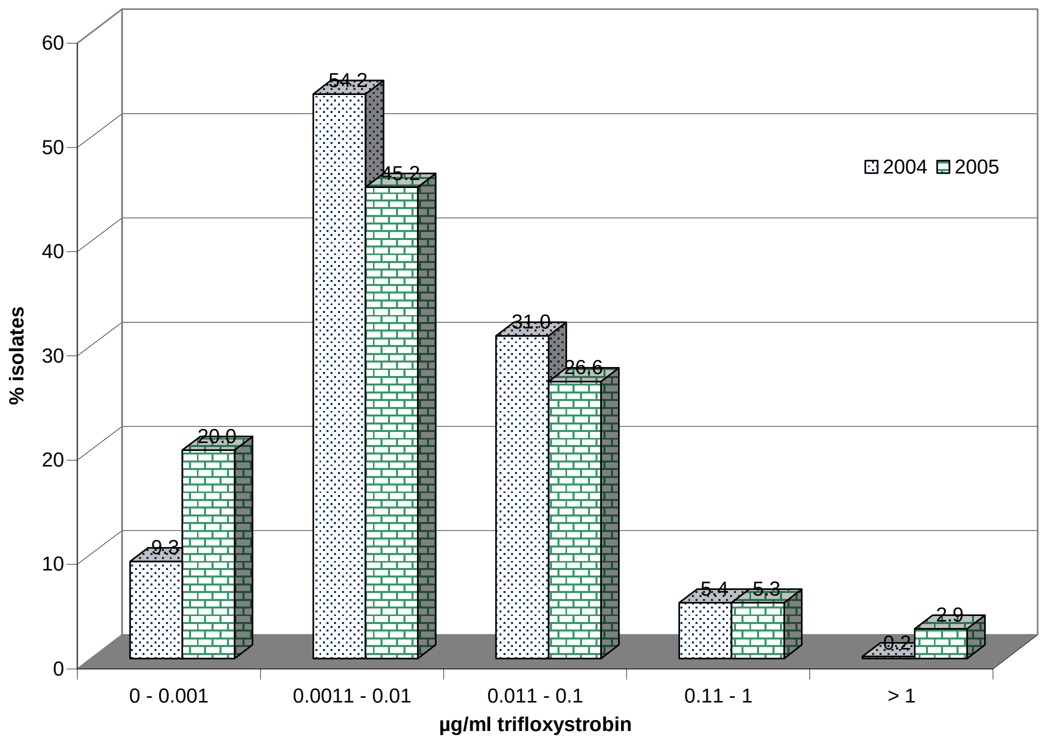


Fig 7. Sensitivity of *C. beticola* isolates collected in MN and ND to trifloxystrobin (Gem) from 2004-2005



DETECTING GENETIC DIVERSITY OF BNYVV AND QUANTIFYING INCIDENCE OF RHIZOMANIA IN FIELDS PLANTED TO RESISTANT VARIETIES

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Beet necrotic yellow vein virus (BNYVV), which causes rhizomania of sugar beet, causes major reductions in root yield and quality wherever it occurs. When the pathogen is first introduced into a field, yield losses may be minimal. However, in subsequent crops, root yield and quality are both significantly reduced. In the United States, the disease was first identified in California in 1984, but now it occurs in every major sugar beet production region in the country. Fortunately, strong genetic resistance, conferred by the *Rz1* gene, was identified soon after rhizomania was identified in the United States, and it has been incorporated into regionally adapted cultivars that allow profitable sugar beet production in fields infested with the pathogen. However, in the Imperial Valley of California in 2002, plants in a field planted to a rhizomania resistant cultivar began to express symptoms of rhizomania. Severe rhizomania has also occurred in Minnesota sugar beet fields planted to rhizomania tolerant cultivars. In Minnesota, the occurrence of rhizomania in disease tolerant cultivars was primarily restricted to individual plants. However, in 2004 and 2005 discrete spots of diseased plants appeared and this essentially ruled out "seed issues" as the cause for disease development. Therefore, inoculum density of viruliferous *P. betae,* soil edaphic factors, or a new resistance-breaking strain of BNYVV is likely the reason for disease development in rhizomania resistant cultivars. It is important to determine how extensive breakdown of rhizomania resistance is in the United States, whether the etiology of rhizomania in fields planted to rhizomania tolerant cultivars is the same in different production regions, and to devise strategies for managing the problem. One of the goals of our research on rhizomania is to investigate the cause and incidence of rhizomania in fields planted to disease tolerant cultivars. In order to meet this goal, we conducted studies in 2005 with the following objectives: 1) Detect and map genetic variation among resistance-breaking isolates of BNYVV, and 2) Quantify the incidence of rhizomania in fields planted to disease tolerant cultivars and estimate yield loss.

Methods

Objective 1. Detect and map genetic variation among resistance-breaking isolates of BNYVV. Sugar beet plants exhibiting typical, diagnostic symptoms of rhizomania were collected from fields planted to rhizomania tolerant cultivars in California and Minnesota. Since the *Rz1* gene only confers tolerance to BNYVV and does not prevent infection of the root, asymptomatic beets were also collected from the same fields where resistance was breaking down in hopes of obtaining wild type, non resistance-breaking isolates of BNYVV. 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.

Objective 2. Quantify the incidence of rhizomania in fields planted to disease tolerant cultivars and estimate yield loss. In the 2005 growing season, three fields south of Crookston, MN and seven fields south of Willmar, MN were selected for study. These fields were selected because they were planted with rhizomania tolerant cultivars and exhibited a high incidence of blinkers, and spots of diseased plants, throughout all or part of the field. Within each field, five areas were sampled. Each sampling area was geo-referenced and stand counts were made on ten feet of row. Blinkers were counted on the stand count row and the five adjacent rows. Approximately 15 blinkers and 15 healthy sugar beet plants were collected from the general area but outside the counted rows. The sugar beets were rated for rhizomania severity on a scale from 0-4, with 0 as healthy and 4 as severely diseased. The individual blinker and healthy plants were bulked separately at each location. This gave a total of five paired samples for each field. Each sample was processed at the factory for sucrose content and root yield. *Beet necrotic yellow vein virus* (BNYVV) was assayed by enzyme-linked immunosorbent assay (ELISA) on feeder root tissue of the taproot.

A white tarp, measuring 1' X by 10', was placed at each sample location so that it could be identified in aerial photography (Fig. 2). Immediately after the fields were sampled on the ground, digital images were acquired at an altitude of approximately 1700' mean sea level (800' 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' resolution. Images were geo-rectified using ArcView version 9.1 (ESRI, Redlands, CA). The G/B ratio was calculated for each pixel in the image using ENVI version 4.1 (RSI, Boulder, CO) (Fig.3A). Pixels were classified using unsupervised classification with three classes that represented healthy beets, diseased beets and background (soil) (Fig. 3B). The area and percent of each class was calculated for each image.

Results and Discussion

Results of the study on genetic variability among isolates of BNYVV are shown in Table 1 and Figure 1. In greenhouse studies, resistance-breaking isolates of BNYVV from California were highly virulent on cultivars that contained the *Rz1* gene, and virus titers were high in infected plants. Wild type isolates from the same fields were not able to replicate well in rhizomania tolerant cultivars and virus titers were significantly lower than those achieved by the resistance-breaking isolates (data not shown). Sequence analysis of the RNA 3 P25 ORF from the different isolates of BNYVV revealed a high degree of nucleotide sequence homology. However, amino acid analysis revealed differences between California wild type isolates and resistance-breaking isolates of BNYVV. The resistance-breaking isolates from California were also genetically distinguishable from isolates of BNYVV obtained from blinkers in Minnesota (Table 1). Amino acids 67,68, and 135 from the P25 RNA3 ORF can be used to distinguish the California resistance-breaking isolates of BNYVV from all other isolates but it is uncertain whether the $V_{67}L_{68}E_{135}$ motif associated with the resistance-breaking isolates is actually responsible for the ability of these isolates to overcome *Rz1*. The fact that the amino acid motif of isolates from blinkers in Minnesota differs from the California resistance-breaking isolates suggests that the two are genetically distinguishable and that perhaps mechanisms of virulence are different. However, additional tests need to be performed to verify this hypothesis.

Table 1. Amino acid substitutions in the *Beet necrotic yellow vein virus* P25 protein, associated with resistant breaking isolates and blinkers from California and Minnesota, respectively.

Source	**Isolate**[y]	**Amino acid**[z]		
		67	**68**	**135**
California	Ch*	V	L	E
	Mag*	V	L	E
	DWe*	V	L	E
	Spr*	V	L	E
	Tam*	V	L	E
	Salinas 2005	A	C	D
	Wt CIV2005	A	L	D
Minnesota	Blinker 83*	V	C	D
	Crookston*	A	H	D
	Willmar*	A	C	D
	Glendon 1*	A	C	D
	Climax*	A	C	D
	Wt15 2000	A	C	D

[x] Blinker is the term used to describe an individual sugar beet infected by *Beet necrotic yellow vein virus* (BNYVV), which exhibits the florescent yellow foliage typically associated with rhizomania, surrounded by symptomatic beets with dark green foliage.

[y] Isolates followed by an asterisk "*" represent resistance-breaking CIV-BNYVV from California, or BNYVV isolates recovered from blinkers in Minnesota. Salinas 2005 and Wt CIV 2005 represent wild type, non-resistance breaking isolates from Salinas, CA and the Imperial Valley, respectively. Wt15 2000 is a wild type isolate from Minnesota.

[z] The $V_{67}L_{68}E_{135}$ signature was consistently found in resistance-breaking CIV-BNYVV populations during 2005. Asymptomatic plants from the Imperial Valley are infected by genetically heterogeneous virus populations where $A_{67}L_{68}D_{135}$ is the predominant signature. The $A_{67}C_{68}D_{135}$ signature frequently has been found in many virus populations collected outside of the Imperial Valley, both from symptomatic and asymptomatic plants.

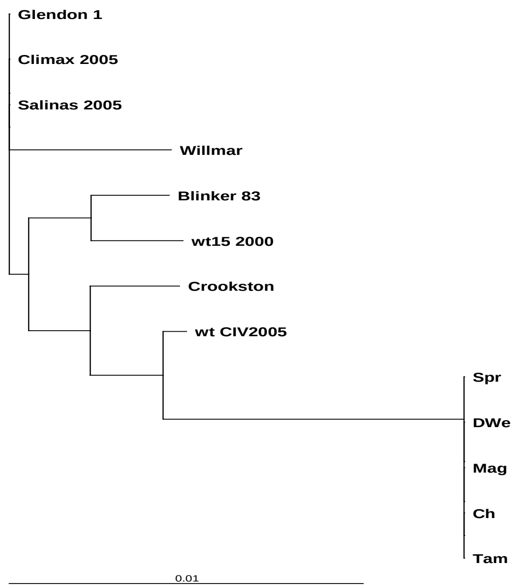

Figure 1. Phylogram generated from nucleotide sequence from the RNA3 P 25 ORF of BNYVV. Resistance – breaking isolates of BNYVV from California clearly cluster together and are distantly separated from wild type isolates of BNYVV and isolates obtained from blinkers in Minnesota.

Although isolates of BNYVV obtained from blinkers in Minnesota were genetically different from resistance-breaking strains from California, they were obviously highly virulent and caused significant reductions in root yield and sucrose content (Table 2). Mean root weight of blinkers was reduced approximately 62% compared with asymptomatic, healthy beets growing adjacent to the blinkers. Blinkers also had reduced sucrose content that averaged 1.8 percentage points lower than the healthy beets.

Table 2. Disease rating and yield data from ground truthed plots

Symptom	Disease Rating[y]	Mean Root Wt.(lbs)	Sucrose (%)
Healthy	1.7	1.3	14.6
Blinker[x]	2.5	0.5	12.8

[x] Blinker is the term used to describe an individual sugar beet infected by BNYVV, which exhibits the florescent yellow foliage typically associated with rhizomania, surrounded by healthy beets with dark green foliage.

[y] 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.

When attempting to quantify the incidence of blinkers in the field and whether they were randomly distributed or aggregated, aerial photography was absolutely necessary. From ground level, blinkers often appeared to be randomly distributed but from the air, it was clear that they were clumped into irregular spots, identical to those that appeared when rhizomania first appeared in Minnesota in fields planted to rhizomania susceptible lines.

For aerial photography, the white tarps placed next to the ground truth data collection points were clearly visible from the air (Fig. 2). These allowed the photographer to identify the areas where the ground truth data had been collected and to focus aerial images on those positions in the field. The use of the digital camera to obtain remote images of the diseased spots in the field was highly effective and image analysis was effective in differentiating healthy from diseased plants (Fig. 3) Estimates of percent area of fields affected by rhizomania ranged from 12% to 70%. However, percent area affected did not correlate well with final yield from the sampled fields. For instance, the field with an estimated 12 symptomatic plants yielded 27.2 tons and 15.8% sucrose, while

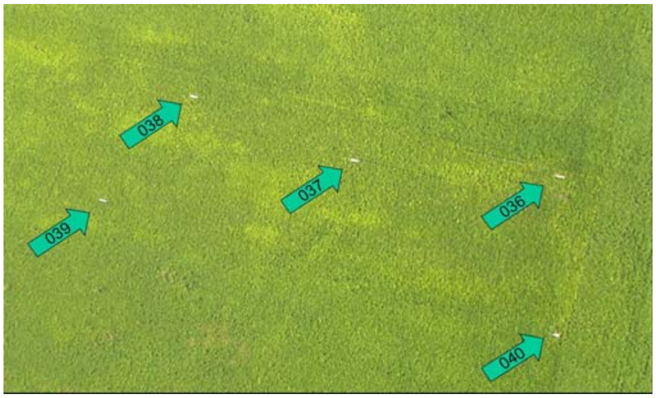

Figure 2. Aerial image of sugar beet field. White tarps mark areas where ground truth data was taken, and large yellow irregular spots of rhizomania are easily identified.

another field in Southern Minnesota with 28% symptomatic plants yielded30.5 tons and 16.2 sucrose (Table 3). It is not uncommon for root yield and sucrose content to be impacted by a number of variable and that partially accounts for this discrepancy. However, it is recognized that our estimates of disease were high when compared to actual ground truth determinations. Larger ground truth plots and better analytical techniques will help resolve this issue.

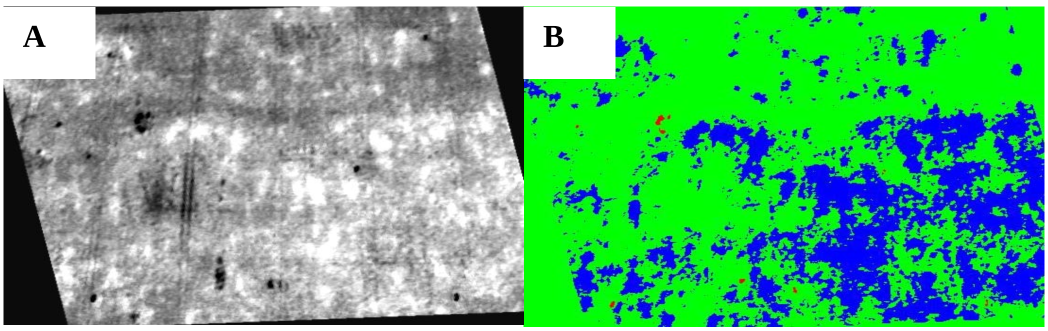

Figure 3. (A) Aerial image processed in ENVI using the blue / green ratio. (B) Aerial image that has been classified using unsupervised classification with three classes.

Table 3. Ground truth and image data from northern and southern Minnesota, 2005.

		Avg Field Yield			Yield Reduction	
Field	Location	Sucrose	Tons	% Blinker*	Sucrose (% points)	Root Yield %
1	Northern	17.3	18.3	**59**	2.4	67
2	Northern	17.0	18.8	**54**	1.8	62
3	Northern	17.3	18.4	**70**	1.9	64
4	Southern	15.0	21.0	**21**	1.9	69
5	Southern	15.8	22.8	**19**	1.8	60
6	Southern	15.8	27.2	**12**	1.7	47
7	Southern	15.4	26.7	**35**	1.3	50
8	Southern	16.2	30.5	**28**	2.0	50
9	Southern	16.0	23.3	**31**	1.6	54
10	Southern	15.6	26.1	**39**	1.4	56

***** data obtained from aerial images using unsupervised classification.