2020-2025 Nitrogen Research Report

Southern Minnesota Beet Sugar Cooperative

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Overview and Purpose Statement

The purpose of this report is to provide a comprehensive review of the nitrogen research done to generate the data and subsequent recommendations for Southern Minnesota Beet Sugar Cooperative. Principal authors include Dr. John Lamb (Professor Emeritis, University of Minnesota), David Mettler (Research Agronomist, SMBSC), and Mark Bloomquist (Director of Research, SMBSC).

This document has been compiled using Research Reports from 2019-2025. These Research Reports have been provided to allow a full review of the trial work done in those years as compared to viewing only the combined data set or analysis. Only trials that had a response to additional nitrogen over the soil residual were used in the combined analysis. In addition, only trials that had a total nitrogen treatment over 200lbs and an extractable sugar per acre over 8,500lbs were used in the analysis. The research reports “2019 Nitrogen Rate Trials”, “2022 and 2023 Previous Crops Trials”, “2021-2023 Potassium by Nitrogen Rate Trials”, “2024 Variety by Nitrogen Rate Trial”, “2025 Variety by Nitrogen Rate Trial”, and “2023-2025 Phosphorus by Nitrogen Rate Trials” are not included in the combined analysis but are provided as supplemental information.

Nitrogen Response Curve 2020-2025

David Mettler[1], **Mark Bloomquist**[2], and **John A. Lamb**[3],
[1]Research Agronomist, [2]Research Director, SMBSC, Renville, MN
[3]Professor Emeritus, University of Minnesota, St. Paul, MN

Nitrogen management is critical for optimizing yield while also managing production costs. Understanding the impacts that nitrogen deficiency or excess nitrogen can have on stand and yield is important information for making input decisions.

Research Objective

- Summarize research conducted over the past 6 years to provide nitrogen fertilizer guidelines for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methodology

Eleven trials were conducted over a period of six years from 2020 to 2025. The previous crop for ten of the eleven trials was field corn and one followed soybean. These trials all had a positive response to the application of spring urea that resulted in increased extractable sugar per acre over the untreated check. All trials were designed with treatments that increased nitrogen in increments of 30lbs of N from the soil residual to over 200lbs of total N. All trials had treatments that yielded over 8500lbs of extractable sugar per acre. There were four other trials that did not meet these requirements and thus were not included in the dataset.

Prior to planting, the urea treatments were broadcast by hand and incorporated with a small field cultivator. Standard sugar beet production practices were used to keep the trials weed and disease free. Each plot was 35ft long and 6 rows wide. The center two rows of each six-row plot were harvested using a six-row defoliator and a two-row research harvester. The beets harvested from the center two rows were weighed on the harvester and two samples of those beets from each plot were used for quality analysis at the SMBSC tare lab. The individual trial data was analyzed for significance using SAS GLM version 9.4. For individual site information see yearly research reports located on the SMBSC website. The combined dataset was analyzed using SAS NLIN version 9.4.

Results

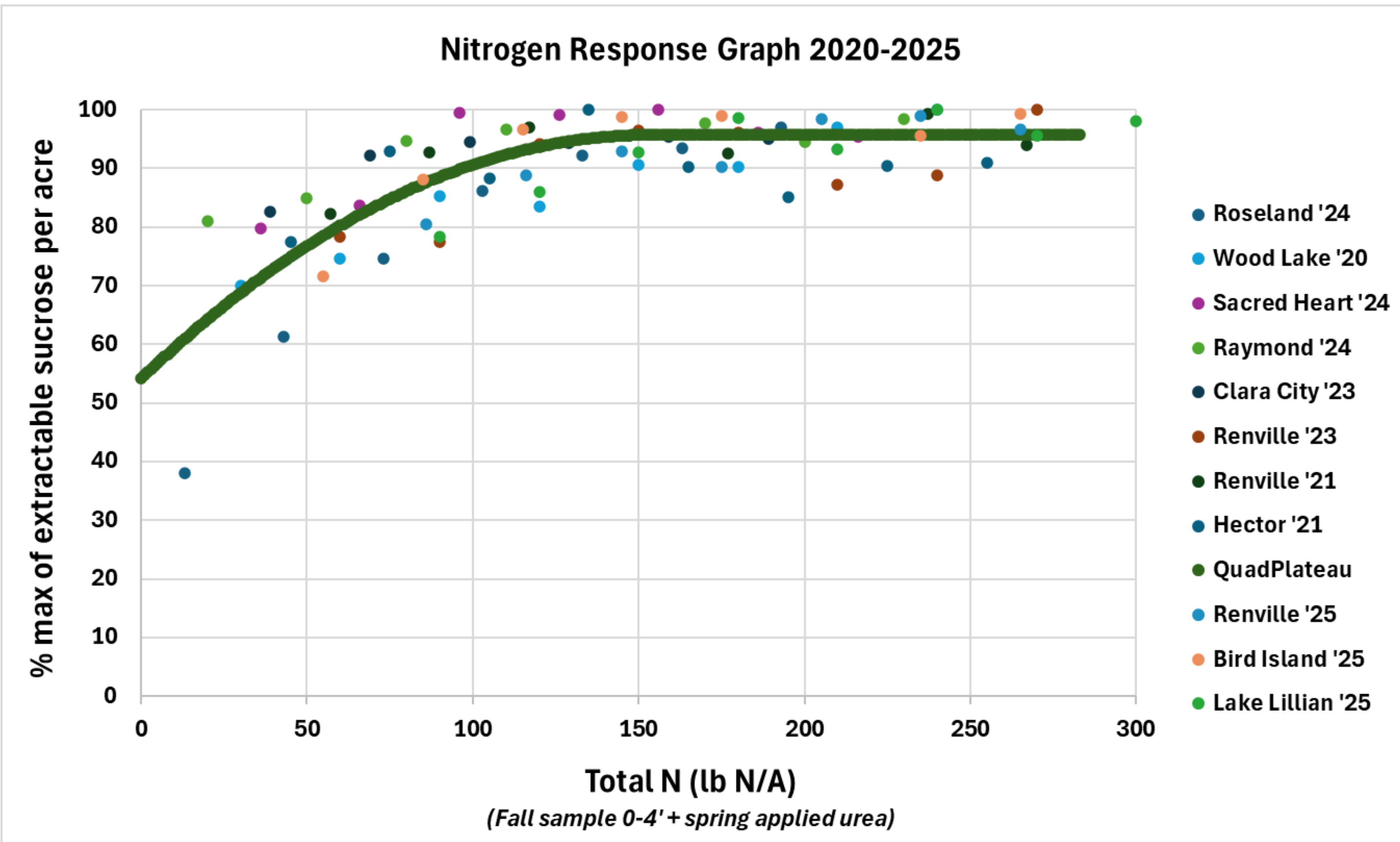
The analysis of the combined dataset showed that a quadratic plateau ($R^2 = 0.64$) had a better fit than a quadratic polynomial regression ($R^2 = 0.59$). The optimum nitrogen rate for the quadratic plateau was 153lbs of total N based on applied plus fall residual soil sample from 0-4ft. This is an increase of approximately 20lbs from the previous dataset analyzed in 2020.

Discussion

In 2025 the University of Minnesota updated the nitrogen fertilizer application rates for both corn following corn and corn following soybean. When data from 2022-2024 trials were added to the long-term dataset the suggested nitrogen rates increased by about 10lbs per acre for both previous crops. Dr. Dan Kaiser and Dr. Fabian Fernandez cited that the nitrogen requirements for growing corn have increased as grain yields have increased but also indicated that increasing precipitation amounts may be impacting nitrogen requirements. Denitrification is likely to increase in wet years with above average precipitation. This agrees with observations from sugar beet research at SMBSC. The 2020 season saw below average rainfall at the northern location following soybean with no response to additional nitrogen. The southern location following field corn received roughly six more inches of rainfall and had a significant increase in yield with increasing nitrogen rates. The following 2021 season was a drought with a low response to nitrogen and the 2022 season also saw minimal response to nitrogen applications in a year with moderate rainfall. The 2023, 2024, and 2025 seasons saw above average rainfall and higher than expected responses to additional nitrogen. In wet years there appears to be more of a response to the application of nitrogen at higher rates compared to drier years and this dataset is more heavily weighted to wetter years. This may be one reason why the response to nitrogen has increased roughly 20lbs of nitrogen per acre in this dataset compared to the dataset analyzed from 2010-2020.

Another factor that may contribute to this trend is a change in tillage practices. As more growers adopt reduced tillage practices more residue is left on the soil surface or lightly incorporated. Urease enzyme activity on corn residue significantly increases the risk of nitrogen loss when urea-based fertilizers are surface applied and can result in ammonia volatilization. Warm temperature, high soil moisture, and soil pH > 7 also increases the risk of ammonia volatilization. The current dataset from 2020-2025 would warrant increasing the nitrogen recommendation from 110-150 to 130-170lbs. Within this range, fields following soybean or other low residue crops would be at the lower end of the range, while fields following field corn should be 150-170lbs of total N. Four out of five trials conducted following soybean did not response to additional nitrogen even with low soil nitrate residuals.

One thing to keep in mind when considering total N is when the nitrogen will be applied. The nitrogen trials conducted have shown significant stand loss when spring urea applications reach 90lbs of N/A or higher. As urea is hydrolyzed in the soil, ammonia is formed. High concentrations of ammonia can impact the germination and emergence of sugar beet seeds. Along with the amount of urea applied, environmental conditions after planting will impact how severe the stand loss may be. Trials conducted in 2025 showed that blends of ESN with urea reduced stand loss when the urea portion was kept to 60lbs/A of N or lower. An in-season application of nitrogen between the 4-8lf stage is an option and may be helpful on low organic matter coarse textured soils versus applying all the nitrogen preplant. Caution would be advised when considering broadcasting spring nitrogen as UAN with pre-emerge herbicides. This application method carries a significant risk of nitrogen loss from ammonia volatilization as previously mentioned.



Nitrogen Rate Trials for 2020

John A. Lamb[1], David Mettler[2], and Mark Bloomquist[3]
[1]Professor Emeritus University of Minnesota, St. Paul, MN,
[2]Research Agronomist, [3]Research Director, SMBSC, Renville, MN

Justification:

Nitrogen management is a top priority for production of high-quality sugar beet. With the continued changes in sugar beet production, it is important to continue to update N fertilizer guidelines with new information.

Objective:

Provide current N fertilizer guidelines for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methods and Materials:

In 2020, two locations in the Southern Minnesota Beet Sugar Cooperatives growing area had studies that had a N fertilizer rate component to them. One location near Wood Lake and the other near Blomkest. Soil samples were taken for each location prior to the study. The results are reported in Table 1. The soil nitrate-N to a depth of four feet was low at each location, 30 and 43 lb N/A. The N fertilizer rates at the Wood Lake location were 0, 30, 60, 90, 120, 150, 180, and 210 lb N/A and 0, 20, 50, 80, 110, and 140 lb N/A at the Blomkest location. The Wood Lake location had 12 replications of the N rates and the Blomkest location had six. The fertilizer N source was urea applied prior to planting. Stand counts were taken after emergence. The locations were harvested by machine in October and quality samples were taken at that time. Quality was determined in the Southern Minnesota Beet Sugar Cooperative tare lab.

Table 1. Soil test results for Wood Lake and Blomkest locations in 2020.

Soil test	Wood Lake	Blomkest
Soil nitrate-N 0-4 ft. (lb N/A)	30	43
Olsen -P 0-6 in. (ppm)	69	18
K 0-6 in. (ppm)	274	194
pH 0-6 in. (unitless)	7.5	7.4
Organic matter 0-6 in. (%)	4.5	5.4

Results:

The 2020 growing season was significantly better than 2018 and 2019. The average root yield was 35 tons/A and the average sucrose was 18 % at the Wood Lake location and 41.1 tons/A and 17.9 % at the Blomkest location.

Wood Lake:

The addition of N fertilizer significantly affected root yield, extractable sucrose per ton, and extractable sucrose per acre at the Wood Lake location in 2020, Table 2 and Figures 1, 2, and 3. The response was linear for all variables. The soil test nitrate-N was low and a positive response for root yield and extractable sucrose per acre was expected. The positive response of root yield and extractable sucrose per acre maximized at the top N rate applied. This rate was 210 lb N/Acre of fertilizer with a soil test nitrate-N plus fertilizer N of 240. This is greater than the current guideline. Also unexpected was the increase in extractable sucrose per ton with N application. While the increase was small, normally the application of N fertilizer reduces extractable sucrose per ton.

Table 2. The effect of nitrogen on root yield, extractable sucrose per ton, and extractable sucrose per acre at the Wood Lake location in 2020. (Data provided by Dan Kaiser U of MN)

Soil test nitrate-N plus fertilizer N	N rate	Root yield	Extractable sucrose per ton	Extractable sucrose per acre
lb N/A	lb N/A	ton/A	lb/ton	lb/A
30	0	28.6	296	8477
60	30	30.3	296	9034
90	60	34.4	293	10342
120	90	34.1	299	10117
150	120	37.6	293	10973
180	150	36.0	303	10938
210	180	38.5	305	11747
240	210	40.9	297	12116
Statistics	N rate	0.0001	0.04	0.0001
	C.V.	7.4	3.2	8.4
	Mean	35.1	298	10429

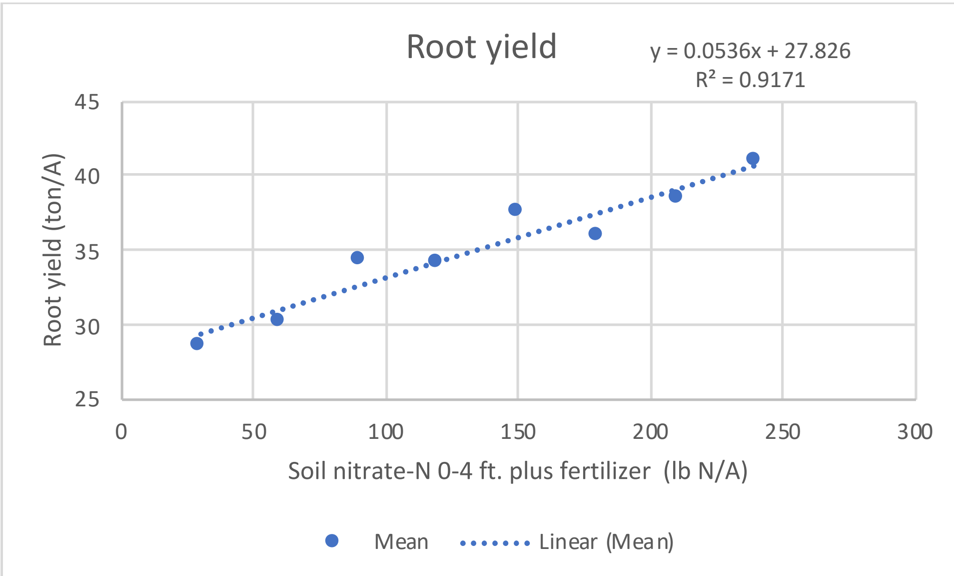


Figure 1. The effect of soil nitrate-N plus fertilizer N on root yield at the Wood Lake location in 2020. (Data provided by Dan Kaiser U of MN).

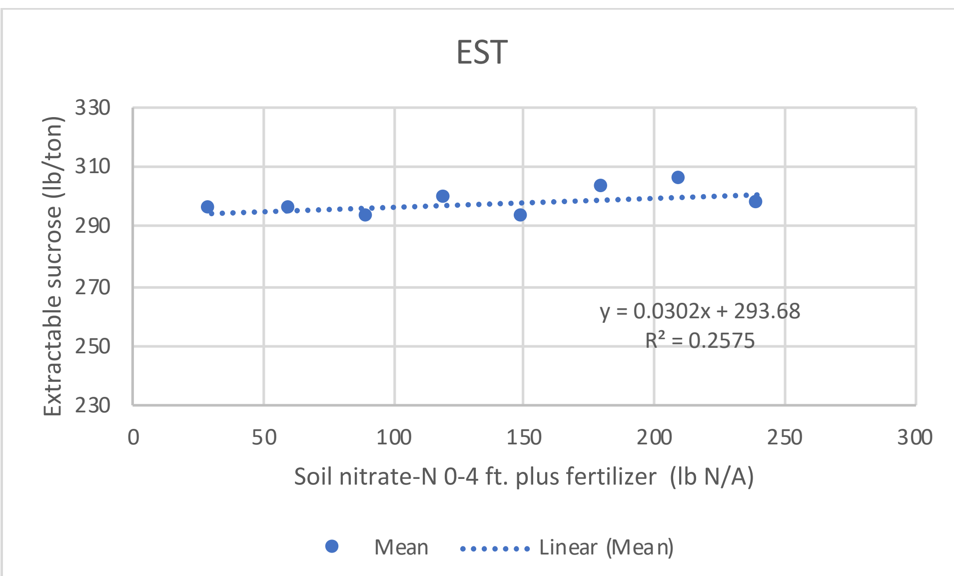


Figure 2. The effect of soil nitrate-N plus fertilizer N on extractable sucrose per ton at the Wood Lake location in 2020. (Data provided by Dan Kaiser U of MN).

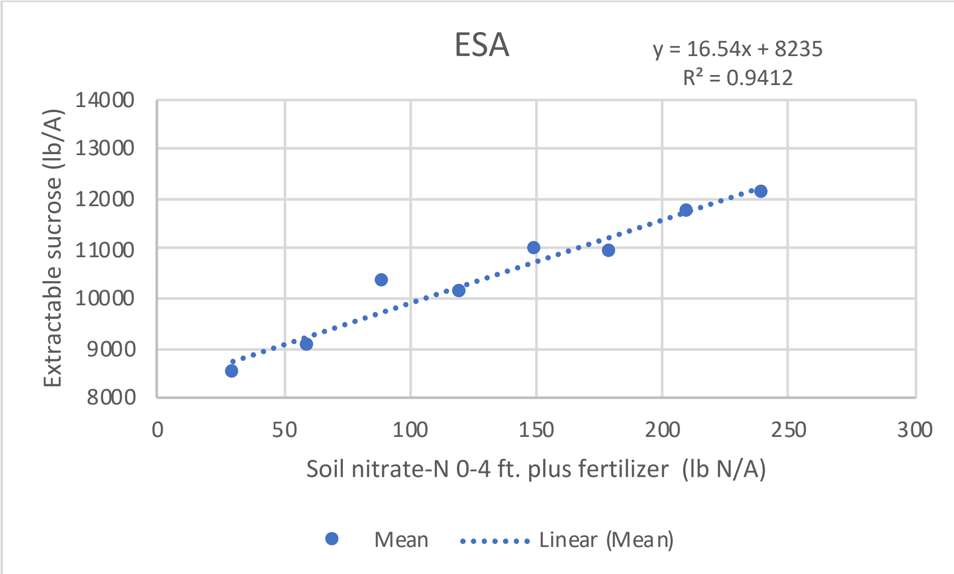


Figure 3. The effect of soil nitrate-N plus fertilizer N on extractable sucrose per acre at the Wood Lake location in 2020. (Data provided by Dan Kaiser U of MN).

<u>Blomkest:</u>

The addition of N fertilizer at the Blomkest location did not significantly affect the root yield or the extractable sucrose per acre, Table 3, Figures 4, 5, and 6. This was not expected as the soil test nitrate-N to a depth of four feet was low at 43 lb N/A. Root yield and extractable sucrose per acre were very good, 40.3 tons/A and 12,402 lb/A with no fertilizer N applied. The extractable sucrose per acre was increased slightly by the addition of fertilizer N.

Table 3. The effect of nitrogen on root yield, extractable sucrose per ton, and extractable sucrose per acre at the Blomkest location in 2020.

Soil test nitrate-N plus fertilizer N	N rate	Root yield	Extractable sucrose per ton	Extractable sucrose per acre
lb N/A	lb N/A	ton/A	lb/ton	lb/A
43	0	40.3	300	12402
63	20	42.3	297	12576
93	50	41.5	305	12648
123	80	42.1	305	12833
153	110	40.7	315	12818
183	140	39.6	308	12188
Statistics	N rate	0.19	0.03	0.52
	C.V.	5.0	2.8	5.4
	Mean	41.1	305	12600

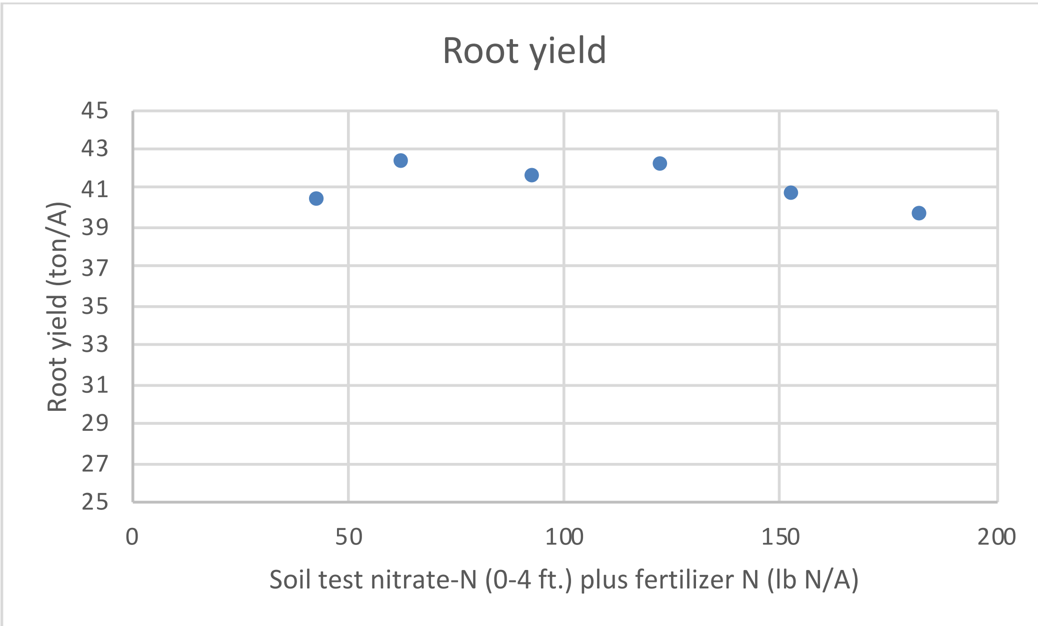


Figure 4. The effect of soil nitrate-N plus fertilizer N on root yield at the Blomkest location in 2020.

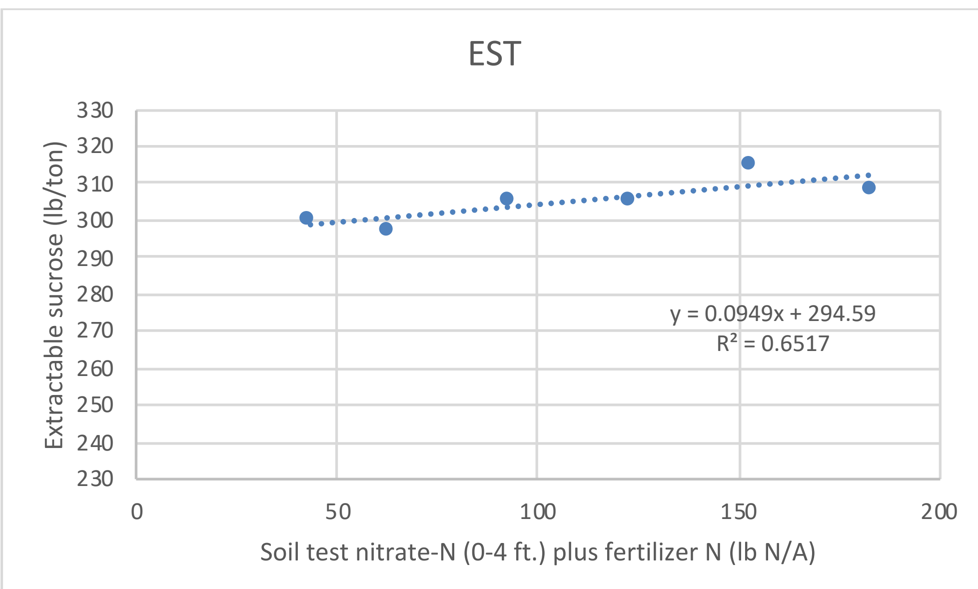


Figure 5. The effect of soil nitrate-N plus fertilizer N on extractable sucrose per ton at the Blomkest location in 2020.

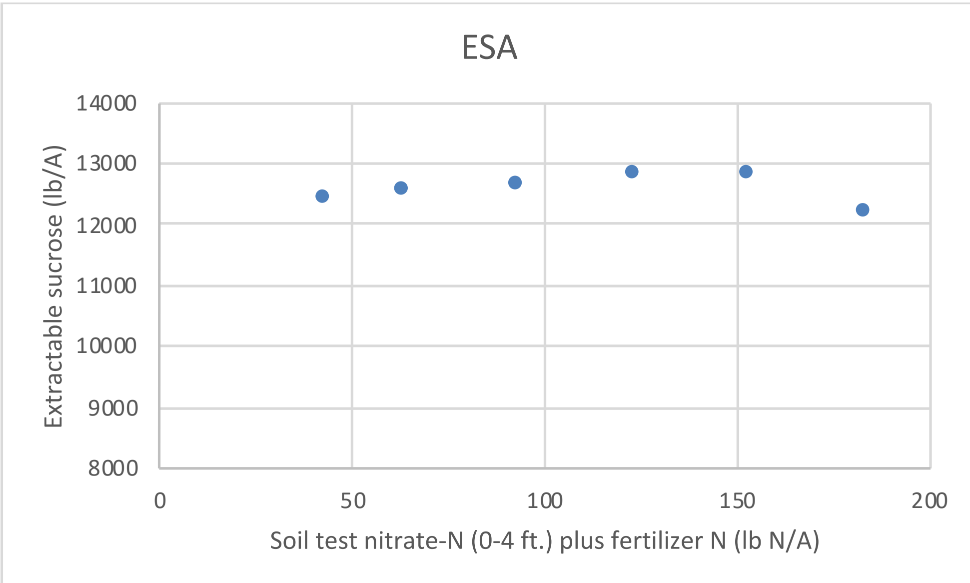


Figure 6. The effect of soil nitrate-N plus fertilizer N on extractable sucrose per acre at the Blomkest location in 2020.

Summary:

The responses to N application were not as expected for root yield, extractable sucrose per ton, and extractable sucrose per acre at either location in 2020. With the low soil test nitrate-N, we expected the application of N fertilizer to increase the root yield and extractable sucrose per acre at both locations. At Wood Lake, both of these parameters increased but did not maximum at the greater N rates. At the Blomkest location, we did not get a response to N fertilizer even though the soil test nitrate-N was low. Why did this happen? There was a difference in organic matter between the locations of about 0.9 %. While that could explain some of the difference, it does not explain it all. Another difference between these two sites was the previous crop. The Wood Lake site followed field corn while the Blomkest site followed soybean. The difference in the amount of plant residue from the previous crop may have impacted the amount of nitrogen available at these two locations. The small increase in extractable sucrose per ton was also not expected nor is it explainable.

What does this mean for the N fertilizer guideline currently used? This guideline is based on many locations of data and because the information for the Wood Lake site had a positive response, it will be added to that information. Current guidelines based on research from 2010 to 2020 indicate that the optimum extractable sucrose per acre can be achieved with 123 lb N/A as soil test nitrate-N to a depth of four feet plus fertilizer N.

Split Nitrogen Applications in Southern Minnesota 2020 – non-irrigated heavy textured soils.

John A. Lamb[1], David Mettler[2], and Mark Bloomquist[3]
[1]Professor Emeritus, University of Minnesota, St. Paul, MN
[2]Research Agronomist, [3]Research Director, SMBSC, Renville, MN

Introduction and Objective:

Producing sucrose in Minnesota requires growers to optimize their N application for increasing root yield with the decreasing effect of N application on sucrose concentration and purity. The optimum N rate has been the topic of many research studies with the N fertilizer being applied pre-plant. There has been interest in splitting the N application between pre-plant and sometime during the growing season to "spoon feed" the sugar beet root for optimum root yield while not having negative effects on sucrose concentration and purity. The objective of this study was to determine if split applications of N fertilizer can improve root yield without decreasing root quality. The sub-objectives were A: to conduct an N rate study to supply more information for the N fertilizer recommendations and also determine if the site was responsive to N application and B: to determine if a split N application was superior to a pre-plant or an in-season application.

Methods and Materials:

To meet the objectives, a study was conducted during the 2020 growing season at one location within the Southern Minnesota Beet Sugar Cooperative growing area. The initial soil test values are reported in Table 1. Ten treatments, Table 2, were established. Treatments 1 through 6 were used to determine the response to N application while treatments 3, 4, 7, 8, 9, and 10 were used to compare N application timing responses. The experiment was a randomized complete block design with six replications. The plots were six – 22 inch rows wide and 35 ft. long. The pre-plant N applications were broadcast treatments of urea (46-0-0). The urea was incorporated immediately after application. The in-season N applications were injected between the sugar beet rows as liquid urea ammonium nitrate solution (32-0-0). The Blomkest location was planted on April 25, 2020 to SES 863 and the in-season N application occurred on May 26, 2020. This site was harvested on October 14, 2020. The previous crop was soybean.

Table 1. Soil test information for 2020 in-season N location.

Soil test and depth	Blomkest
Nitrate-N (lb/A) 0-48 inches	43
Olsen P (ppm) 0-6 inches	18
Soil test K (ppm) 0-6 inches	194
pH (unitless) 0-6 inches	7.4
Organic matter (%) 0-6 inches	5.4

Table 2. Treatments for N application study at Blomkest location, 2020.

Treatment number	Total N applied (ST* + Fertilizer)	Preplant*	Split
	-------------------- lb N/acre --------------------		
1	43	0	0
2	63	ST+20	0
3	93	ST+50	0
4	123	ST+80	0
5	153	ST+110	0
6	183	ST+140	0
7	93	25	25
8	123	40	40
9	93	0	50
10	123	0	80

*ST = Soil test nitrate-N to a depth of four ft.

The treatments were based on the nitrate-N soil test taken to a depth of 4 feet. The soil test was 43 lb N/A in the 0-4 ft depth.

Results and Discussion:

This study was analyzed as a randomized complete block design. With this analysis, the response to pre-plant N application and the effect of different methods of application was evaluated. The conditions for growth in 2020 were very good. The root yield and extractable sucrose per acre for the check plot was 40.3 tons per acre and 12,354 lbs sucrose per acre.

Nitrogen fertilizer response:

Of the measured parameters, nitrogen fertilizer application affected extractable sucrose per ton, Table 3. Root yield, purity, and extractable sucrose per acre were not affected by N application.

Extractable sucrose per ton: Extractable sucrose per ton was affected by N application, Table 3. The N response was linear with a maximum extractable sucrose at the 183 lb N per acre, soil test nitrate-N plus fertilizer N applied, Figure 1. This response to N fertilizer was not maximized.

Nitrogen fertilizer and timing:

Three different application methods and timings at two N fertilizer rates were applied in 2020. The treatments were N application at pre-plant, at side-dressing and half the N applied at pre-plant and half at side-dressing. The N rates used were 50 and 80 lb N/A. These treatments did not affect any of the measured parameters; root yield, purity, extractable sucrose per ton, or extractable sucrose per acre Table 3. The split treatment root yield, purity, extractable sucrose per ton, and extractable sucrose per acre where not different from the check.

Table 3. Root yield, purity, extractable sucrose per ton, and extractable sucrose per acre for all treatments in 2020 at the Blomkest location, LSMEANS.

N rate (lb N/A)		Total N*	Root yield	Purity	Extractable sucrose	
Pre-plant	In-season	lb N/A	ton/A	%	lb/ton	lb/A
0	0	43	40.3	90.7	299	12354
20	0	63	42.3	90.7	297	12576
50	0	93	41.5	91.2	305	12648
80	0	123	42.1	91.3	305	12833
110	0	153	40.7	91.3	315	12818
140	0	183	39.4	91.0	308	12138
25	25	93	42.3	91.4	305	12907
40	40	123	41.7	90.6	298	12423
0	50	93	42.4	90.4	293	12405
0	80	123	40.8	90.8	301	12307
Grand mean			41.4	90.9	303	12562
			Statistical Analysis			
Treatment			0.29	0.17	0.004	0.52
N rate			0.19	0.52	0.03	0.52
Check vs Split trts			0.16	0.43	0.54	0.49
C.V. (%)			5.0	0.7	2.7	5.1

*Total N is the amount of nitrate-N in soil to four feet plus fertilizer applied.

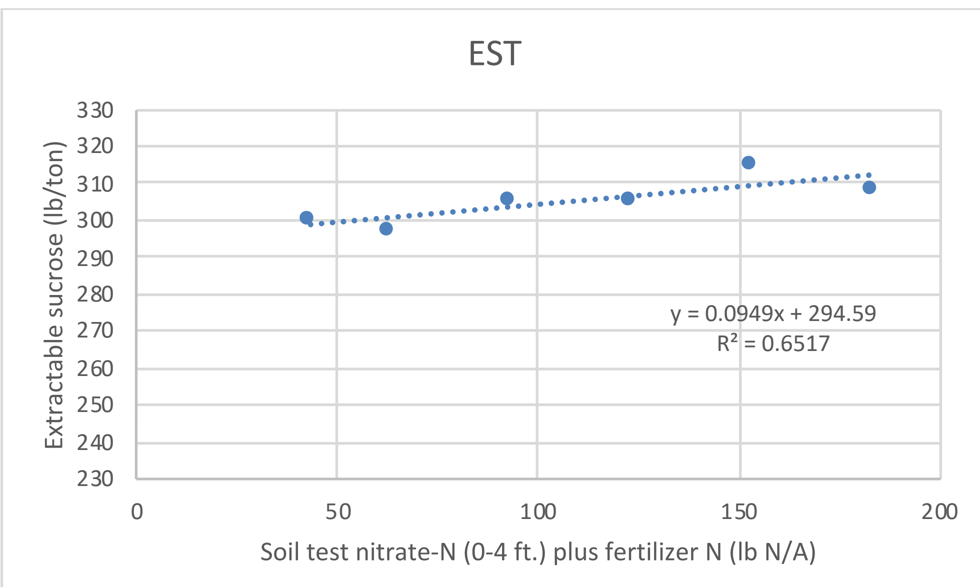


Figure 1. The effect of soil nitrate-N plus fertilizer N on extractable sucrose per ton at the Blomkest location in 2020.

Summary:

In 2020, weather conditions were near ideal for sugar beet production. Even with a low soil test nitrate-N, root yield, purity, and extractable sucrose per acre did not respond to the addition of N fertilizer. Extractable sucrose per ton was increased with increasing N application. Because of the lack of response to N application for root yield, purity, and extractable sucrose per acre, the time of N application did not affect those parameters. Even though extractable sucrose per ton was affected by N application, the split treatments did not significantly affect extractable sucrose per ton. The evaluation of this information would indicate that the use of split applications of N fertilizer did not help or hurt sugar beet production at this location in 2020.

Nitrogen Rate Trials for 2021

John A. Lamb[1], David Mettler[2], and Mark Bloomquist[3]
[1]Professor Emeritus University of Minnesota, St. Paul, MN,
[2]Research Agronomist, and [3]Research Director, SMBSC, Renville, MN

Introduction: Nitrogen management is a top priority for production of high-quality sugar beet. With the continued changes in sugar beet production practices, it is important to continue to update N fertilizer guidelines with new information.

Objective: Provide current N fertilizer guidelines for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methods and Materials: In 2021, two locations in the Southern Minnesota Beet Sugar Cooperatives growing area had studies with a N fertilizer rate component to them. One location near Renville, MN and the other near Hector, MN. Fall soil samples were taken for each location prior to the study. The results are reported in Table 1. The soil nitrate-N to a depth of four feet was low at each location, 55 lb N/A and 45 lb N/A at Renville and Hector, respectively. The N fertilizer rates were 0, 30, 60, 90, 120, 150, 180, and 210 lb N/A. There were six replications of the N rates at the Renville location and eight replications of the N rates at the Hector location. The fertilizer N source was urea applied and incorporated prior to planting. Stand counts were taken after emergence. The locations were harvested by machine in October and quality samples were taken at that time. Quality was determined in the Southern Minnesota Beet Sugar Cooperative tare lab.

Table 1. Soil test results for Renville and Hector locations in 2021.

Soil test	Renville	Hector
Soil nitrate-N 0-4 ft. (lb N/A)	55	45
Olsen -P 0-6 in. (ppm)	3	7
K 0-6 in. (ppm)	166	125
pH 0-6 in. (unitless)	8.0	7.7
Organic matter 0-6 in. (%)	6.7	2.9

Results: The 2021 growing season was droughty up to mid-August and then significant precipitation occurred at each site. The average root yield was 43.4 tons/A and the average sucrose was 16.6 % at the Renville location and 40.0 tons/A and 14.8 % at the Hector location.

Renville Results: The addition of N fertilizer significantly affected root yield and extractable sucrose per acre at the Renville location in 2021, Table 2, Figures 1, 2, and 3. Extractable sucrose per ton was not significantly affected by N application. The response for root yield and extractable sucrose per acre was a quadratic plateau. Root yield was optimized at 191 lb soil test nitrate-N plus fertilizer N (0 to 4 feet) with a plateau at 44.4 tons/A, Figure 1. Extractable sucrose per ton was not affected by the addition of fertilizer N. Normally the application of N fertilizer reduces extractable sucrose per ton, Figure 2. Extractable sucrose per acre response at the Renville site was maximized at 117 lb soil test nitrate-N plus fertilizer N/A, Figure 3. The soil test nitrate-N was low and a positive response for root yield and extractable sucrose per acre was expected. The 117 lb/A is well within the current N suggestions for optimum extractable sucrose per acre.

Table 2. The effect of nitrogen on root yield, extractable sucrose per ton, and extractable sucrose per acre at the Renville location in 2021.

Soil test nitrate-N plus fertilizer N	N rate	Root yield	Extractable sucrose per ton	Extractable sucrose per acre
lb N/A	lb N/A	ton/A	lb/ton	lb/A
55	0	38.4	275	10599
85	30	41.7	286	11950
115	60	44.1	284	12495
145	90	44.0	280	12311
175	120	43.4	276	11944
205	150	45.7	281	12891
235	180	46.0	278	12813
265	210	43.9	271	12120
Statistics	N rate	0.02	0.68	0.03
	C.V.	7.9	4.7	9.0
	Mean	43.4	279	12141

Hector Results: The addition of N fertilizer at the Hector location did significantly affect the root yield, extractable sucrose per ton, and the extractable sucrose per acre, Table 3, Figures 1, 2, and 3. This was expected as the soil test nitrate-N to a depth of four feet was 45 lb N/A. Root yield was optimized at 40.4 tons/A with 145 lb soil test nitrate-N plus fertilizer N/A, Figure 1, while the optimum extractable sucrose per acre was with 93 lb soil test nitrate-N plus fertilizer N/A, Figure 3. Extractable sucrose per ton was reduced with the addition of fertilizer N, Figure 2. The reduction was linear with the greatest extractable sucrose at 250 lb/ton with 0 lb N/A applied and reducing to 236 lb/ton with the 210 lb N/A application.

Table 3. The effect of nitrogen on root yield, extractable sucrose per ton, and extractable sucrose per acre at the Hector location in 2021. (Data provided by Dan Kaiser U of MN)

Soil test nitrate-N plus fertilizer N	N rate	Root yield	Extractable sucrose per ton	Extractable sucrose per acre
lb N/A	lb N/A	ton/A	lb/ton	lb/A
45	0	33.1	250	8282
75	30	39.5	247	9723
105	60	38.2	249	9520
135	90	43.0	249	10677
165	120	40.2	244	9789
195	150	41.2	231	9516
225	180	43.0	237	10019
255	210	42.9	236	10253
Statistics	N rate	0.0001	0.0009	0.0001
	C.V.	7.4	4.0	7.0
	Mean	40.0	243	9704

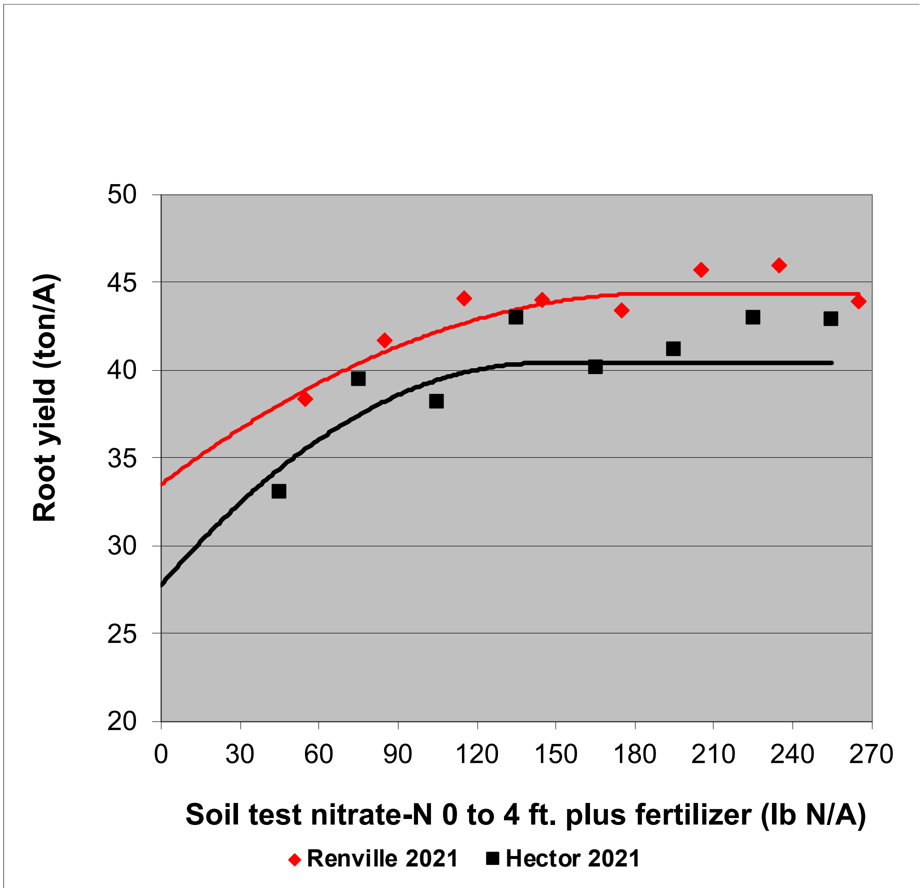


Figure 1. Root yield at Renville and Hector as affected by soil test nitrate-N (0-4 feet) plus fertilizer N in 2021.

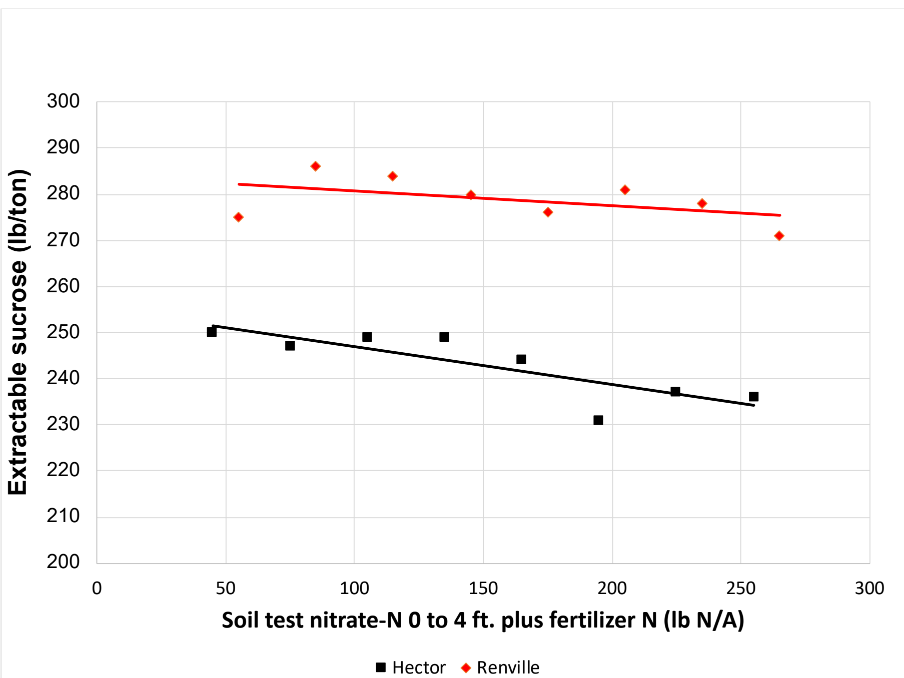


Figure 2. Extractable sucrose per ton at Renville and Hector as affected by soil test nitrate-N (0-4 feet) plus fertilizer N in 2021.

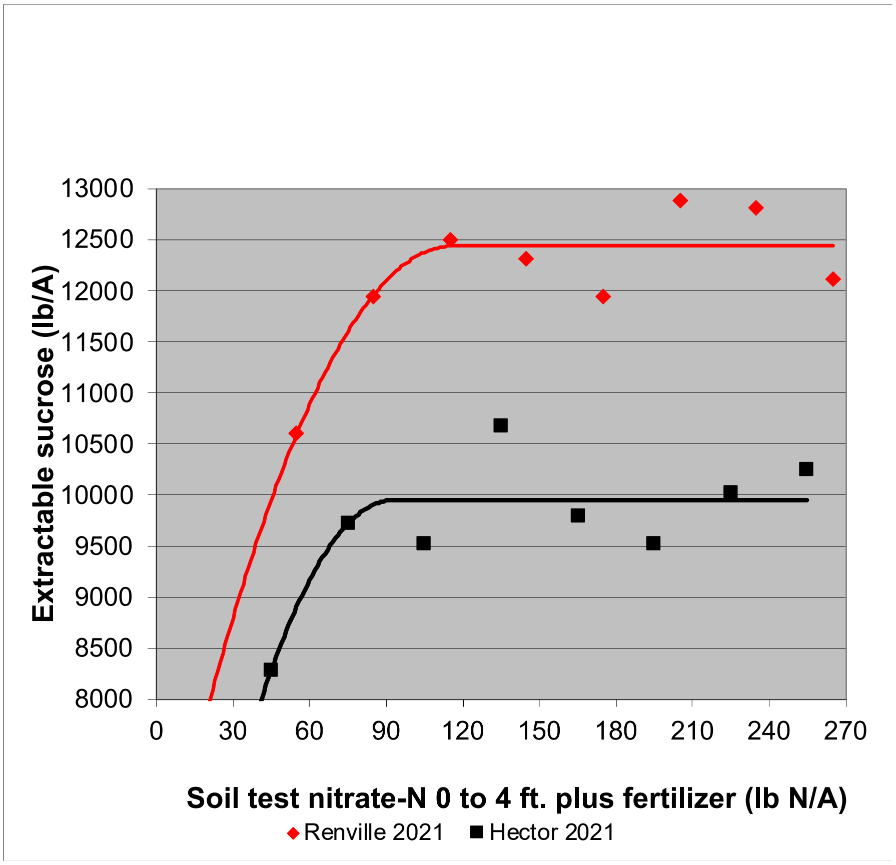


Figure 3. Extractable sucrose per acre at Renville and Hector as affected by soil test nitrate-N (0-4 feet) plus fertilizer N in 2021.

Conclusion: The responses to N application occurred for root yield and extractable sucrose per acre at both locations in 2021. The optimum soil test nitrate-N plus fertilizer N level was 191 lb N/A for root yield and 117 lb N/A for extractable sucrose per acre at the Renville location. The optimum soil test nitrate-N plus fertilizer N was 145 lb N/A for root yield and 93 lb N/A for extractable sucrose per acre at the Hector location in 2021. Extractable sucrose per ton was reduced by N application at the Hector site and not affected at Renville.

What does this mean for the N fertilizer guideline currently used? This guideline is based on many locations of data over the years. Because the information for both sites in 2021was a positive and significant response to added N fertilizer, the data from these sites will be added to the database. Current guidelines based on research from 2010 to 2021 indicate that the optimum extractable sucrose per acre can be achieved with 117 lb N/A as soil test nitrate-N to a depth of four feet plus fertilizer N with N fertilizer cost of $0.75 per lb N and sugar price at $0.17 per lb.

Nitrogen Rate and Placement Trials 2022

David Mettler[1], **Mark Bloomquist**[2], and **John A. Lamb**[3],
[1]Research Agronomist, [2]Research Director, SMBSC, Renville, MN
[3]Professor Emeritus University of Minnesota, St. Paul, MN

Nitrogen management is a priority for production of high-quality sugar beets. The use of nitrogen placement could offset the input cost of nitrogen and lower the overall use rate through more efficient use and availability.

Research Objective

- Provide nitrogen fertilizer guidelines for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methodology

Two trials were established in 2022 using randomized complete block design. One trial was located north of Renville following soybean and the other trial was located south of Renville following field corn. Both sites were soil sampled in the fall of 2021 to develop treatment rates for the trials in 2022 (Table 1). The treatments for each site were not identical but shared similar treatments which included broadcast urea rates, placement of liquid 32% N (UAN), and use of nitrogen fixing biological products (Tables 2 and 3). Both trial sites were planted on May 24th using Crystal M089. Prior to planting, the urea treatments were broadcast by hand and worked in with a small field cultivator. The liquid 32% N treatments were applied at planting using a 360 Bandit system and CO_2 as a propellant for the fertilizer. The 360 Bandit dribbles the liquid three inches either side of the row at a depth of 0.75 to one inch (Photo 2). For the surface dribble treatment, the hoses were removed from the disc and allowed to drag along the soil surface (Photo 3). The biological nitrogen fixing treatments were applied on June 17th for both trials using a bicycle sprayer. The bicycle sprayer was equipped with XR11002 nozzles with a spray volume of 17gpa. Standard sugar beet production practices were used to keep the trial weed and disease free (Photo 1). Each plot was 35ft long and 6 rows wide. The center two rows of each six-row plot were harvested on September 19th for Renville South and October 13th for Renville North using a six-row defoliator and a two-row research harvester. The beets harvested from the center two rows were weighed on the harvester and a sample of those beets were used for quality analysis at the SMBSC tare lab. The data was analyzed for significance using SAS GLM version 9.4.

Table 1. Soil test results for the two trial locations from fall soil sample in 2021.

Soil test	Renville North	Renville South
Soil nitrate-N 0-4 ft. (lb N/A)	45	45
Olsen P 0-6 in. (ppm)	7.5	13
K 0-6 in. (ppm)	128	222
pH 0-6 in. (unitless)	7.8	7.3
Organic matter 0-6 in. (%)	5.6	4.0

Photo 1. Drone image of Renville North trial on September 28th.

Photos 2 & 3. The 360 Bandit system installed on the 6-row research planter. The dribble treatment visible in the soil surface after planting at the Renville South trial.

Results

The site north of Renville following soybean showed no significant responses for any of the yield or quality parameters (Table 2). The site south of Renville following field corn only responded to N application for extractable sugar per acre (Table 3). For the differences in extractable sugar per acre (ESA), the check, which had no additional nitrogen applied, had lower ESA than most of the other treatments.

Conclusions

The results of these trials are not entirely surprising. In the last decade of nitrogen research at SMBSC, most nitrogen trials fail to generate a positive response to the addition of more nitrogen over the residual nitrogen that's already present in the field. In the most recent years, trials following field corn have generally had a greater response to additional nitrogen compared to trials following soybean. Because of the lack of response to the addition of nitrogen, the comparison of methods of application cannot be made at the site located south of Renville while the response to nitrogen for extractable sugar per acre at the northern site was to the addition of the first unit of nitrogen. There were no statistical differences between the application methods. These nitrogen placement trials will be conducted again in 2023.

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Table 2. Yield and quality data for the site north of Renville following soybean harvested on October 13th.

Entry	Treatment	Applied N	Total N	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	Check	0	45	16.2	31.6	13.1	262.4	8294.9	88.2
2	Broadcast Urea	30	75	16.6	32.2	13.6	271.9	8749.2	88.8
3	Broadcast Urea	60	105	16.5	31.7	13.6	271.2	8591.8	88.7
4	Broadcast Urea	90	135	16.4	33.1	13.5	270.6	8960.5	89.2
5	Broadcast Urea	120	165	16.6	32.1	13.6	271.9	8739.4	88.8
6	Broadcast Urea	150	195	16.0	31.5	13.1	262.3	8254.0	88.7
7	Broadcast Urea	180	225	16.5	32.1	13.7	273.9	8801.8	89.5
8	Broadcast Urea	210	255	16.7	30.1	13.8	276.3	8331.6	89.3
9	2x2	30	75	16.3	32.6	13.3	265.7	8677.4	88.5
10	2x2	60	105	16.3	32.9	13.3	265.6	8724.1	88.3
11	Urea + Utrisha N	30	75	16.4	32.8	13.4	267.8	8784.9	88.3
12	Urea + Envita	30	75	16.2	32.6	13.2	263.0	8583.8	88.1
13	2x0 Dribble	30	75	16.4	32.1	13.4	268.6	8611.1	88.6
14	2x0 Dribble	60	105	16.5	32.7	13.6	271.6	8866.2	89.0
			Mean	16.4	32.1	13.4	268.8	8640.8	88.7
			CV%	2.4	5.3	3.7	3.7	6.6	1.0
			Pr>F	0.29	0.27	0.29	0.29	0.61	0.20
			lsd(0.05)	ns	ns	ns	ns	ns	ns

Table 3. Yield and quality data for the site south of Renville following field corn harvested on September 19th.

Entry	Treatment	Applied N	Total N	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	Check	0	45	14.6	34.4	11.8	235.4	8070.2 c	88.6
2	Broadcast Urea	30	75	14.8	37.8	12.3	244.9	9254.4 a	89.6
3	Broadcast Urea	60	105	14.8	38.4	12.0	240.5	9237.1 a	88.6
4	Broadcast Urea	90	135	14.8	39.3	11.9	237.7	9347.5 a	88.0
5	2x2	30	75	14.8	36.3	12.1	240.9	8738.2 abc	88.7
6	2x2	60	105	14.9	36.7	12.2	244.2	8965.6 ab	89.0
7	2x2	90	135	14.8	39.2	12.2	243.2	9534.3 a	89.3
8	Urea + Entiva	30	75	14.8	37.9	12.0	239.0	9045.5 ab	88.1
9	Urea + Utrisha N	30	75	14.7	39.8	11.9	236.8	9408.2 a	88.3
10	Urea + Terramar	30	75	15.0	38.0	12.1	242.9	9253.1 a	88.5
11	2x0 Dribble	60	105	14.5	37.4	11.7	233.3	8722.2 abc	88.3
12	2x0 Dribble	90	135	14.6	38.4	11.9	237.6	9114.5 ab	89.0
			Mean	14.7	37.6	12.0	239.5	9006.4	88.7
			CV%	2.0	6.4	2.5	2.5	6.3	0.8
			Pr>F	0.38	0.11	0.18	0.18	0.03	0.09
			lsd(0.05)	ns	ns	ns	ns	812.5	ns

Nitrogen Rate and Placement Trials 2023

David Mettler[1], **Mark Bloomquist**[2], and **John A. Lamb**[3],
[1]Research Agronomist, [2]Research Director, SMBSC, Renville, MN
[3]Professor Emeritus University of Minnesota, St. Paul, MN

Nitrogen management is a priority for production of high-quality sugar beets. The use of nitrogen placement could offset the input cost of nitrogen and lower the overall use rate through more efficient use and availability.

Research Objective

- Provide nitrogen fertilizer guidelines for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methodology

Two trials were established in 2023 using randomized complete block design. One trial was located near the Murdock piling site following soybean and the other trial was located near Clara City following field corn. Both sites were soil sampled in the fall of 2022 to develop treatment rates for the trials in 2023 (Table 1). The treatments for each site were identical with treatments including broadcast urea rates, placement of liquid 32% N (UAN), and use of nitrogen fixing biological products (Tables 2 and 3). The Murdock site was planted on May 9th, and the Clara City site was planted on May 24th. Both sites were planted using Crystal M089. Prior to planting, the urea treatments were broadcast by hand and incorporated with a small field cultivator. The liquid 32% N treatments were applied at planting using a 360 Bandit system with CO_2 as a propellant for the fertilizer. The 360 Bandit dribbled the liquid three inches either side of the row at a depth from the soil surface of 0.75 to one inch (Photo 2). For the surface applied UAN dribble treatment, the hoses were removed from the disc and allowed to drag along the soil surface (Photo 3). The Biopath, Generate, and Alpha Complete treatments were applied through the infurrow system on the planter with a 6gpa application volume. The Utrisha N treatments were applied with the bicycle sprayer on June 9th at the Murdock trial and June 15th at the Clara City trial. The bicycle sprayer was equipped with XR11002 nozzles with a spray volume of 17gpa. Standard sugar beet production practices were used to keep the trial weed and disease free. Each plot was 35ft long and 6 rows wide. The center two rows of each six-row plot were harvested on September 19th at Clara City and October 11th at Murdock using a six-row defoliator and a two-row research harvester. The beets harvested from the center two rows were weighed on the harvester and two samples of those beets from each plot were used for quality analysis at the SMBSC tare lab. The data was analyzed for significance using SAS GLM version 9.4.

Table 1. Soil test results for the two trial locations from fall soil sample in 2022.

Soil test	Murdock	Clara City
Soil nitrate-N 0-4 ft. (lb N/A)	34	39
Olsen P 0-6 in. (ppm)	3	8
K 0-6 in. (ppm)	178	199
pH 0-6 in. (unitless)	8.1	7.9
Organic matter 0-6 in. (%)	5.5	5.8

Results

There were no significant differences between any of the treatments at the Murdock site (Table 3). The root yield data for this site had some variability caused by rhizoctonia root rot. There may be numerical differences, however, these differences are not statistically significant because of the variability caused by the rhizoctonia.

There was a significant increase in root yield at the Clara City site up to an additional 60lbs per acre of nitrogen (Table 2). Adding additional nitrogen over 60lbs did not result in greater root yield compared to the 60lbs N per acre (99lbs per acre Total N) nitrogen treatment. There were also some differences in quality parameters with the check (residual N only), and the highest two rates of additional N having lower quality than some of the other treatments with lower amounts of additional N applied.

Photos 2 & 3. The 360 Bandit system installed on the 6-row research planter. The dribble treatment visible on the soil surface after planting.

Conclusions

In the past decade of nitrogen research at SMBSC, many nitrogen trials have failed to generate a positive response to the addition of nitrogen over the residual nitrogen that's already present in the field. In the most recent years, trials following field corn have generally had a greater response to additional nitrogen compared to trials following soybean. Because of the lack of response to the addition of nitrogen following soybean, a comparison of the methods of application cannot be made at the site located north of the Murdock piling site. The Clara City site, which followed field corn, had a slight increase in root yield with the addition of nitrogen, however, there were no statistical differences between the application methods. These nitrogen placement trials will be conducted again in 2024 to complete a third year of evaluation into the methods of nitrogen application.

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Table 2. Root yield and quality data for the Clara City trial following field corn. Trial harvested on September 19th.

Entry	Treatment	Applied N	Total N	Percent Sugar	Root Yield Tons/Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	Check	0	39	16.9	27.1 d	14.4 cdef	286.6 cde	7749.8	91.0 abcd
2	Broadcast Urea	30	69	17.3	29.3 bcd	14.8 ab	295.5 ab	8650.1	91.3 a
3	Broadcast Urea	60	99	17.4	29.9 abcd	14.9 a	297.1 a	8871.9	91.3 ab
4	Broadcast Urea	90	129	17.0	30.8 abc	14.4 cdef	287.5 cde	8858.2	90.7 d
5	Broadcast Urea	120	159	16.9	31.3 ab	14.3 def	286.0 cde	8946.4	90.8 bcd
6	Broadcast Urea	150	189	16.7	31.6 ab	14.1 f	282.2 e	8922.6	90.7 cd
7	Broadcast Urea	180	219	16.8	33.1 a	14.2 ef	284.1 de	9384.5	90.7 cd
8	3x1 32%	30	69	17.0	30.6 abc	14.4 bcdef	288.6 bcde	8819.0	91.0 abcd
9	3x1 32%	60	99	17.1	31.3 ab	14.5 abcde	290.7 abcd	9096.0	90.9 abcd
10	3x0 32%	30	69	17.2	27.9 cd	14.6 abcd	292.7 abc	8175.6	91.3 a
11	3x0 32%	60	99	17.2	29.5 bcd	14.6 abcd	292.6 abc	8626.3	91.1 abcd
12	Utrisha N	30	69	17.2	29.3 bcd	14.7 abc	293.9 abc	8609.9	91.3 ab
13	BioPath	30	69	17.2	29.9 abcd	14.6 abcd	292.1 abc	8725.6	91.0 abcd
14	Generate	30	69	17.1	27.6 cd	14.4 bcdef	289.0 bcde	7971.5	90.8 cd
15	Alpha Complete	30	69	17.1	27.6 cd	14.6 abcde	291.8 abcd	8031.9	91.2 abc
			Mean	17.1	29.8	14.5	290.0	8629.3	91.0
			CV%	1.7	6.6	1.6	1.6	6.4	0.3
			Pr>F	0.2042	0.0275	0.0191	0.0239	0.0536	0.0492
			lsd (0.05)	ns	3.3	0.4	7.9	ns	0.5

Table 3. Root yield and quality data for the Murdock trial following soybean. Trial harvested on October 11th.

Entry	Treatment	Applied N	Total N	Percent Sugar	Root Yield Tons/Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	Check	0	34	16.5	36.5	13.9	276.8	10079.2	90.3
2	Broadcast Urea	30	64	16.8	34.9	14.1	281.7	9816.5	90.1
3	Broadcast Urea	60	94	16.7	35.1	14.0	280.4	9870.7	90.4
4	Broadcast Urea	90	124	16.6	36.1	14.0	278.9	10149.8	90.4
5	Broadcast Urea	120	154	16.7	36.1	14.0	279.9	10108.3	90.5
6	Broadcast Urea	150	184	16.5	40.6	13.8	276.2	11116.9	89.9
7	Broadcast Urea	180	214	16.5	35.2	13.8	275.4	9682.1	90.1
8	3x1 32%	30	64	16.6	35.9	13.9	278.2	9927.6	90.3
9	3x1 32%	60	94	16.6	40.4	13.9	278.2	11265.0	90.2
10	3x0 32%	30	64	16.8	35.4	14.1	280.8	9925.6	90.1
11	3x0 32%	60	94	16.5	35.0	13.8	276.6	9664.3	90.3
12	Utrisha N	30	64	16.4	35.0	13.7	274.2	9743.3	90.1
13	BioPath	30	64	16.5	33.7	13.9	276.6	9372.7	90.3
14	Generate	30	64	16.8	33.1	14.1	281.9	9380.0	90.5
15	Alpha Complete	30	64	16.8	34.4	14.1	281.5	9671.9	90.2
			Mean	16.6	35.8	13.9	278.5	9987.4	90.2
			CV%	1.9	12.7	2.0	2.0	11.9	0.4
			Pr>F	0.75	0.89	0.70	0.65	0.90	0.57
			lsd (0.05)	ns	ns	ns	ns	ns	ns

Nitrogen Rate and Placement Trials 2024

David Mettler[1], **Mark Bloomquist**[2], and **John A. Lamb**[3],
[1]Research Agronomist, [2]Research Director, SMBSC, Renville, MN
[3]Professor Emeritus, University of Minnesota, St. Paul, MN

Nitrogen management is a priority for the production of high-quality sugar beets. The use of nitrogen placement could offset the input cost of nitrogen and lower the overall use rate through more efficient use and availability.

Research Objective

- Provide nitrogen fertilizer guidelines for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methodology

Two trials were established in 2024 using randomized complete block design. One trial was located near Sacred Heart following soybean and the other trial was located near Roseland following field corn. Both sites were soil sampled in the fall of 2023 to develop treatment rates for the trials and sampled again in the spring of 2024 to identify any changes in soil nitrate (Table 1). The treatments for each site were identical with treatments including broadcast urea rates, placement of liquid 32% N (UAN), and use of additional nutrient management products (Tables 2 and 3). The Sacred Heart site was planted on April 23rd using Beta 9284 and the Roseland site was planted on April 25th using Beta 9131. Prior to planting, the urea treatments were broadcast by hand and incorporated with a small field cultivator. The liquid 32% N treatments were applied at planting using a 360 Bandit system with CO_2 as a propellant for the fertilizer. The 360 Bandit dribbled the liquid three inches either side of the row at a depth from the soil surface of 0.75 to one inch (Photo 1). For the surface applied UAN dribble treatment, the hoses were removed from the disc and allowed to drag along the soil surface (Photo 2). The Receptor treatment was applied through the infurrow system on the planter with a 6gpa application volume. The Envita SC, Transit Foliar, and Lalstim Osmo treatments were applied with the bicycle sprayer on June 11th at both trial sites when the beets were at the 10 leaf stage. Description of products used in this trial can be found in the appendix. The bicycle sprayer was equipped with XR11002 nozzles with a spray volume of 17gpa. Percent canopy cover ratings were taken in late June and mid-July (Figures 1 and 2). Standard sugar beet production practices were used to keep the trial weed and disease free. Each plot was 35ft long and 6 rows wide. The center two rows of each six-row plot were harvested on September 17th at Roseland and October 3rd at Sacred Heart using a six-row defoliator and a two-row research harvester. The beets harvested from the center two rows were weighed on the harvester and two samples of those beets from each plot were used for quality analysis at the SMBSC tare lab. The data was analyzed for significance using SAS GLM version 9.4.

Table 1. Soil test results for the two trial locations from fall soil sample in 2023.

Soil test	Sacred Heart	Roseland
Fall Soil nitrate-N 0-4 ft. (lb N/A)	36	12.5
Spring Soil nitrate-N 0-4 ft. (lb N/A)	80	26
Olsen P 0-6 in. (ppm)	10	5
K 0-6 in. (ppm)	181	178
pH 0-6 in. (unitless)	7.8	7.9
Organic matter 0-6 in. (%)	5.2	6.5

Results

Both sites had a significant yield response to additional nitrogen (Tables 2 and 3). The Roseland site following field corn had more of a response to higher nitrogen rates than the Sacred Heart site following soybean but neither had a linear response (Figure 1).
The differences in root yield between equivalent rates in the nitrogen placement treatments were minimal. The only significant difference in those comparisons was the 30lb surface dribble had less root yield than the 30lb broadcast urea treatment at the Roseland site. This is similar to results in other years. There have generally been no differences in nitrogen placement treatments unless the surface dribble had less root yield. The commercial products tested in furrow or foliar had no impact on yield. The correlation between percent canopy cover ratings and extractable sugar per acre were high with R values of 0.8967 on June 25th and 0.9831 on July 18th at the Sacred Heart site and R values of 0.9903 on June 24th and 0.9914 on July 17th at the Roseland site (Figures 2 and 3).

Photos 1 & 2. The 360 Bandit system installed on the 6-row research planter. The dribble treatment visible on the soil surface after planting.

Conclusions

Both sites had very low fall soil nitrate tests in 2023, however the Sacred Heart site following soybean increased significantly in soil nitrate over the warm fall and spring months leading up to planting (Table 1). With the increase in soil nitrate, it is not surprising that the site following soybean had less of a response to additional nitrogen compared to the field corn site with the high amount of corn residue tying up soil nitrate. Based on the spring soil sample the soybean site maxed out yield with 130lbs of total nitrogen and the field corn site maxed out with 160lbs of total nitrogen. However, based on the fall soil sample the soybean site would have maxed out at 100lbs and the field corn site 130lbs of total nitrogen. This stresses the importance of an accurate soil test so that we do not under or overapply nitrogen. A soil test will be more accurate the later it is taken in the fall (lower soil temps), but even better if taken in the spring as mineralization can be significant in some years. The potential increased efficiency of placing nitrogen closer to the row with a 3x1 system over broadcast urea was not realized over the last 3 years of testing and is possibly detrimental to root yield if UAN is applied as a surface dribble. None of the commercial infurrow or foliar applied products proved beneficial this year or in previous years of testing. The high correlation between percent canopy cover and extractable sugar per acre will continue to be investigated to determine if it could be a useful tool in the future to compare treatments when root yields are not able to be collected. Overall, the testing from this year agreed with the current recommendation of 110 to 150lbs of total nitrogen based on a fall soil test.

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Table 2. Root yield and quality data for the Roseland trial following field corn. Trial harvested on September 17th.

Entry	Treatment	Applied N	Total N	Percent Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	Check	0	13	16.1 bcd	12.4 g	13.7 abc	273.3 abc	3401.6 g	91.1
2	Broadcast Urea	30	43	16.3 abc	19.8 de	13.8 abc	276.5 abc	5480.5 de	90.9
3	Broadcast Urea	60	73	16.4 abc	23.6 c	14.0 a	280.6 a	6659.7 c	91.7
4	Broadcast Urea	90	103	16.5 abc	27.6 b	13.9 ab	278.4 ab	7703.1 b	90.8
5	Broadcast Urea	120	133	16.5 ab	29.4 ab	14.0 a	280.4 a	8237.2 ab	91.1
6	Broadcast Urea	150	163	16.6 a	29.3 ab	14.2 a	284.7 a	8348.4 ab	91.6
7	Broadcast Urea	180	193	16.5 abc	30.8 ab	14.1 a	281.8 a	8657.6 a	91.7
16	Broadcast Urea	210	223	16.4 abc	32.0 a	13.9 a	279.0 a	8932.3 a	91.2
8	3x1 32%	30	43	16.4 abc	17.6 ef	14.0 a	279.1 a	4914.5 def	91.2
9	3x1 32%	60	73	16.3 abc	21.2 cd	13.8 abc	275.7 abc	5860.9 cd	90.7
10	3x0 32%	30	43	15.8 de	15.5 fg	13.2 cd	264.9 cd	4084.1 fg	90.4
11	3x0 32%	60	73	16.1 cd	21.4 cd	13.3 bcd	266.7 bcd	5697.2 de	89.7
12	Receptor	30	43	15.6 e	18.7 de	13.0 d	259.9 d	4842.6 ef	90.0
13	Envita SC	30	43	16.4 abc	20.8 cde	13.9 ab	278.2 ab	5784.7 cde	91.1
14	Transit Foliar	30	43	16.1 cd	17.8 ef	13.7 abc	274.9 abc	4915.0 def	91.7
15	Lalstim Osmo	30	43	16.4 abc	20.6 cde	13.9 ab	278.1 ab	5721.5 cde	91.1
			Mean	16.3	22.4	13.8	275.8	6202.6	91.0
			CV%	1.8	10.0	3.0	3.0	10.7	1.1
			Pr>F	0.0008	<.0001	0.0085	0.0085	<.0001	0.2651
			lsd (0.05)	0.43	3.18	0.59	11.88	948.52	ns

Table 3. Root yield and quality data for the Sacred Heart trial following soybean. Trial harvested on October 3rd.

Entry	Treatment	Applied N	Total N	Percent Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	Check	0	36	17.3	32.8 g	14.7 bcd	293.3 bcde	9615.2 f	90.8 abc
2	Broadcast Urea	30	66	17.2	34.7 fg	14.6 cd	291.0 de	10088.6 ef	90.6 bc
3	Broadcast Urea	60	96	17.7	39.6 abcd	15.1 a	302.6 a	11984.1 ab	91.3 ab
4	Broadcast Urea	90	126	17.3	40.9 ab	14.6 cd	291.8 de	11931.3 abc	90.3 bc
5	Broadcast Urea	120	156	17.3	41.2 a	14.6 cd	292.2 cde	12043.7 a	90.5 bc
6	Broadcast Urea	150	186	17.1	40.3 abc	14.4 d	287.0 e	11571.3 abcd	90.1 c
7	Broadcast Urea	180	216	17.3	39.7 abcd	14.5 cd	289.6 de	11494.2 abcd	90.1 c
8	3x1 32%	30	66	17.4	36.0 efg	14.7 abcd	294.6 abcde	10619.4 de	90.9 abc
9	3x1 32%	60	96	17.4	37.4 cdef	14.8 abc	295.4 abcde	11011.7 bcde	91.0 abc
10	3x0 32%	30	66	17.5	36.5 def	15.1 ab	301.2 abc	10989.1 cde	91.8 a
11	3x0 32%	60	96	17.4	38.5 abcde	14.7 bcd	293.1 bcde	11292.2 abcd	90.6 bc
12	Receptor	30	66	17.4	35.9 efg	14.8 abc	296.9 abcd	10642.0 de	91.2 ab
13	Envita SC	30	66	17.4	37.5 bcdef	14.9 abc	296.5 abcd	11092.2 abcd	91.2 ab
14	Transit Foliar	30	66	17.5	36.3 defg	15.1 ab	301.0 abc	10896.5 de	91.7 a
15	Lalstim Osmo	30	66	17.6	35.2 efg	15.1 ab	301.6 ab	10611.1 de	91.7 a
			Mean	17.4	37.5	14.8	295.2	11058.8	90.9
			CV%	1.4	6.5	2.1	2.1	6.3	0.8
			Pr>F	0.1235	0.0002	0.0191	0.0210	0.0002	0.0120
			lsd (0.05)	ns	3.5	0.4	9.0	986.3	1.0

Figure 1. Comparison of nitrogen response between sites following soybean or field corn based on the 2023 fall soil sample.

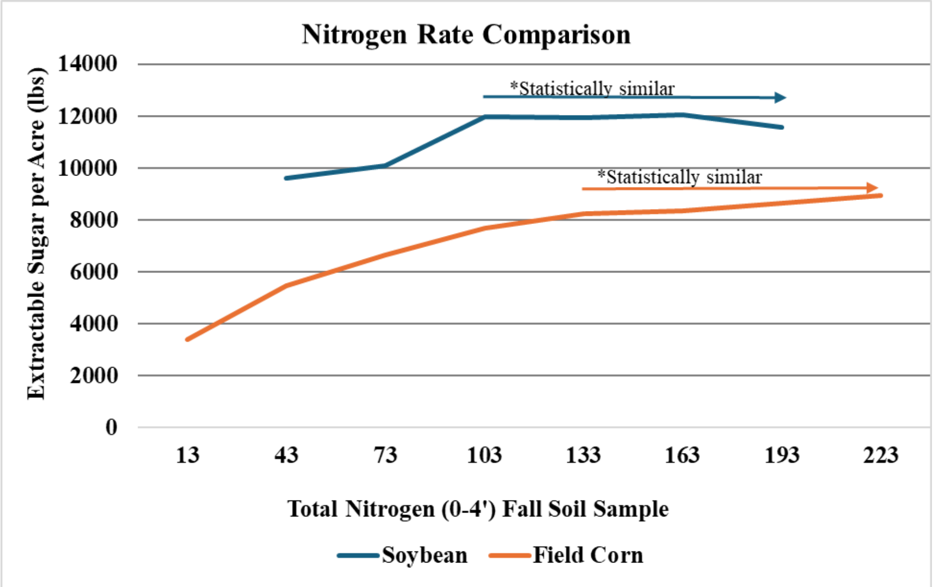


Figure 2. Percent canopy cover ratings taken on June 24th and July 17th at Roseland correlated with Extractable Sugar per Acre.

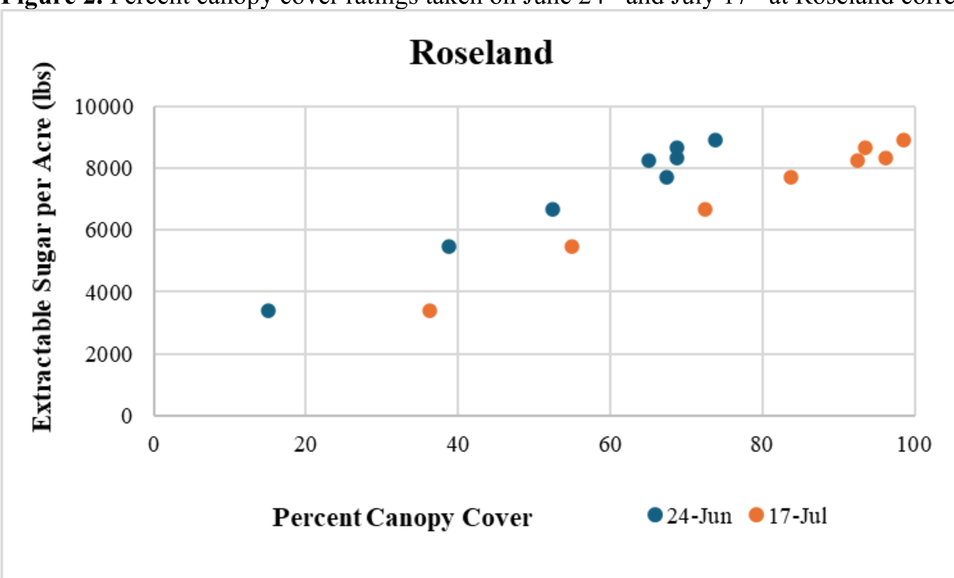
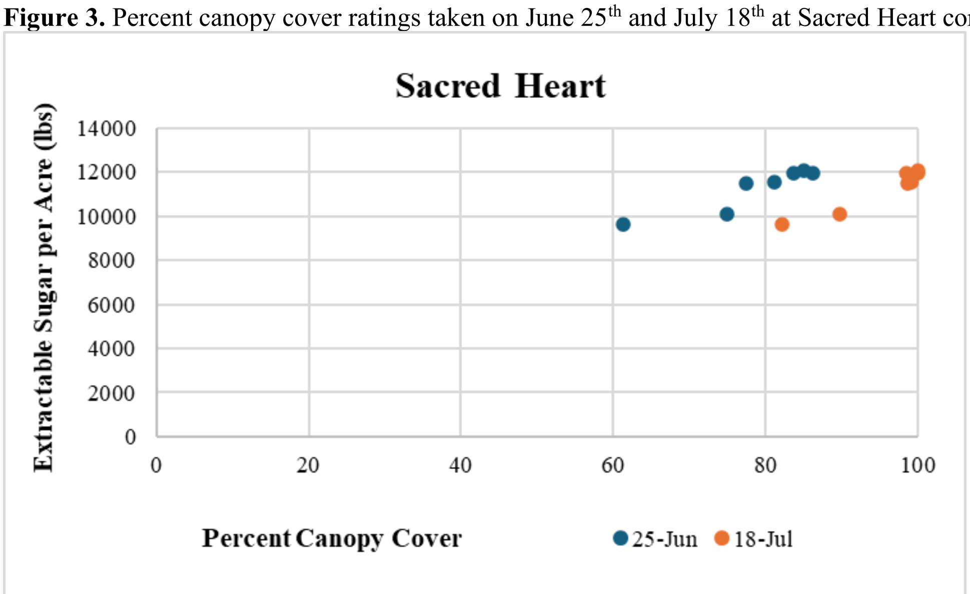


Figure 3. Percent canopy cover ratings taken on June 25th and July 18th at Sacred Heart correlated with Extractable Sugar per Acre.



Nitrogen Rate Trials 2025

David Mettler[1], **Mark Bloomquist**[2], and **John A. Lamb**[3],
[1]Research Agronomist, [2]Research Director, SMBSC, Renville, MN
[3]Professor Emeritus, University of Minnesota, St. Paul, MN

Nitrogen management is important for optimizing yield while also managing production costs. Understanding the impacts that nitrogen deficiency or excess nitrogen can have on stand and yield is important information for making input decisions.

Research Objective

- Provide nitrogen guidelines for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.
- Screen various commercial products for any merit in increasing sugar beet production.
- Evaluate the potential for blends of ESN to reduce stand loss from spring applied urea.

Methodology

Four trials were established in 2025 using randomized complete block design. Trials were located near Lake Lillian, Bird Island, and Renville. Sites were soil sampled in the fall of 2024 to develop treatment rates for the trials and sampled again in the spring of 2025 to identify any changes in soil nitrate (Table 1). The nitrogen ladder increments for each site were identical, however two sites contained treatments with blends of ESN and all sites contained several additional foliar or in-furrow treatments (Tables 2, 3, 4, and 5). All of the trials were planted using Beta 9131. Planting and harvest dates are listed in Table 1. Prior to planting, the urea and ESN treatments were broadcast by hand and incorporated with a small field cultivator. The three sites with a low phosphorus test also had triple super phosphate broadcast applied. The in-furrow and foliar treatments are described above the individual site tables. Percent canopy cover ratings were taken in mid-July to assess the impact of nitrogen rates on canopy development. Ratings were taken on a 0-100 scale rating the percentage of canopy cover versus bare ground. CLS ratings (1-9) were taken on September 8th at the three sites following field corn to assess the impact that nitrogen may have on CLS disease severity. Standard sugar beet production practices were used to keep the trials weed and disease free. Each plot was 35ft long and 6 rows wide. The center two rows of each six-row plot were harvested using a six-row defoliator and a two-row research harvester. The beets harvested from the center two rows were weighed on the harvester and two samples of those beets from each plot were used for quality analysis at the SMBSC tare lab. The data was analyzed for significance using SAS GLM version 9.4. Only reps 1-3 were harvested at the Lake Lillian site due to flooding that negatively impacted rep 4.

Table 1. Soil test results for the four trial locations from fall soil sample in 2024 and important dates.

Soil test	Bird Island	Lake Lillian	Renville Corn	Renville SB
Fall Soil nitrate-N 0-4 ft. (lb N/A)	55	90	85	55
Spring Soil nitrate-N 0-4 ft. (lb N/A)	58	104	112.5	108.5
Olsen P 0-6 in. (ppm)	11	6	5	6
K 0-6 in. (ppm)	242	114	128	163
pH 0-6 in. (unitless)	7.2	7.9	7.7	7.9
Organic matter 0-6 in. (%)	5.9	3.2	4.9	5.4
Planting Date	4/23/25	5/6/25	4/30/25	4/21/25 & 5/14/25
Harvest Date	9/12/25	10/2/25	9/25/25	9/15/25
Previous Crop	Field Corn	Field Corn	Field Corn	Soybean

Results

All of the sites following field corn had a significant increase in ESA with the first 60lbs of additional nitrogen but no significant increase in ESA over 60lbs applied (Figure 1). There was no response to additional nitrogen applied at the site following soybean. Any additional foliar or in-furrow treatments at any of the sites had no significant impact on ESA. Several of the sites had significant stand loss at higher rates of spring applied urea (Figure 2). Stand loss was reduced at the Lake Lillian site when blends of ESN were used to reduce the amount of urea applied but keeping total nitrogen the same (Table 5). The stand loss at the Renville SB site was severe due to crusting that occurred after planting. The crusting combined with high rates of spring urea caused severe stand loss and led to the trial being replanted. The stand count data in Table 3 is from the original planting. The percent canopy ratings taken in mid-July correlated highly with the extractable sugar per acre at the end of the season with R values of 0.918 at Lake Lillian, 0.903 at Renville, and 0.962 at Bird Island (Figure 3). The CLS ratings taken on September 8th showed either no impact on disease severity with nitrogen rates or that the disease severity was less for the plots with less nitrogen applied. The CLS ratings were highly correlated with percent canopy at two sites with R Values of 0.893 at Lake Lillian and 0.978 at Bird Island (Figure 4). The Renville Corn location had no significant differences in CLS ratings and only had an R value of 0.707.

Conclusions

The residual nitrogen only increased slightly following field corn when comparing fall and spring soil samples. However, the site following soybean almost doubled the residual nitrogen (Table 1). Between the high residual nitrogen and low crop residue compared to field corn it is not surprising to not see a response to additional nitrogen at the site following soybean (Table 3). Based on the fall soil samples the sites following field corn responded positively to additional nitrogen up to 115, 145, and 150lbs of total N. None of the commercial in-furrow or foliar applied products proved beneficial this year or in previous years of testing. The high correlation between percent canopy cover and extractable sugar per acre this year and last year indicate that it could be a useful tool in the future to compare treatments if plots are not able to be harvested. The impact of nitrogen on CLS disease severity was not overly surprising. The plots with the lower rates of nitrogen were slower to develop a full canopy so this would have delayed the onset of the disease by not providing an environment conducive to disease development as these plots would have had better airflow in the canopy compared to higher nitrogen plots with thick canopies. Overall, the testing from this year agreed with the current recommendation of 110 to 150lbs of total nitrogen based on a fall soil test. Crops with less residue and high organic matter soils can likely be on the lower side of the recommendations. For sugar beets following field corn it would be best to be at the high end of the recommendation. Going over 150lbs of total N is likely not going to cause a reduction in ESA. However, if rates over 90lbs of N as urea are applied in the spring it is possible to see some stand loss and significant stand loss under certain conditions.

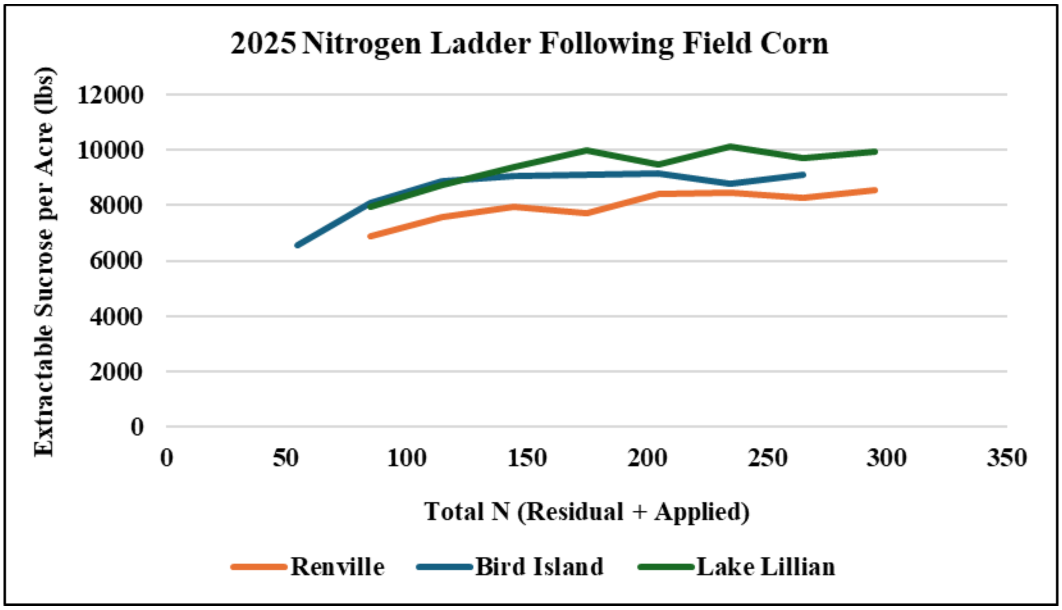


Figure 1. Nitrogen response following field corn.

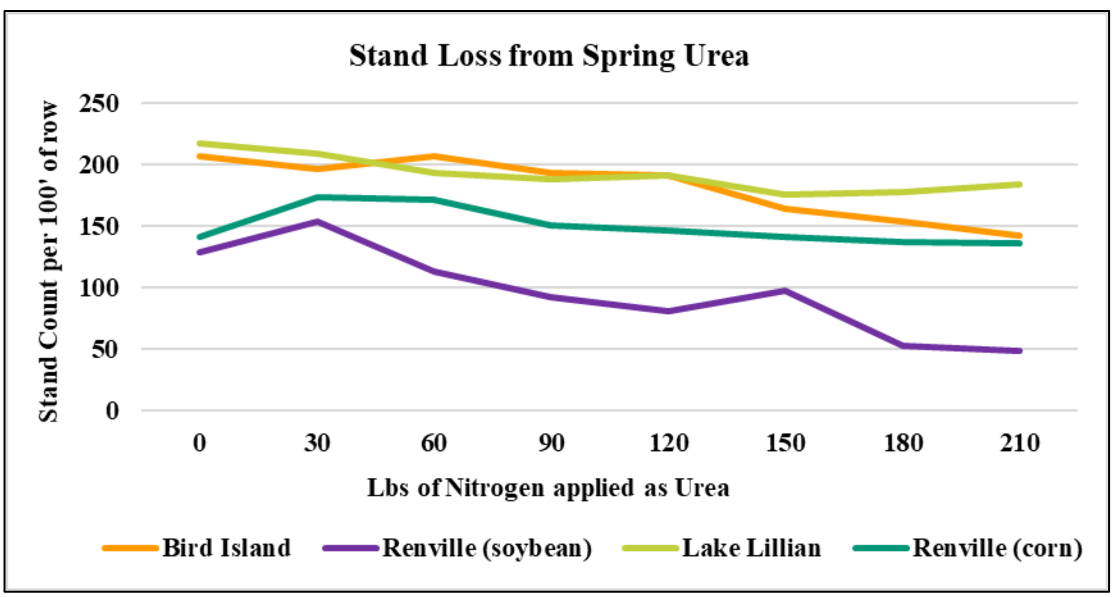


Figure 2. Stand loss from spring applied urea across all four sites.

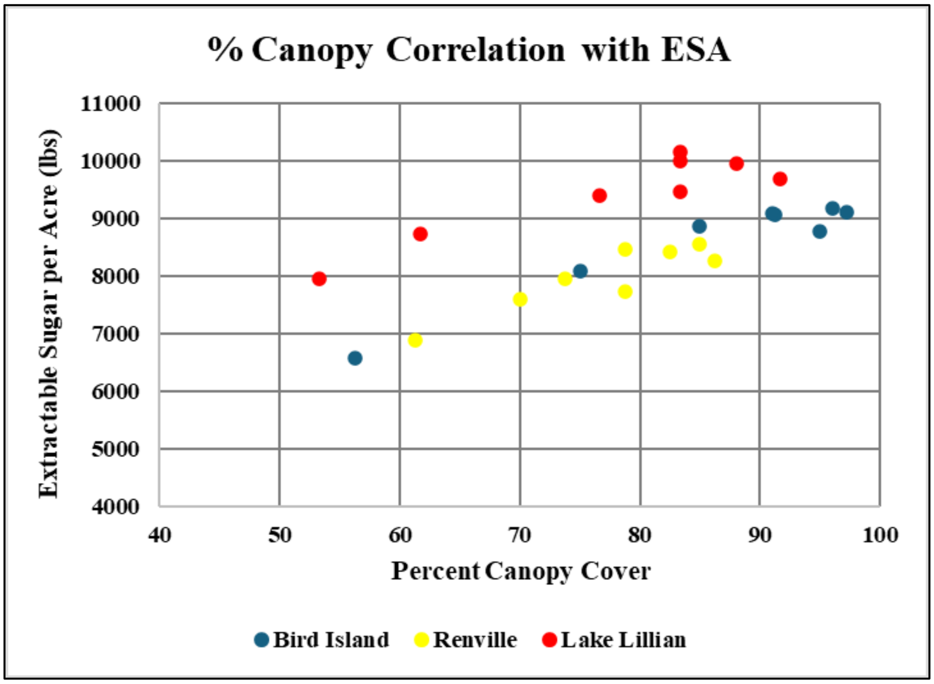


Figure 3. Percent canopy cover taken in mid-July and correlated with extractable sugar per acre for the nitrogen ladder treatments for the sites following field corn.

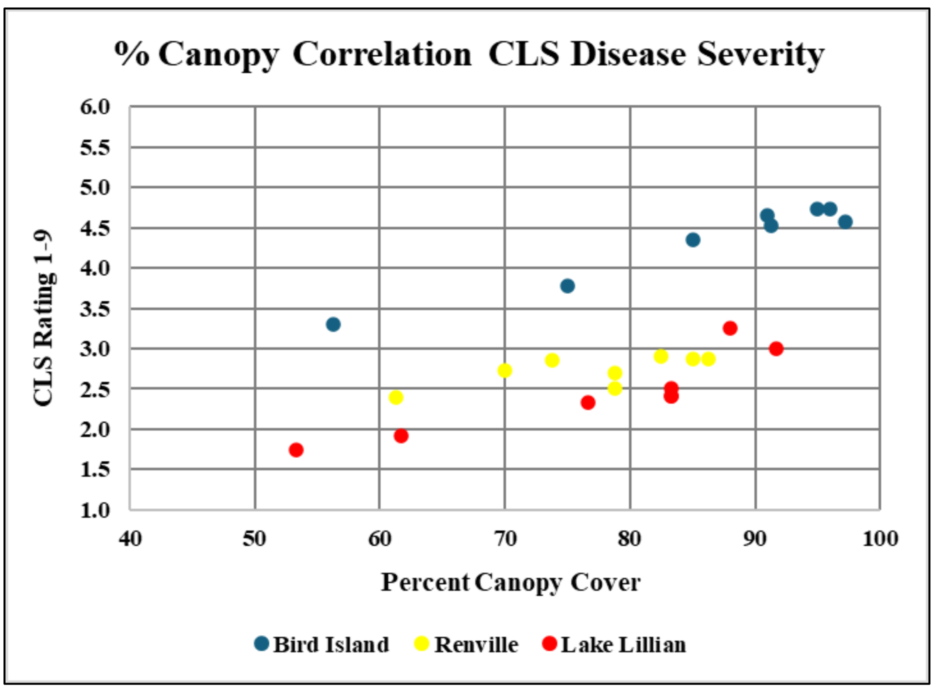


Figure 4. CLS ratings taken on September 8th and correlated with percent canopy cover taken in mid-July for the nitrogen ladder treatments for the sites following field corn.

Table 2. Yield, canopy rating, stand count, and CLS rating data for the Renville trial following field corn. Foliar applications for treatments 10 and 12 were made on June 21st, July 18th, and August 12th using a spray volume of 20gpa.

Entry	Treatment	N Rate	Total N	Percent Sugar	Tons Per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity	% Canopy Rating 15-Jul	CLS Rating (1-9) 8-Sep	Stand Count per 100' row 27-May
1		0	85	14.9 abcd	27.1 f	12.7 abcd	254.6 abcd	6885.1 d	91.8	61.3 f	2.4	141.3
2		30	115	15.1 ab	29.3 ef	13.0 a	258.9 ab	7595.5 cd	92.0	70.0 e	2.7	173.8
3		60	145	15.2 ab	30.7 de	12.9 ab	258.8 ab	7944.0 abc	92.0	73.8 cde	2.9	171.3
4		90	175	14.8 abd	30.7 de	12.6 abcd	251.8 abcd	7720.8 bc	91.7	78.8 bc	2.7	151.3
5		120	205	14.8 bcd	33.7 abc	12.5 bcd	250.3 bcd	8414.8 ab	91.6	82.5 ab	2.9	146.3
6		150	235	14.6 d	34.3 ab	12.3 d	246.6 d	8452.9 ab	91.5	78.8 bc	2.5	141.3
7		180	265	14.7 cd	33.1 abcd	12.5 cd	249.3 cd	8260.1 abc	91.6	86.3 a	2.9	137.5
8		210	295	14.6 d	34.7 a	12.3 d	246.1 d	8545.2 a	91.4	85.0 a	2.9	136.3
10	Max N Pact @ 2gal	60	145	15.0 abc	31.6 bcde	12.8 abc	255.7 abc	8087.0 abc	91.8	75.0 cde	2.9	163.8
12	Foliar K2O (20%), Mg (4%), Mn (2.5%), S (6.5%), B (0.05%), Mo (0.03%) @ 1gal	60	145	15.2 a	29.9 ef	13.0 a	259.7 a	7763.0 abc	91.9	76.3 cd	2.8	178.8
			Mean	14.9	31.4	12.7	253.3	7944.7	91.7	76.25	2.75	156.4
			CV%	2.0	6.3	2.4	2.4	7.0	0.3	5.53	9.67	15.5
			Pr>F	0.0399	0.0001	0.0305	0.0367	0.0127	0.0688	<.0001	0.1635	0.1004
			lsd (0.05)	0.4	2.8	0.4	8.9	800.7	ns	6.07	ns	ns

Table 3. Yield, canopy rating, and stand count data for the Renville trial following soybean. Foliar applications for treatments 9 and 10 were made on July 18th and August 13th using a spray volume of 20gpa.

Entry	Trt	N Rate	ESN Rate	Total N	Percent Sugar	Tons Per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity	Canopy Rating 18-Jul	Stand Count per 100' row 4 leaf
1		0	0	55	15.5 ab	19.7	13.3 ab	265.7 a	5221.5	92.1	52.5	128.8 ab
2		30	0	85	15.3 abcde	21.2	13.0 abcde	260.2 abcd	5515.7	91.8	62.5	153.8 a
3		60	0	115	15.4 ab	20.1	13.2 ab	263.9 ab	5300.1	91.9	56.3	113.8 bcde
4		90	0	145	15.0 de	19.6	12.8 cde	255.1 cd	5010.6	91.7	58.8	92.5 cde
5		120	0	175	15.4 abcd	21.6	13.1 abc	262.4 abc	5678.7	91.7	62.5	81.3 ef
6		150	0	205	15.0 cde	20.5	12.8 cde	255.2 cd	5213.2	91.5	61.3	97.5 bcde
7		180	0	235	15.3 abcde	19.8	13.1 abcd	261.1 abc	5179.6	92.0	60.0	52.5 f
8		210	0	265	15.4 abc	20.0	13.1 abc	262.1 abc	5243.1	91.6	62.5	48.8 f
9	Max N Pact @ 2gal	90	0	145	15.5 ab	21.0	13.2 ab	264.5 ab	5538.5	91.9	63.8	88.8 de
10	Foliar K2O (20%), Mg (4%), Mn (2.5%), S (6.5%), B (0.05%), Mo (0.03%) @ 1gal	90	0	145	15.6 a	20.2	13.3 a	266.8 a	5372.1	92.1	61.3	101.3 bcde
11		60	30	145	14.9 e	19.8	12.7 de	253.4 d	5010.2	91.9	57.5	122.5 abc
12		30	60	145	15.4 ab	21.4	13.1 abc	262.4 abc	5622.8	91.6	62.5	116.3 bcd
13		0	90	145	15.4 abc	21.8	13.1 abc	262.9 ab	5738.6	91.8	65.0	100.0 bcde
14		120	60	235	15.2 bcde	22.5	12.9 bcde	257.8 bcd	5808.2	91.6	66.3	105.0 bcde
15		60	120	235	15.3 abcde	21.6	13.0 abcde	259.6 abcd	5607.3	91.6	67.5	106.3 bcde
16		0	180	235	14.9 e	20.9	12.7 e	253.3 d	5288.6	91.6	62.5	118.8 bcd
				Mean	15.3	20.7	13.0	260.4	5396.8	91.8	61.4	101.7
				CV%	1.8	11.2	2.0	2.0	11.1	0.4	14.03	23
				Pr>F	0.0062	0.8620	0.0078	0.0062	0.7704	0.2728	0.699	<0.001
				lsd (0.05)	0.4	ns	0.4	7.54	ns	ns	ns	33.3

Table 4. Yield, canopy rating, stand count, and CLS rating data for the Bird Island trial. Biopath was applied in-furrow at 1 quart for treatment 9 and Generate was applied at 1 pint for treatment 10. The in-furrow treatments were applied with a volume of 6gpa. Treatment 10 also included a broadcast treatment of Generate at 1 pint per acre using a bike sprayer at 17gpa at the 10-12lf stage.

Entry	Treatment	N Rate	Total N	Percent Sugar	Tons Per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity	% Canopy Rating 19-Jun	% Canopy Rating 16-Jul	CLS Rating (1-9) 8-Sep	Stand Count per 100' row 4 leaf
1		0	55	15.2	25.5 a	12.9	257.4	6574.7 a	91.4	28.8 e	56.3 d	3.3 d	207.5 a
2		30	85	15.1	31.5 b	12.8	256.6	8085.1 b	91.6	42.5 d	75.0 c	3.8 c	196.3 ab
3		60	115	15.2	34.2 bc	13.0	259.5	8864.0 bc	91.7	56.3 abc	85.0 b	4.4 b	207.5 a
4		90	145	15.3	34.9 c	13.0	260.2	9063.0 c	91.6	56.3 abc	91.3 ab	4.5 ab	177.5 bcd
5		120	175	15.3	35.0 c	13.0	260.0	9084.2 c	91.5	53.8 bc	91.0 ab	4.7 ab	191.3 abc
6		150	205	15.1	35.8 c	12.8	257.0	9174.9 c	91.6	62.5 ab	96.0 a	4.7 ab	164.1 cde
7		180	235	15.0	34.5 c	12.7	254.6	8765.6 c	91.5	52.5 c	95.0 a	4.7 ab	153.8 de
8		210	265	15.0	36.0 c	12.6	253.3	9118.4 c	91.4	65.0 a	97.3 a	4.6 ab	142.4 e
9	Biopath	90	145	15.1	36.2 c	12.8	257.2	9298.6 c	91.8	58.8 abc	91.3 ab	4.6 ab	193.8 ab
10	Generate	90	145	15.1	34.8 c	12.8	256.6	8929.6 c	91.7	60.0 abc	90.0 ab	4.9 a	195.0 ab
			Mean	15.1	33.9	12.8	257.1	8716.0	91.6	53.6	86.8	4.4	185.1
			CV%	1.5	5.9	1.9	1.9	6.3	0.4	11.8	6.2	6.51	11.1
			Pr>F	0.5502	<.0001	0.4732	0.6532	<.0001	0.9452	<.0001	<.0001	<.0001	0.002
			lsd (0.05)	ns	2.90	ns	ns	797.7	ns	9.16	7.79	0.42	29.3

Table 5. Yield, canopy rating, stand count, and CLS rating data for the Lake Lillian trial. Treatments 9 and 10 had Envita applied at 5g per acre with Prefer 90 NIS at 0.25% v/v using a bike sprayer at 17gpa spray volume at the 2-4lf stage and again at the 10-12lf stage.

Entry	Treatment	N Rate	ESN Rate	Total N	Percent Sugar	Tons Per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity	% Canopy Rating 1-Jul	% Canopy Rating 16-Jul	CLS Rating (1-9) 8-Sep	Stand Count per 100' row 4 leaf
1		0	0	90	15.3 a	30.2 d	13.2 a	263.2 a	7956.2 de	92.2	28.8 g	53.3 g	1.8 e	217.5 a
2		30	0	120	15.2 ab	33.5 cd	13.0 abc	260.1 abcd	8725.3 cd	91.9	33.8 fg	61.7 fg	1.9 de	208.8 ab
3		60	0	150	15.1 abc	36.5 bc	12.9 abcd	258.0 abcde	9405.1 bc	92.0	43.8 ef	76.7 de	2.3 cde	193.8 abcde
4		90	0	180	15.2 ab	38.4 ab	13.0 abc	260.6 abcd	10008.4 ab	92.2	47.5 cde	83.3 bcd	2.4 bcd	188.8 bcde
5		120	0	210	14.9 bc	37.6 ab	12.6 bcde	252.3 cdef	9466.8 bc	91.7	50.0 bcde	83.3 bcd	2.4 bcd	191.3 bcde
6		150	0	240	15.0 abc	39.4 ab	12.9 abcd	257.8 abcde	10144.0 ab	92.3	51.3 bcde	83.3 bcd	2.5 bcd	176.3 e
7		180	0	270	14.4 d	39.7 ab	12.2 e	244.2 f	9689.5 ab	91.6	56.3 abc	91.7 ab	3.0 ab	177.5 de
8		210	0	300	14.7 cd	39.7 ab	12.5 de	250.4 ef	9947.0 ab	91.9	55.0 abcd	88.0 abcd	3.3 a	183.8 cde
9	Envita	0	0	90	15.3 a	30.1 d	13.1 ab	261.1 abc	7877.9 e	91.8	27.5 g	56.7 fg	1.9 de	210.0 ab
10	Envita	30	0	120	15.0 abc	33.3 cd	12.8 abcd	256.3 abcde	8538.1 de	92.0	33.8 fg	66.7 ef	2.3 cde	206.3 abc
11		60	30	180	15.3 ab	38.2 ab	13.1 ab	262.0 ab	10001.1 ab	92.2	50.0 bcde	81.7 bcd	2.5 bcd	203.8 abc
12		30	60	180	15.1 abc	38.6 ab	13.0 abc	259.2 abcde	10005.2 ab	92.1	48.8 bcde	76.7 de	2.4 bcd	200.0 abcde
13		0	90	180	15.1 abc	36.5 bc	12.9 abcd	257.8 abcde	9395.2 bc	92.0	45.0 de	80.0 cd	2.2 cde	201.3 abcd
14		120	60	270	14.9 abc	38.8 ab	12.6 bcde	253.2 bcde	9828.9 ab	91.6	52.5 abcde	89.0 abc	2.6 bc	188.8 bcde
15		60	120	270	14.7 cd	39.8 ab	12.6 cde	251.9 def	10023.1 ab	92.1	58.8 ab	91.7 ab	2.8 abc	202.5 abc
16		0	180	270	14.8 bcd	41.0 a	12.6 cde	252.1 def	10349.3 a	91.7	62.5 a	96.3 a	2.5 bcd	208.8 ab
				Mean	15.0	37.0	12.8	256.3	9460.1	92.0	46.6	78.8	2.4	197.4
				CV%	1.8	5.7	2.1	2.1	5.2	0.5	15.2	8.8	14.7	8.8
				Pr>F	0.0086	<.0001	0.0087	0.0086	<.0001	0.7607	<.0001	<.0001	0.0015	0.0401
				lsd (0.05)	0.44	3.5	0.44	8.9	816.4	ns	10.1	11.6	0.67	24.6

SMBSC Southern Minnesota Agricultural Research

Variety x Nitrogen Rate Trial 2024

David Mettler[1], **Mark Bloomquist**[2], and **John A. Lamb**[3],
[1]Research Agronomist, [2]Research Director, SMBSC, Renville, MN
[3]Professor Emeritus, University of Minnesota, St. Paul, MN

Nitrogen management is a priority for the production of high-quality sugar beets. Differences in nitrogen use efficiency between varieties would be beneficial information for growers to optimize yield potential.

Research Objective

- Provide nitrogen fertilizer guidelines based on variety for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methodology

The trial was established near Sacred Heart following soybean in 2024 using randomized complete block design. The site was soil sampled in the fall of 2023 to develop treatment rates and sampled again in the spring of 2024 to identify any changes in soil nitrate over the winter (Table 1). The Sacred Heart site was planted on April 22nd using Beta 9284 and Beta 9131. Prior to planting, the urea treatments were broadcast by hand and incorporated with a small field cultivator. Percent canopy cover ratings were taken in late June and mid-July. Standard sugar beet production practices were used to keep the trial weed and disease free. Each plot was 35ft long and six rows wide. The center two rows of each six-row plot were harvested on October 3rd using a six-row defoliator and a two-row research harvester. The beets harvested from the center two rows were weighed on the harvester, and two samples of those beets from each plot were used for quality analysis at the SMBSC tare lab. The data was analyzed for significance using SAS GLM version 9.4.

Table 1. Soil test results from the fall soil sample in 2023.

Soil test	Sacred Heart
Fall Soil nitrate-N 0-4 ft. (lb N/A)	60
Spring Soil nitrate-N 0-4 ft. (lb N/A)	136
Olsen P 0-6 in. (ppm)	5
K 0-6 in. (ppm)	142
pH 0-6 in. (unitless)	8.0
Organic matter 0-6 in. (%)	6.1

Results

A significant amount of nitrogen mineralization occurred between the fall soil sample and planting (Table 1). This mineralization resulted in less differences occurring between nitrogen rates than would have been expected given the fall soil sample results (Table 2). Differences in root yield and ESA were generally lower for the zero nitrogen applied treatment for both varieties with no differences between plots that had any rate of nitrogen applied.

Conclusions

No significant differences were observed between the two varieties tested and their response to increasing nitrogen rates. The response to increasing nitrogen rates was minimal with the high nitrogen residual present after mineralization.

Southern Minnesota Agricultural Research

Table 2. Root yield and quality data.

Entry	Variety	Applied N	Total N	Percent Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	9284	0	60	17.1	39.3 bc	14.5	290.0	11395.0 bc	90.9 ab
2	9284	50	110	17.3	39.7 abc	14.6	292.1	11596.5 abc	90.6 bc
3	9284	100	160	17.1	41.5 ab	14.5	289.0	11968.3 a	90.5 bc
4	9284	150	210	17.1	41.3 ab	14.4	288.3	11902.7 ab	90.5 bc
5	9131	0	60	17.2	37.8 c	14.7	293.1	11081.4 c	91.3 a
6	9131	50	110	17.0	41.8 a	14.6	290.7	12131.9 a	91.3 a
7	9131	100	160	17.1	41.5 ab	14.5	290.2	12022.1 a	91.0 ab
8	9131	150	210	16.8	41.5 ab	14.2	282.9	11731.5 ab	90.3 c
			Mean	17.1	40.5	14.5	289.5	11728.7	90.8
			CV%	1.7	4.0	1.8	1.8	3.2	0.4
			Pr>F	0.5902	0.0217	0.2395	0.2516	0.0095	0.0042
			lsd (0.05)	ns	2.4	ns	ns	544.8	0.6

Variety x Nitrogen Rate Trial 2025

David Mettler[1], **Mark Bloomquist**[2], and **John A. Lamb**[3],
[1]Research Agronomist, [2]Research Director, SMBSC, Renville, MN
[3]Professor Emeritus, University of Minnesota, St. Paul, MN

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- Provide nitrogen fertilizer guidelines based on variety for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methodology

The trial was established near Renville following field corn in 2025 using randomized complete block design. The site was soil sampled in the fall of 2024 to develop treatment rates and sampled again in the spring of 2025 to identify any changes in soil nitrate over the winter (Table 1). The Renville site was planted on April 30th using Beta 9284 and Crystal M977. Prior to planting, the urea treatments were broadcast by hand and incorporated with a small field cultivator. Percent canopy cover ratings were taken on July 15th. Standard sugar beet production practices were used to keep the trial weed and disease free. Each plot was 35ft long and six rows wide. The center two rows of each six-row plot were harvested on September 25th using a six-row defoliator and a two-row research harvester. The beets harvested from the center two rows were weighed on the harvester, and two samples of those beets from each plot were used for quality analysis at the SMBSC tare lab. The data was analyzed for significance using SAS GLM version 9.4.

Table 1. Soil test results from the fall soil sample in 2024.

Soil test	Renville
Fall Soil nitrate-N 0-4 ft. (lb N/A)	90
Spring Soil nitrate-N 0-4 ft. (lb N/A)	87
Olsen P 0-6 in. (ppm)	5
K 0-6 in. (ppm)	128
pH 0-6 in. (unitless)	7.7
Organic matter 0-6 in. (%)	4.9

Results

Soil nitrate levels were unchanged between fall and spring soil samples. Both varieties responded positively to the addition of nitrogen and had similar extractable sugar per acre (Table 2). The only significant difference between the two varieties and their response to nitrogen was the lower ESA for Crystal M977 when no additional nitrogen was applied. The percent canopy ratings taken in mid-July were highly correlated with final ESA for nitrogen rate for both varieties. 0.999 for Crystal M977 and 0.951 for Beta 9284.

Conclusions

The results of this trial and other trials in the recent past do not suggest a significant difference in nitrogen use efficiency between varieties that are generally considered to perform differently from a quality vs tons perspective. There may be small differences in nitrogen use efficiency, but those differences may not be large enough to change nutrient managements tactics depending on the variety being planted.

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Table 2. Yield, stand counts, and mid-July canopy ratings.

Entry	Variety	N Rate	Total N	Percent Sugar	Tons Per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity	% Canopy Rating 15-Jul	Stand Count per 100' row 27-May
1	Beta 9284	0	90	14.6	27.6 c	12.4	247.9	6863.1 c	91.7 abc	47.5 c	157.5
2	Beta 9284	50	140	14.7	28.5 bc	12.5	250.2	7139.5 bc	91.8 ab	60.0 b	148.8
3	Beta 9284	100	190	14.7	31.7 a	12.6	251.2	7970.4 a	92.1 a	71.3 ab	145.0
4	Beta 9284	150	240	14.5	30.6 ab	12.2	244.6	7496.5 abc	91.5 bc	71.3 ab	130.0
5	Crystal M977	0	90	14.7	24.1 d	12.6	251.4	6045.3 d	92.1 a	46.3 c	150.0
6	Crystal M977	50	140	14.7	27.7 c	12.6	251.0	6958.0 c	91.9 ab	62.5 b	152.5
7	Crystal M977	100	190	14.6	29.8 abc	12.4	247.1	7362.9 abc	91.4 c	68.8 ab	141.3
8	Crystal M977	150	240	14.6	31.8 a	12.3	246.4	7840.3 ab	91.6 bc	76.3 a	160.0
			Mean	14.6	29.0	12.4	248.7	7209.5	91.8	63.0	148.1
			CV%	1.7	6.1	2.0	2.0	7.0	0.3	12.4	15.6
			Pr>F	0.7082	<.0001	0.2935	0.4237	0.0007	0.0132	<.0001	0.6846
			lsd (0.05)	ns	2.6	ns	ns	739.7	0.394	11.5	ns

Previous Crop Trial 2022-2023

David Mettler[1], **Mark Bloomquist**[2], and **John A. Lamb**[3],
[1]Research Agronomist, [2]Research Director, SMBSC, Renville, MN
[3]Professor Emeritus University of Minnesota, St. Paul, MN

Nitrogen management is a priority for production of high-quality sugar beets. Previous crop can affect nitrogen availability and earlier harvested crops like sweet corn and spring wheat tend to have less residue potentially leading to better planting conditions for the following sugar beet crop.

Research Objective

- Provide previous crop and nitrogen fertilizer guidelines for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methodology

A two-year trial was conducted near Bird Island (2021-2022) and near Hector (2022-2023) as a split block with four replications. In the first year of the trials four rotational crops were planted in randomized blocks: field corn, soybean, sweet corn, and spring wheat. Soil samples were taken in the spring prior to planting the four rotational crops and fertilizer applications were made using University of Minnesota recommendations for each crop. The fertilizer treatments were applied broadcast in the spring and incorporated using a small field cultivator. Standard practices were used to keep the four rotational crops weed and disease free. Important dates and average yields are reported in Table 1. The previous crops were machine harvested with small research combines except for the sweet corn (Photo 1). The sweet corn was hand harvested and then mowed to chop up the stalks. The 2021 crop year was abnormally dry, especially in the area where this trial was located as illustrated with the large soil cracks (Photo 2). As a result, the yields were somewhat suppressed, most notable the field corn.

For the second year of the trials, sugar beets were planted into each of the previous crops. The previous crop blocks were soil sampled to a depth of four feet in the fall prior to planting sugar beets. Prior to planting, the blocks were separated into 3 treatments for each crop. These treatments were residual nitrogen only, 110 lbs total N per acre, and 150 lbs total N per acre (Tables 2 and 3). Each of these plots were 6 rows wide. Nitrogen treatments were applied as urea and incorporated with a small field cultivator. The Bird Island site was planted on May 23, 2022 using Crystal M089 and the Hector site was planted on May 10, 2023 using Crystal M089. Standard grower practices were used to keep the site weed and disease free. The center two rows of each six-row plot were harvested on September 20, 2022 at Bird Island and October 5, 2023 at Hector using a six-row defoliator and a two-row research harvester. The sugar beet roots harvested from the center two rows were weighed on the harvester and two samples of those beets from each plot were used for a quality analysis at the SMBSC tare lab. The data were analyzed for significance using SAS GLM version 9.4.

Table 1. Planting date, harvest date, and yield for the four rotational crops in 2021 near Bird Island and in 2022 near Hector.

Previous Crop	Planting Date	Harvest Date	Yield per Acre
Bird Island, 2021			
Field Corn	May 6th	October 19th	140 bushels
Soybean	May 7th	October 6th	55 bushels
Sweet Corn	May 6th	August 10th	9 tons
Spring Wheat	April 22nd	August 2nd	51 bushels
Hector, 2022			
Field Corn	May 7th	October 14th	203 bushels
Soybean	May 7th	September 29th	59 bushels
Sweet Corn	May 7th	August 9th	8.8 tons per acre
Spring Wheat	May 6th	August 17th	50 bushels

Photos 1 & 2. Combine used to harvest the spring wheat. Sweet corn in the dry summer conditions during the 2021 season.

Table 2. The Bird Island previous crop trial had 12 treatments that were based upon previous crop and total N (Residual + Applied).

Treatment	1	2	3	4	5	6	7	8	9	10	11	12
Previous Crop	Field Corn	Field Corn	Field Corn	Soybean	Soybean	Soybean	Sweet Corn	Sweet Corn	Sweet Corn	Spring Wheat	Spring Wheat	Spring Wheat
Residual N (lbs/A)	42	42	42	47	47	47	76	76	76	11	11	11
Applied N (lbs/A)	0	68	108	0	63	103	0	34	74	0	99	139
Total N (lbs/A)	42	110	150	47	110	150	76	110	150	11	110	150

Table 3. The Hector previous crop trial had 12 treatments that were based upon previous crop and total N (Residual + Applied).

Treatment	1	2	3	4	5	6	7	8	9	10	11	12
Previous Crop	Field Corn	Field Corn	Field Corn	Soybean	Soybean	Soybean	Sweet Corn	Sweet Corn	Sweet Corn	Spring Wheat	Spring Wheat	Spring Wheat
Residual N (lbs/A)	39	39	39	39	39	39	90	90	90	24	24	24
Applied N (lbs/A)	0	71	111	0	71	111	0	20	60	0	86	126
Total N (lbs/A)	39	110	150	39	110	150	90	110	150	24	110	150

Results

The crop planted in the year prior to sugar beets had a significant impact on the sugar beet root yield (Figure 1). Sugar beet planted after sweet corn had higher root yield compared to those following the other three crops tested in this trial. The sugar beet planted after spring wheat had a greater root yield than field corn and soybean in 2023 but not in 2022. Nitrogen rate also had a significant impact on root yield (Figure 1) and quality (Table 4). In 2022 increasing the nitrogen rate to 110 lbs per acre of total N dramatically increased root yield following all previous crops, with only a slight increase following sweet corn. Root yields did not substantially increase when the nitrogen rate was increased to 150 lbs per acre of total N. In 2023 the response to N was mixed with a less dramatic increase in root yield with increasing N, however, the root yield still increased slightly with greater rates of N, with the exception of sugar beet following sweet corn. Increasing the rate of N had a consistent negative impact on quality in both 2022 and 2023 (Table 4).

Table 4. The effect of nitrogen rate on sugar beet quality across previous crops for 2022 and 2023.

	2022			2023		
Total N (lbs/A)	*Extractable Sugar %*	*Extractable Sugar Per Ton*	*Purity %*	*Extractable Sugar %*	*Extractable Sugar Per Ton*	*Purity %*
Residual N*	12.4c	247b	90.0b	13.9bc	277b	90.0b
110	12.1b	242b	89.6ab	13.8b	276b	89.8ab
150	11.8a	235a	89.3a	13.6a	272a	89.6a
$LSD_{(0.05)}$	0.21	3.9	0.50	0.16	3.2	0.23

*Residual N = residual N depends on the previous crop (Tables 2 and 3).

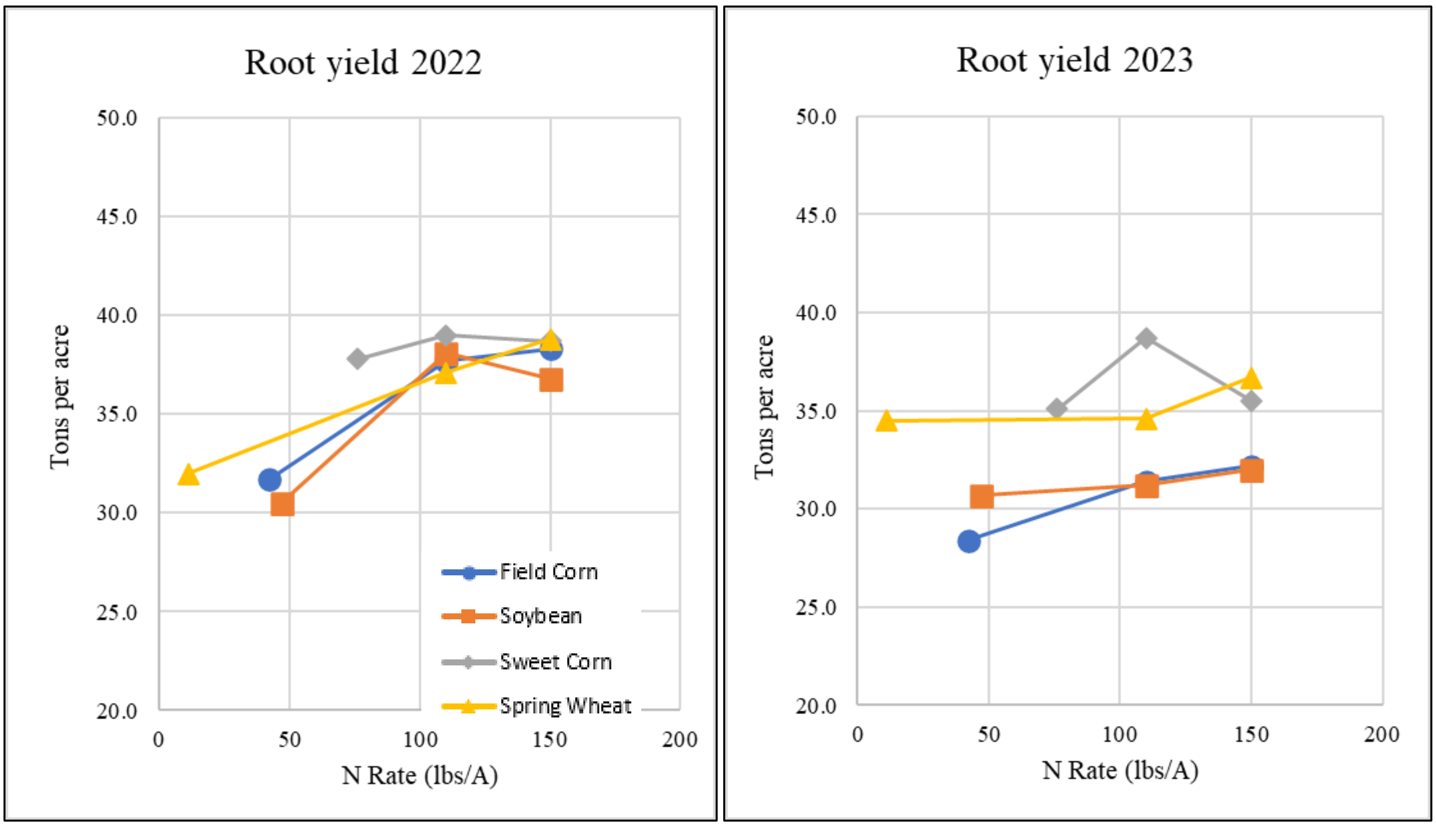

Figure 1. The effect of nitrogen and previous crop on root yield.

Conclusions

Root yields in the SMBSC Agronomic Practice Database have indicated that canning crops such as sweet corn and peas have a positive impact on the following sugar beet crop. This could be caused by the early harvest of the canning crops and lower crop residue levels. The early harvest of these crops gives the residue ample time to breakdown, which leads to less tie-up of nitrogen in the next year and potentially creates a better seed bed to plant sugar beets. Spring wheat also has the benefit of an early harvest, however, if the grain that is dropped during harvest is allowed to grow, like it was in this trial, then the volunteer wheat cover crop can also tie-up nitrogen and create a less ideal seed bed than if the volunteer wheat cover crop was terminated earlier.

Fertilizing each of the previous crops up to 110 and 150 lbs per acre of total N had a consistent negative impact on quality in 2022 and 2023. This negative impact was not drastic but something to consider when applying nitrogen, especially if it's not needed. The results from these trials would indicate that less nitrogen is needed following sweet corn to optimize root yield. These trials would also indicate that the benefit of increasing total N from residual levels to 110 is substantial, while the further increase to 150 lbs per acre of total N is less beneficial and often not significant.

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Potassium by Nitrogen Rate Trial 2021-2023

David Mettler[1], **Mark Bloomquist**[2], and **John A. Lamb**[3],

[1]Research Agronomist, [2]Research Director, SMBSC, Renville, MN

[3]Professor Emeritus University of Minnesota, St. Paul, MN

Nitrogen management is a priority for production of high-quality sugar beets. However, many other nutrients also play a role in plant growth. It is important to understand how the availability of other major nutrients may be impacted by varying levels of nitrogen.

Research Objective

- Provide potassium and nitrogen fertilizer guidelines for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methodology

This experiment was conducted over 3 years as a 3 x 5 factorial with four replications. Soil samples were taken in the fall prior to treatment application (Table 1). The nitrogen fertilizer rates were varied due to differences in residual nitrogen between the sites. However, for the combined analysis the rates will be presented as low, medium, and high. The low rate is the control with no additional nitrogen applied (52lbs average total N). The medium rate is the middle of the recommended range for total nitrogen (128lbs average total N). The high rate is on the high side or above the recommended nitrogen rate (198lbs average total N). The potassium fertilizer rates were 0, 30, 60, 90, and 120 lb K_2O/A. The potassium and nitrogen treatments were applied broadcast in the spring and incorporated using a small field cultivator. The nitrogen source was urea (46-0-0), and the potassium source was potash (0-0-60). The sites were planted with a good root disease variety to mitigate any impacts from disease. Dual Magnum was applied preemergence and other standard practices were used post emergence to keep the sites weed free. The center two rows of each six-row plot were harvested using a six-row defoliator and a two-row research harvester. The planting and harvest dates for each site can be found in Table 1. The beets harvested from the center two rows were weighed on the harvester and a sample of those beets were used for a quality analysis at the SMBSC tare lab. The data was analyzed for significance using SAS GLM version 9.4.

Table 1. Fall soil sample results and important dates for all three locations.

Soil test	Hector, 2021	Redwood Falls, 2022	Renville, 2023
Soil nitrate-N 0-4 ft. (lb N/A)	45	77	33
Olsen P 0-6 in. (ppm)	7	14	3
K 0-6 in. (ppm)	168	228	224
pH 0-6 in. (unitless)	7.7	7.7	8.0
Organic matter 0-6 in. (%)	4.7	5.6	5.3
Previous Crop	Field corn	Field corn	Soybean
Planting Date	April 30th	May 16th	May 4th
Harvest Date	September 29th	October 6th	September 18th

Results

Across all three years the application of potassium had no impact on the root yield or quality of sugar beets regardless of the amount of nitrogen applied (Table 2). The increased rate of nitrogen applied had a positive impact on tons per acre and extractable sugar per acre (Table 3). There was also an interaction between nitrogen and year for the quality parameters. This interaction occurred because the impact of nitrogen on the quality parameters varied between the 3 years that this study was conducted (Figure 1).

Conclusions

It was speculated that as nitrogen rates increase the rates of other nutrients, such as potassium, would also need to be increased. However, increasing potassium rates as nitrogen rates increase does not have any impact if there are already sufficient levels of potassium. The impact of nitrogen on root yield was expected with an increase from the control to the rate that was within the recommended range, but no increase in root yield occurred as the rate of nitrogen was increased beyond the recommended range. Increasing nitrogen rates beyond the recommended range had a negative impact on quality two out of three years. The environment plays a large role in nitrogen availability, and we do not always get the response we may expect. Most of the time applying a high rate of nitrogen will likely have a negative impact on quality, however, there are times when the opposite can happen, as was the case with this study in 2022. Nitrogen remains a very important nutrient for growing a profitable sugar beet crop. However, growers need to be aware of the risk and reward of applying too much or too little nitrogen.

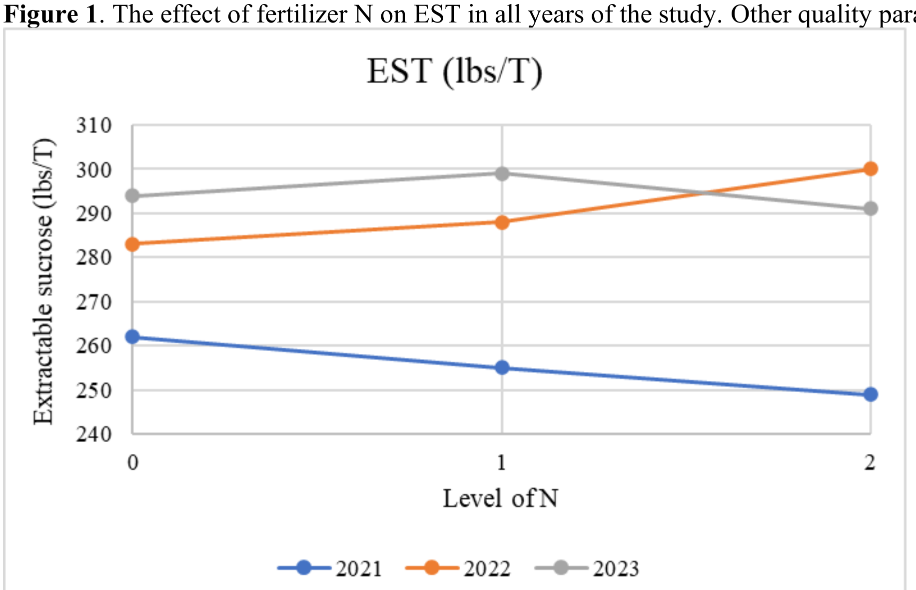
Table 2. The effect of fertilizer K_2O on root yield and quality averaged across N rates.

Level of K_2O (lbs)	Percent Sugar	Root Yield Tons/Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs)	Extractable Sugar per Acre (lbs)	Percent Purity
0	16.8	34.2	13.9	279.0	9481.0	89.4
30	16.9	34.0	14.0	279.3	9431.1	89.2
60	16.9	34.4	14.0	280.4	9591.4	89.4
90	16.9	34.6	14.0	280.4	9677.5	89.4
120	17.0	34.7	14.1	281.6	9726.1	89.3
Mean	16.9	34.4	14.0	280.1	9591.4	89.3
CV%	3.0	7.8	3.8	3.8	8.1	0.8
Pr>F	0.4448	0.4225	0.5676	0.5636	0.2223	0.0862
lsd (0.05)	ns	ns	ns	ns	ns	ns

Table 3. The effect of fertilizer N on root yield averaged across K rates.

Level of N (lbs)	Root Yield Tons/Acre	Extractable Sugar per Acre (lbs)
Low (52)	30.6 a	8535.6 a
Med (128)	36.1 b	10049.1 b
High (198)	36.6 b	10159.7 b
Mean	34.4	9591.4
CV%	7.8	8.1
Pr>F	0.0011	0.0015
lsd (0.05)	2.9	854.8

Figure 1. The effect of fertilizer N on EST in all years of the study. Other quality parameters had similar results.



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Phosphorus by Nitrogen Rate Trial 2023-2025

David Mettler[1], **Mark Bloomquist**[2], and **John A. Lamb**[3],
[1]Research Agronomist, [2]Research Director, SMBSC, Renville, MN
[3]Professor Emeritus University of Minnesota, St. Paul, MN

Nitrogen management is a priority to produce high-quality sugar beets. However, many other nutrients also play a role in plant growth. It is important to understand how the availability of other major nutrients such as phosphorus may be impacted by varying levels of nitrogen.

Research Objective

- Provide phosphorus and nitrogen fertilizer guidelines for sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area.

Methodology

These trials were conducted as a 3 x 5 factorial with four replications from 2023-2025 in fields near Renville, Minnesota. Soil samples were taken in the fall prior to treatment application (Table 1). The applied nitrogen fertilizer rates were 0, 45, and 115lbs N/A in 2024 and 2025. In 2023 the applied nitrogen rate was 0, 70, and 140lbs N/A as that site had a lower soil residual. The phosphorus fertilizer rates were 0, 15, 30, 45, and 60lbs P_2O_5/A. The phosphorus and nitrogen treatments were applied broadcast in the spring and incorporated using a small field cultivator. The nitrogen source was urea (46-0-0), and the phosphorus source was triple super phosphate (0-46-0). Standard practices were used to keep the site weed and disease free. The center two rows of each six-row plot were harvested using a six-row defoliator and a two-row research harvester. The beets harvested from the center two rows were weighed on the harvester and two samples of those beets were used for a quality analysis at the SMBSC tare lab. The data was analyzed for significance using SAS GLM version 9.4. In 2024 and 2025 a starter fertilizer treatment of a mix of 3 gal 6-24-6 plus 3 gal of water applied at a rate of 6 gal/A was added to compare against the broadcast P_2O_5. Three gallons of 6-24-6/A delivers 2 lbs N/A, 8 lbs P_2O_5 /A, and 2 lbs K_2O /A.

Table 1. Soil test results and important dates for all three trial locations.

	2023	2024	2025
Fall Soil nitrate-N 0-4 ft. (lb N/A)	33	55	85
Spring Soil nitrate-N 0-4 ft. (lb N/A)	62	67	76
Olsen P 0-6 in. (ppm)	3	4	5
K 0-6 in. (ppm)	224	136	128
pH 0-6 in. (unitless)	8.0	8.1	7.7
Organic matter 0-6 in. (%)	5.3	5.8	4.9
Previous Crop	Soybean	Soybean	Field Corn
Planting Date	May 4th	April 23rd	April 30th
Harvest Date	September 18th	October 3rd	September 25th

Results

The application of phosphorus and nitrogen did not have an interaction on yield or quality. The application of phosphorus did not impact any quality parameters and only increased yield with the first rate of additional P_2O_5 (Tables 5, 6, and 7). The use of starter (3 gal/A of 6-24-6) alone had similar root yield to all other phosphorus treatments at the same nitrogen rate (Tables 8 and 9). The application of nitrogen had a negative impact on quality in 2023 and 2025 but no impact in 2024 (Tables 2, 3, and 4). The yield response to nitrogen was linear in 2024 but plateaued in 2023 and 2025 after 100 and 130lbs/A of total nitrogen (soil test plus fertilizer N) respectively.

Conclusions

Phosphorus having a significant impact on root yield was not surprising as the soil sample results indicated very low soil test levels of phosphorus (Table 1). What was surprising was that increasing the rate of phosphorus only improved root yield up to 15 – 30lbs of additional phosphate/A with no further increase in root yield after those rates (Table 5, 6, and 7). The response to additional nitrogen over the control was expected and consistent with previous studies when conducted on sites with low residual nitrogen (Tables 2, 3, and 4). After sufficiency levels were met there does not appear to be any benefit to increasing the rate of phosphorus if the rate of nitrogen is increased. However, if the phosphorus needs are not met, root yield will be reduced even with high levels of nitrogen. These trials stress the importance of soil sampling and understanding the underlying nutrient levels of a field prior to planting.

Figure 1. Drone images from 2023 trial on June 15th and July 20th showing reduced foliage in plots that were deficient in phosphorus, nitrogen, or both.

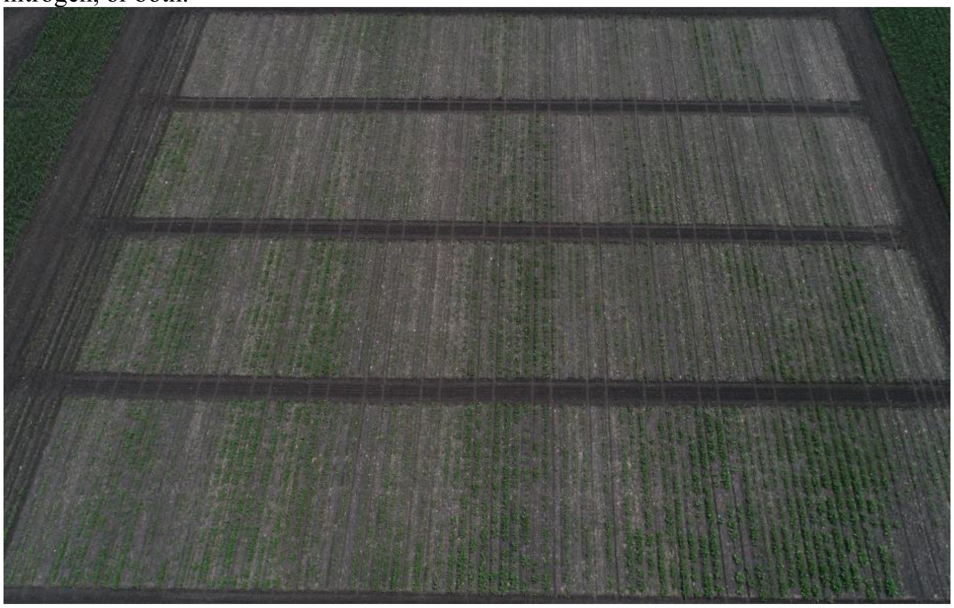

Figure 2. Drone image from the 2024 trial on June 13th showing reduced foliage in plots that were deficient in phosphorus, nitrogen, or both.

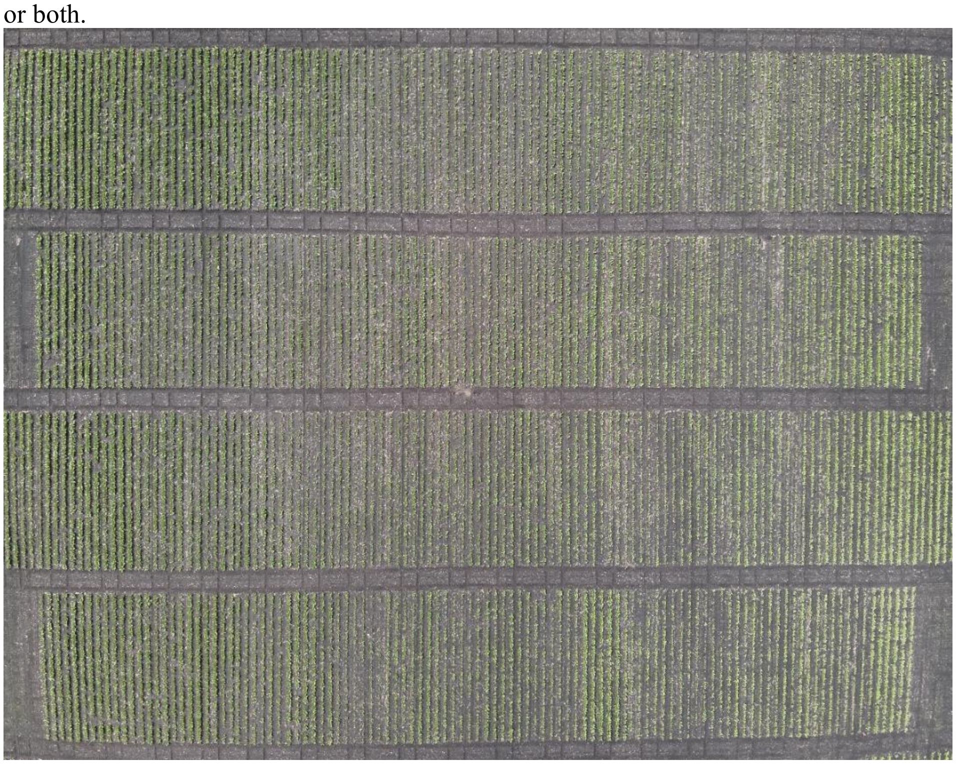

Figure 3. Drone image from the 2025 trial on July 16th showing reduced foliage in plots that were deficient in phosphorus, nitrogen, or both.

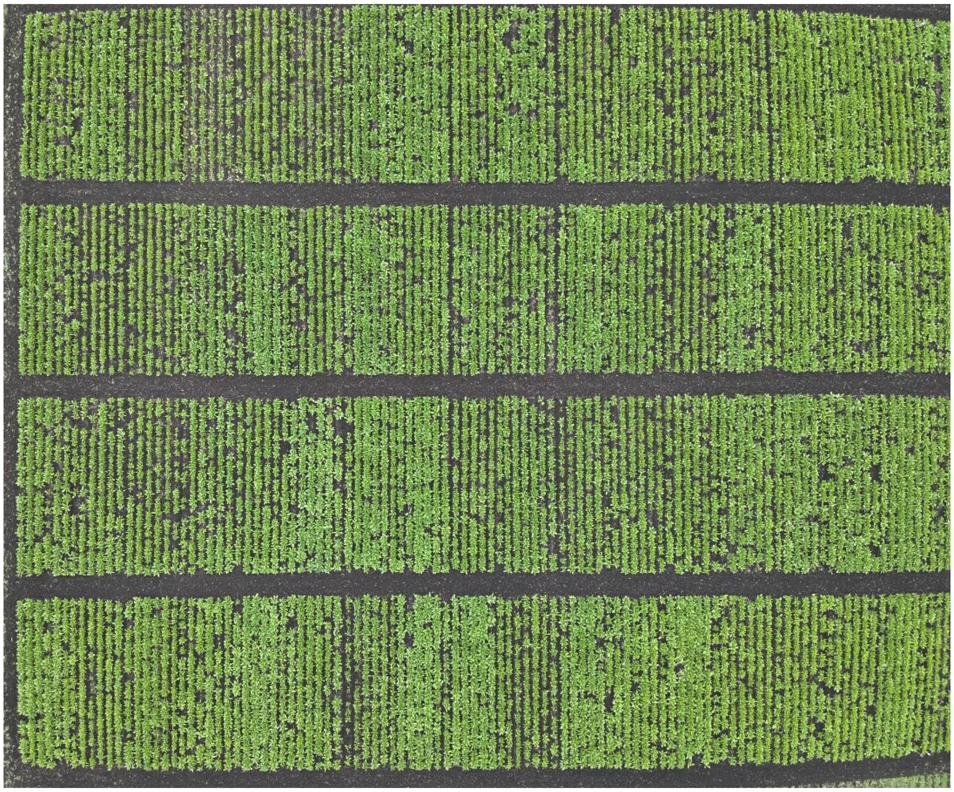

Table 2. 2023 The effect of fertilizer N on yield and quality averaged across P_2O_5 rates.

N Rate (lbs per acre)	Total N (lbs per acre)	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
0	33	17.2 a	28.0 b	14.4 a	288.8 a	8101.9 b	90.1
70	102	17.2 a	32.1 a	14.4 a	288.1 a	9269.8 a	89.9
140	173	16.9 b	31.7 a	14.1 b	283.0 b	8976.7 a	90.0
	Mean	17.1	30.6	14.3	286.6	8782.8	90.0
	CV%	1.7	10.6	1.7	1.7	11.0	0.4
	Pr>F	0.0011	0.0004	0.0008	0.0008	0.0012	0.2451
	lsd (0.05)	0.18	2.07	0.16	3.11	614.40	ns

Table 3. 2024 The effect of fertilizer N on yield and quality averaged across P2O5 rates.

N Rate (lbs per acre)	Total N (lbs per acre)	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
0	55	17.5	31.4 c	14.9	298.0	9343.3 c	90.9
45	100	17.5	35.5 b	14.8	296.3	10518.1 b	90.8
115	170	17.4	37.6 a	14.8	295.0	11081.5 a	90.6
	Mean	17.5	34.8	14.8	296.4	10314.3	90.8
	CV%	1.5	6.8	1.8	1.8	6.1	0.6
	Pr>F	0.5429	<.0001	0.2402	0.2216	<.0001	0.121
	lsd (0.05)	ns	1.5	ns	ns	403.8	ns

Table 4. 2025 The effect of fertilizer N on yield and quality averaged across P2O5 rates.

N Rate (lbs per acre)	Total N (lbs per acre)	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
0	85	15.1 a	26.7 b	12.9 a	258.6 a	6906.1 b	92.0
45	130	15.3 a	29.3 a	12.9 a	259.2 a	7589.9 a	91.5
115	200	14.9 b	30.9 a	12.7 b	254.5 b	7871.7 a	91.8
	Mean	15.1	29.0	12.9	257.4	7455.9	91.8
	CV%	1.8	9.3	1.9	1.9	9.3	1.5
	Pr>F	0.0014	<.0001	0.0105	0.0071	0.0002	0.527
	lsd (0.05)	0.17	1.7	0.15	3.1	442.9	ns

Table 5. The 2023 effect of increasing P_2O_5 rates on yield and quality averaged across nitrogen rates.

P2O5 Rate (lbs per acre)	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
0	17.0	24.8 c	14.2	284.5	7070.8 c	90.1
15	17.1	28.9 b	14.3	286.2	8295.0 b	89.8
30	17.1	32.6 a	14.3	286.5	9344.0 a	90.1
45	17.1	33.6 a	14.3	286.8	9637.1 a	90.1
60	17.3	33.1 a	14.5	289.1	9567.1 a	89.9
Mean	17.1	30.6	14.3	286.6	8782.8	90.0
CV%	1.7	10.6	1.7	1.7	11.0	0.4
Pr>F	0.1689	<.0001	0.2578	0.2578	<.0001	0.182
lsd (0.05)	ns	2.68	ns	ns	793.21	ns

Table 6. The 2024 effect of increasing P_2O_5 rates on yield and quality averaged across nitrogen rates.

P2O5 Rate (lbs per acre)	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
0	17.5	32.7 b	14.8	296.7	9675.6 b	90.6
15	17.6	35.3 a	14.9	298.8	10543.2 a	90.7
30	17.4	35.4 a	14.8	295.1	10444.9 a	90.7
45	17.4	35.1 a	14.8	295.8	10375.2 a	90.8
60	17.4	35.6 a	14.8	295.7	10532.5 a	90.9
Mean	17.5	34.8	14.8	296.4	10314.3	90.8
CV%	1.5	6.8	1.8	1.8	6.1	0.6
Pr>F	0.1945	0.0210	0.5976	0.4977	0.0081	0.4811
lsd (0.05)	ns	1.9	ns	ns	521.3	ns

Table 7. The 2025 effect of increasing P_2O_5 rates on yield and quality averaged across nitrogen rates.

P2O5 Rate (lbs per acre)	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
0	15.1	26.6 b	12.9	258.4	6860.5 b	92.0
15	15.1	28.6 ab	12.9	257.1	7363.5 ab	91.8
30	15.2	29.5 a	12.8	256.0	7557.4 a	91.1
45	15.0	29.7 a	12.8	256.5	7617.2 a	92.0
60	15.2	30.5 a	13.0	259.2	7881.0 a	92.0
Mean	15.1	29.0	12.9	257.4	7455.9	91.8
CV%	1.8	9.3	1.9	1.9	9.3	1.5
Pr>F	0.4866	0.0114	0.4414	0.4775	0.0128	0.4391
lsd (0.05)	ns	2.2	ns	ns	571.8	ns

Table 8. The effect of increasing rates of phosphorus and nitrogen analyzed as an RCBD with the addition of a starter fertilizer treatment of 3 gal 6-24-6 mixed with 3 gal of water/A in 2024.

Entry	N Rate (lbs per acre)	P2O5 Rate (lbs per acre)	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	0	0	17.7	28.9 i	15.0	299.3	8641.8 h	90.7
2	0	15	17.7	33.0 efgh	15.0	300.8	9930.0 efg	90.8
3	0	30	17.5	32.7 fgh	14.9	297.9	9729.9 fg	91.0
4	0	45	17.5	30.8 hi	14.9	298.6	9195.1 gh	91.1
5	0	60	17.3	31.5 ghi	14.7	293.3	9219.6 gh	91.1
6	45	0	17.5	35.0 cdef	14.8	295.4	10332.7 cdef	90.7
7	45	15	17.6	34.1 defg	15.0	299.5	10210.1 cdef	90.9
8	45	30	17.4	35.7 bcdef	14.8	295.0	10535.9 bcdef	90.7
9	45	45	17.3	36.6 abcd	14.6	292.6	10687.3 abcde	90.7
10	45	60	17.6	36.2 abcde	15.0	298.8	10824.6 abcd	90.9
11	115	0	17.5	34.1 defgh	14.8	295.3	10052.3 defg	90.5
12	115	15	17.5	38.9 ab	14.8	296.0	11489.5 a	90.5
13	115	30	17.4	37.9 abc	14.7	292.4	11069.0 abc	90.4
14	115	45	17.5	38.0 abc	14.8	296.3	11243.2 ab	90.7
15	115	60	17.4	39.2 a	14.8	294.9	11553.4 a	90.9
16	45	Starter	17.8	35.7 bcdef	15.1	301.9	10779.1 abcde	90.7
		Mean	17.5	34.9	14.8	296.8	10343.3	90.8
		CV%	1.4	6.6	1.7	1.8	6.0	0.5
		Pr>F	0.1581	<.0001	0.2722	0.285	<.0001	0.7932
		lsd (0.05)	ns	3.3	ns	ns	883.6	ns

Table 9. The effect of increasing rates of phosphorus and nitrogen analyzed as an RCBD with the addition of a starter fertilizer treatment of 3 gal 6-24-6 mixed with 3 gal of water/A in 2025.

Entry	N Rate (lbs per acre)	P2O5 Rate (lbs per acre)	Sugar	Tons per Acre	Percent Extractable Sugar	Extractable Sugar per Ton (lbs.)	Extractable Sugar per Acre (lbs.)	Percent Purity
1	0	0	15.2	25.5 f	13.0 abcd	259.1 abcde	6609.7 f	92.0
2	0	15	15.1	26.6 ef	12.9 abcde	257.5 abcdef	6851.9 ef	91.9
3	0	30	15.2	27.2 def	12.9 abcde	258.4 abcdef	7024.0 def	91.8
4	0	45	15.0	26.8 ef	12.9 abcde	257.0 bcdef	6885.2 ef	92.1
5	0	60	15.3	27.4 def	13.1 ab	261.1 abc	7160.0 cdef	92.1
6	45	0	15.3	26.4 ef	13.1 a	261.7 ab	6896.6 ef	92.0
7	45	15	15.2	29.6 bcde	13.0 abc	260.2 abcd	7687.3 abcde	92.0
8	45	30	15.4	29.7 bcde	12.6 e	251.4 f	7467.7 bcdef	89.5
9	45	45	15.2	30.9 abcd	12.9 abcde	258.5 abcdef	8000.9 abc	91.8
10	45	60	15.4	29.9 bcde	13.2 a	264.3 a	7897.3 abcd	92.2
11	115	0	14.9	27.8 cdef	12.7 bcde	254.3 cdef	7075.3 cdef	91.9
12	115	15	14.9	29.8 bcde	12.7 dce	253.6 def	7551.2 bcdef	91.4
13	115	30	15.1	31.7 ab	12.9 abcd	258.4 abcdef	8180.6 ab	91.9
14	115	45	14.9	31.4 abc	12.7 bcde	254.0 cdef	7965.7 abcd	92.0
15	115	60	14.8	34.1 a	12.6 de	252.2 ef	8585.6 a	91.7
16	45	Starter	15.2	28.3 bcdef	13.1 ab	260.7 abcd	7369.9 bcdef	92.2
		Mean	15.1	28.9	12.9	257.6	7450.5	91.8
		CV%	1.9	9.0	2.0	2.0	9.1	1.5
		Pr>F	0.1901	0.0014	0.0298	0.0284	0.0043	0.5368
		lsd (0.05)	ns	3.7	0.36	7.2	965.7	ns

Split Nitrogen Applications in Southern Minnesota 2019 – non-irrigated heavy textured soils.

John A. Lamb and David Mettler

Introduction and Objective:

Producing sucrose in Minnesota requires growers to optimize their N application for increasing root yield with the decreasing effect of N application on sucrose concentration and purity. The optimum N rate has been the topic of many research studies with the N fertilizer being applied pre-plant. There has been interest in splitting the N application between pre-plant and sometime during the growing season to "spoon feed" the sugar beet root for optimum root yield while not having the negative effects on sucrose concentration and purity. The objective of this study is to determine if split applications of N fertilizer can improve root yield without decreasing root quality. The sub-objectives were a. to conduct an N rate study to supply more information for the N fertilizer recommendations and it will also determine if the site is responsive to N application and b. to determine if a split N application is superior to a pre-plant or an in-season application.

Methods and Materials:

To meet the objectives, a study was conducted during the 2019 growing season at two locations within the Southern Minnesota Beet Sugar Cooperative growing area. The initial soil test values are reported in Table 1. Ten treatments, Table 2 and Table 3, were established at each site. Treatments 1 through 6 were used to determine the response to N application while treatments 3, 4, 7, 8, 9, and 10 were used to compare N application timing responses. The experiment was a randomize complete block design with four replications. The plots were six – 22 inch rows wide and 35 ft. long. The pre-plant N applications were broadcast treatments of urea. The urea was incorporated immediately after application. The in-season N applications were injected between the sugar beet plant rows as liquid urea ammonium nitrate solution. The Redwood Falls location was planted on May 16, 2019 to Crystal M623 and the in-season N application occurred on June 19, 2019. This site was harvested on September 19, 2019. The Murdock location was planted on May 31, 2019 to Crystal M623. The in-season application was applied on June 25, 2019. Harvest occurred on October 8, 2019. The previous crops were corn and soybean at Redwood Falls and Murdock, respectively.

Table 1. Soil test information for 2019 In-season N locations.

Soil test and depth	Redwood Falls	Murdock
Nitrate-N (lb/A) 0-48 inches	43	46
Olsen P (ppm) 0-6 inches	5	8
Soil test K (ppm) 0-6 inches	177	208
pH (unitless) 0-6 inches	7.7	7.9
Organic matter (%) 0-6 inches	4.1	5.7

Table 2. Treatments for N application study at Redwood Falls site, 2019.

Treatment number	Total N applied (ST* + Fertilizer)	Preplant*	Split
	-------------------- lb N/acre --------------------		
1	43	0	0
2	63	ST+20	0
3	93	ST+50	0
4	123	ST+80	0
5	153	ST+110	0
6	183	ST+140	0
7	93	25	25
8	123	40	40
9	93	0	50
10	123	0	80

*ST = Soil test nitrate-N to a depth of four feet.
The treatments were based on the nitrate-N soil test taken to a depth of 4 feet. The soil test was 43 lb N/A in the 0-4 ft depth. Previous crop was corn.

Table 3. Treatments for N application study at Murdock site, 2019.

Treatment number	Total N applied (ST* + Fertilizer)	Preplant*	Split
	-------------------- lb N/acre --------------------		
1	46	0	0
2	66	ST+20	0
3	96	ST+50	0
4	126	ST+80	0
5	156	ST+110	0
6	186	ST+140	0
7	96	25	25
8	126	40	40
9	96	0	50
10	126	0	80

*ST = Soil test nitrate-N to a depth of four feet.
The treatments were based on the nitrate-N soil test taken to a depth of 4 feet. The soil test was 46 lb N/A in the 0-4 ft depth. Previous crop was soybean.

Results and Discussion:

This study was analyzed as a randomized complete block design. With this analysis, the response to pre-plant N application and the effect of different methods of application. These sites were planted about 2 to 3 weeks apart because of the wet soils. The Redwood Falls site was planted earlier but had wet soils during much of the growing season. The Redwood Falls site while planted earlier yielded less tonnage and quality than the Murdock site.

Nitrogen fertilizer response:

Stand: Sugar beet stand was measured after emergence on the center two rows of each plots, Table 4 and 5. This measurement included 20 foot of row. At both locations, the stand was reduced by the increased application of fertilizer N (Urea), Figure 1. This was a concern because of the effect the stand could have on root yield and extractable sucrose per acre. An analysis on all of the measured parameters was conducted using stand as a covariable. In this analysis, stand did not significantly affect any of the measured parameters.

Of the measured parameters, nitrogen fertilizer application affected root yield, sucrose, extractable sucrose per ton, and extractable sucrose per acre at both locations, Table 4 and 5. Root purity was not affected by N application.

Root yield: Root yield was affected by N application at both sites in 2019, Figure 2. At the Redwood Falls site the root yield response was quadratic with the maximum root yield occurring at soil test nitrate-N to 4 feet plus fertilizer of 123 lb N/A, Figure 2. At the Murdock the response of root yield to N application was negative, with root yield being reduced by N application, Figure 2.

Sucrose concentration: Sucrose was affected by N application at both locations, Tables 4 and 5. The response at the Redwood Falls site was quadratic. The application of N up to soil test plus fertilizer of 99 lb N/A increased sucrose percentage, Figure 3. After reaching 99 lb N/A the sucrose concentration was reduced. At the Murdock site, the addition of fertilizer N reduced the sucrose concentration 1.4 %.

Extractable sucrose per ton: Extractable sucrose per ton was affected by N application similar to sucrose concentration, Table 4 and 5. The N response was quadratic at the Redwood Falls site with a maximum extractable sucrose at the 95 lb N/A, soil test plus fertilizer applied, Figure 4. The extractable sucrose per ton was decreased 28 lb /ton at the Murdock site with the addition of N fertilizer.

Extractable sucrose per acre: Similar to root yield, the application of N fertilizer affected the amount of extractable sucrose per acre at each site, Table 4 and 5. The Murdock site yielded a greater amount of extractable sucrose per acre compared to the Redwood Falls site. The extractable sucrose per acre at the Redwood Falls site was increased up to the soil test plus fertilizer amount of 121 lb N/A and then the amount of extractable sucrose decreased, Figure 5. At the Murdock site, extractable sucrose was reduced 1100 lb/A with the application of N.

Table 4. Sugar beet stand, root yield, sucrose, purity, extractable sucrose per ton, and extractable sucrose per acre for all treatments in 2019 at the Redwood Falls site, LSMEANS.

N rate (lb N/A)		Total N*	Stand	Root yield	Sucrose	Purity	Extractable sucrose	
Pre-plant	In-season	lb N/A	plants/20 ft. of row	ton/A	%	%	lb/ton	lb/A
0	0	43	41.3	19.3	15.2	91.0	257	4956
20	0	63	41.3	21.1	15.5	92.5	267	5612
50	0	93	39.8	22.3	15.8	93.6	277	6192
80	0	123	39.5	22.9	15.3	91.0	259	5929
110	0	153	34.3	22.8	15.1	90.3	252	5736
140	0	183	35.0	21.7	15.1	91.6	257	5575
25	25	93	38.8	20.7	15.2	90.8	255	5358
40	40	123	39.0	22.4	15.6	90.1	260	5800
0	50	93	42.3	19.9	15.6	92.6	270	5376
0	80	123	42.8	22.8	15.6	92.1	268	6109
Grand mean			39.4	21.6	15.4	91.6	262	5669
				Statistical Analysis				
Treatment			0.003	0.002	0.02	0.20	0.05	0.006
N linear			0.0002	0.003	0.09	0.42	0.16	0.07
N quadratic			0.41	0.003	0.02	0.35	0.05	0.0005
Check vs Split trts			0.57	0.001	0.07	0.50	0.16	0.0006
C.V. (%)			7.4	5.9	2.0	2.0	3.9	7.0

*Total N is the amount of nitrate-N in soil to four feet plus fertilizer applied.

Table 5. Sugar beet stand, root yield, sucrose, purity, extractable sucrose per ton, and extractable sucrose per acre for all treatments in 2019 at the Murdock site, LSMEANS.

N rate (lb N/A)		Total N*	Stand	Root yield	Sucrose	Purity	Extractable sucrose	
Pre-plant	In-season	lb N/A	plants/20 ft of row	ton/A	%	%	lb/ton	lb/A
0	0	46	37.8	24.3	16.3	91.7	279	6689
20	0	66	40.3	24.7	16.8	92.4	290	7139
50	0	96	38.3	26.7	16.3	91.7	278	7461
80	0	126	29.0	22.8	15.4	91.4	261	6008
110	0	156	27.3	22.2	15.1	90.7	254	5655
140	0	186	29.3	23.6	15.5	91.3	264	6154
25	25	96	39.8	24.1	16.4	92.2	283	6814
40	40	126	34.3	25.2	16.3	91.9	279	7007
0	50	96	40.5	25.1	16.5	91.9	284	7298
0	80	126	39.5	25.4	15.8	91.8	270	6637
Grand mean			35.6	24.3	16.0	91.7	274	6654
				Statistical Analysis				
Treatment			0.001	0.16	0.0008	0.32	0.0008	0.005
N rate linear			0.0001	0.07	0.0002	0.09	0.0003	0.004
N rate quadratic			0.95	0.56	0.73	0.92	0.76	0.41
Check vs split trt			0.75	0.60	0.46	0.79	0.58	0.61
C.V. (%)			13.7	7.8	2.9	1.0	3.7	8.2

*Total N is the amount of nitrate-N in soil to four feet plus fertilizer applied.

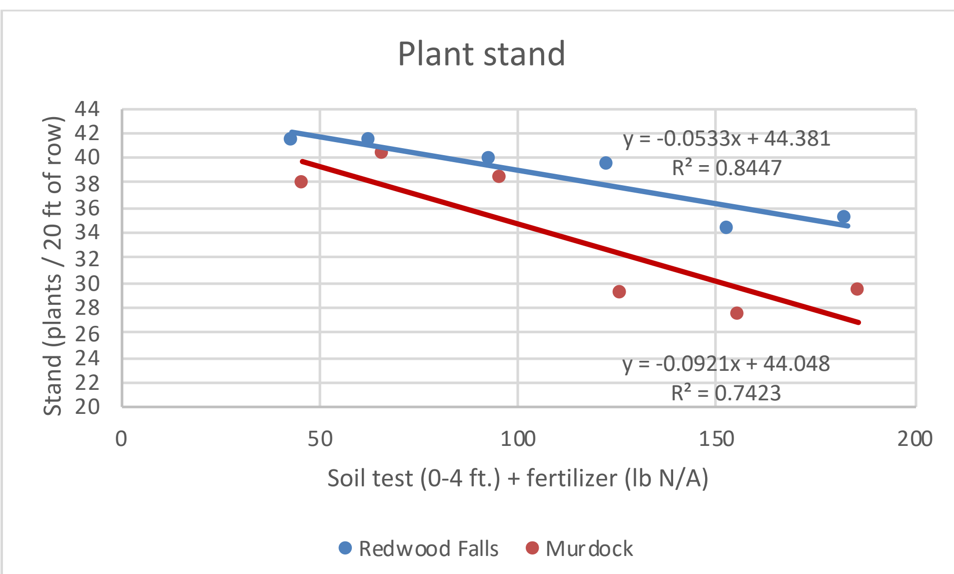

Figure 1. The effect of N fertilizer application on plant stand at Redwood Falls and Murdock sites, 2019.

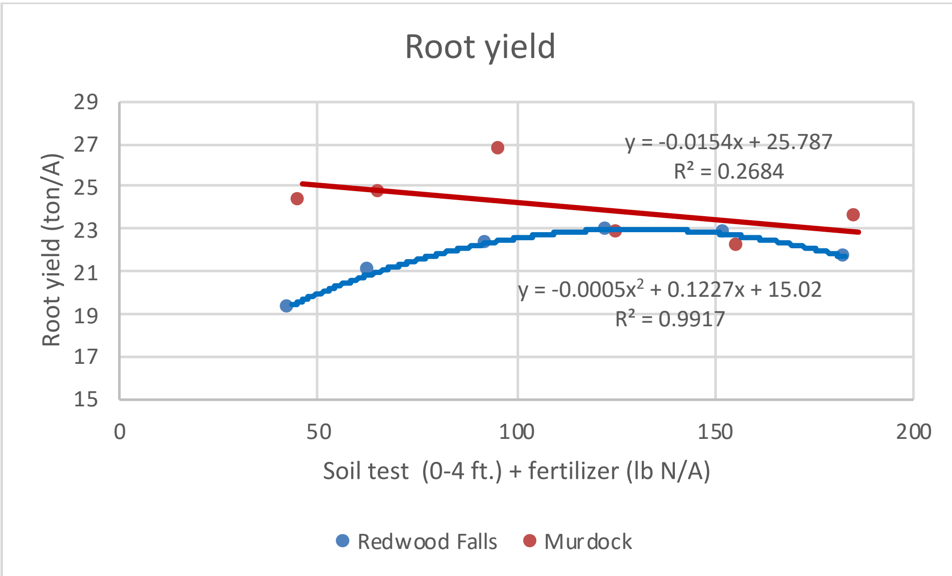

Figure 2. The effect of N fertilizer application on root yield at Redwood Falls and Murdock sites, 2019.

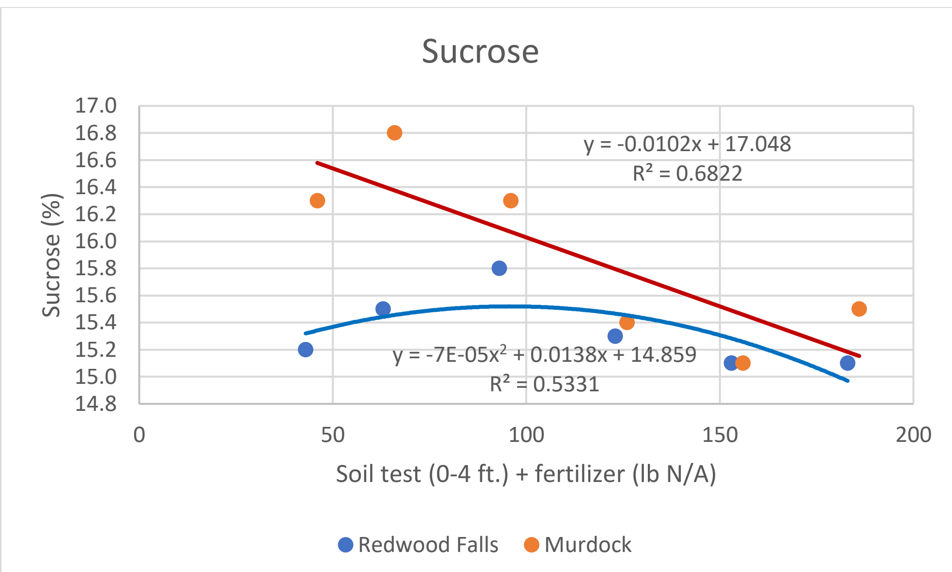

Figure 3. The effect of N fertilizer application on sucrose concentration at Redwood Falls and Murdock sites, 2019.

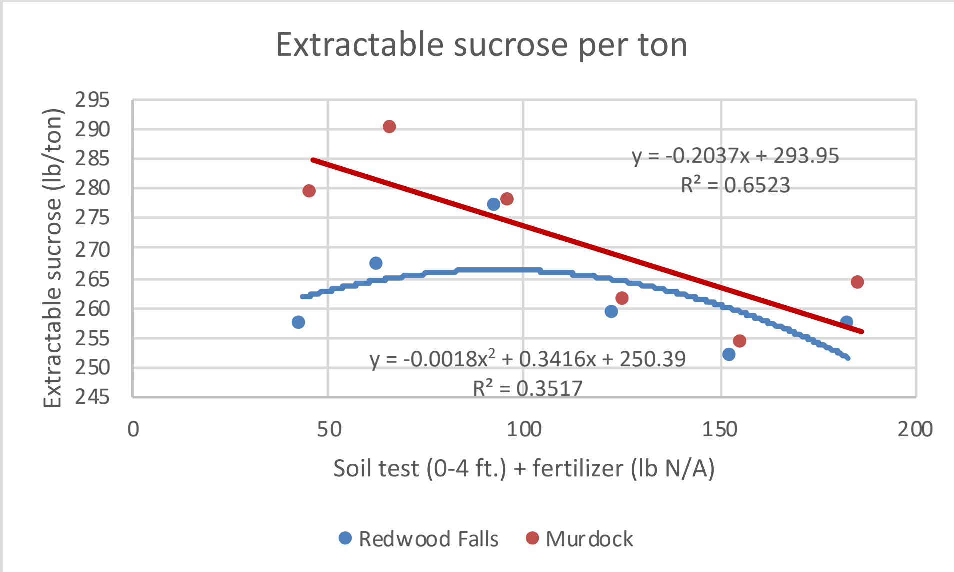

Figure 4. The effect of N fertilizer application on extractable sucrose per ton at Redwood Falls and Murdock sites, 2019.

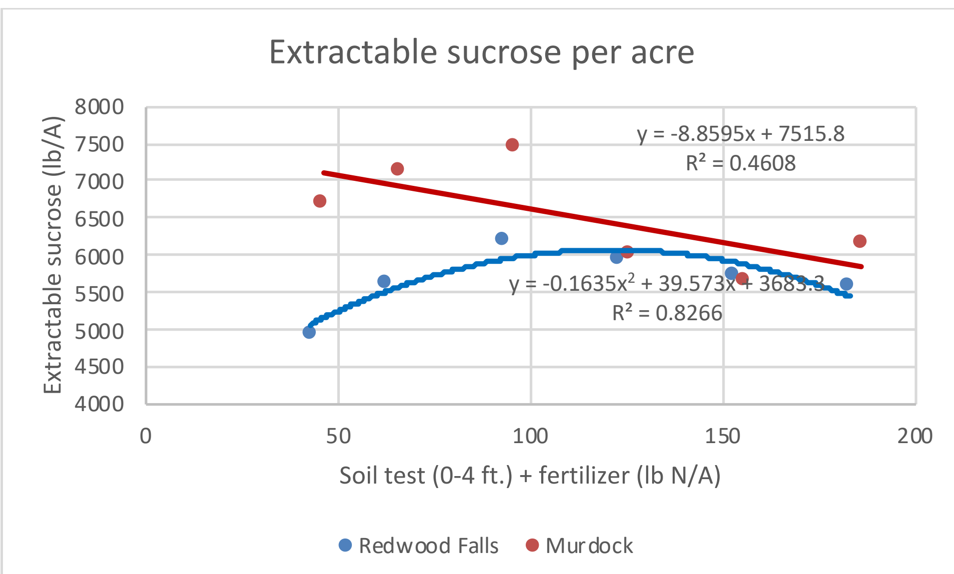

Figure 5. The effect of N fertilizer application on extractable sucrose per acre at Redwood Falls and Murdock sites, 2019.

Nitrogen fertilizer and timing:

Three different application methods and timing at two N fertilizer rates were applied in 2019. The treatments were N application at pre-plant, at side-dressing and half the N applied at pre-plant and half at side-dressing. The N rates used were 50 and 80 lb N/A. These treatments only affected root yield, sucrose concentration, and extractable sucrose per acre at the Redwood Falls site in 2019. There were no significant differences for the parameters measured at the Murdock site. This was because the responses to N fertilizer were negative at the Murdock site.

At the Redwood Falls site, root yield was increased for the sugar beet treated with the different method and timing of N fertilizer compared to the root yield for the no N check treatment, Table 6. For root yield, only the increase in N rate from 50 to 80 lb N/A was responsive. The timing did not affect root yield. For sucrose concentration there was an interaction between N rate and the timing method, Figure 6.

Sucrose concentration was affected by the treatment in an interaction between N rate and Timing/Method, Table 6. Increasing N application rate from 50 to 80 lb N/A at pre-plant reduced sucrose concentration, Figure 7. All the N applied at either 50 or 80 lb/A at side-dress did not affect sucrose concentration while if the N was applied half at pre-plant and half at side-dress (split), the sucrose concentration was increased. The greatest sucrose concentration occurred with 50 lb N/A (96 lb N/A soil test plus fertilizer) applied at pre-plant.

Extractable sucrose was also affected by the N rate by Timing/Method interaction, Table 6. The interaction is presented in Figure 8. Nitrogen applied at pre-plant decreased extractable sucrose per acre when the N rate increased from 50 to 80 lb N/A. At the side-dress and split times of N application, the increase of N fertilizer from 50 to 80 lb N/A increased extractable sucrose per acre. The extractable sucrose per acre with all the N applied at 80 lb N/A at side-dress was similar to the extractable sucrose per acre for the pre-plant application at 50 lb N/A. There was no advantage to using a split application or side-dress N application compared to a pre-plant application. The pre-plant application resulted in a more efficient use of the N fertilizer.

Table 6. The effect of N application timing method on root yield, sucrose, and extractable sucrose per acre at Redwood Falls location 2019, LSMEANS.

N rate (lb N/A)		Total N*	Root yield	Sucrose	Extractable sucrose
Pre-plant	In-season	(lb N/A	ton/A	%	lb/A
0	0	43	19.3	15.2	4956
Rest			22.1	15.5	5820
50	0	93	22.3	15.8	6192
80	0	123	22.9	15.3	5929
25	25	93	20.7	15.2	5358
40	40	123	22.4	15.6	5800
0	50	93	19.9	15.6	5376
0	80	123	22.8	15.6	6109
			Statistical Analysis		
Check vs rest			0.001	0.07	0.0006
N rate			0.005	NS	0.1
Timing			0.20	NS	0.09
N rate * Method			0.21	0.05	0.06
C.V. (%)			5.9	2.0	7.0

*Total N is the amount of nitrate-N in soil to four feet plus fertilizer applied.

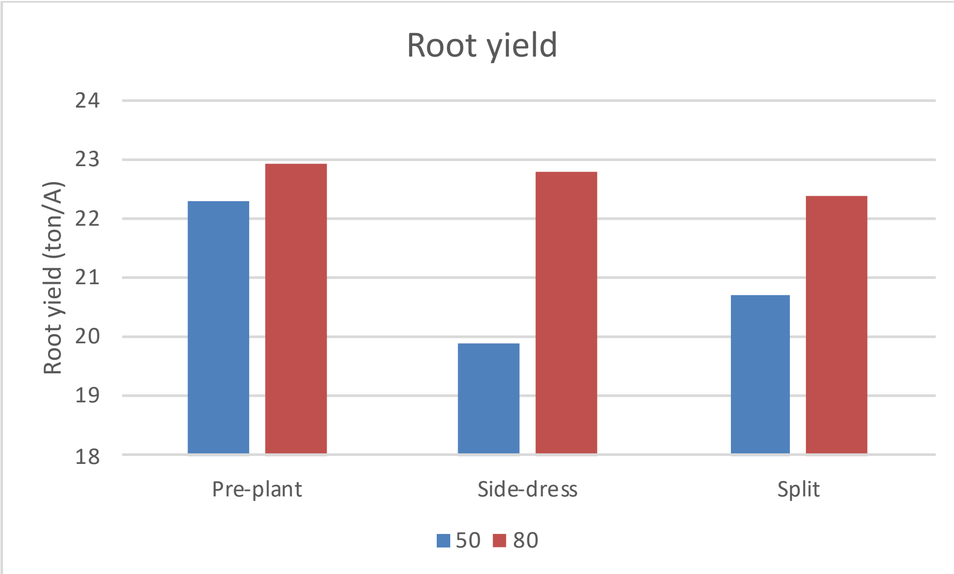

Figure 6. The effect of N application rate and timing/method on root yield at Redwood Falls site in 2019.

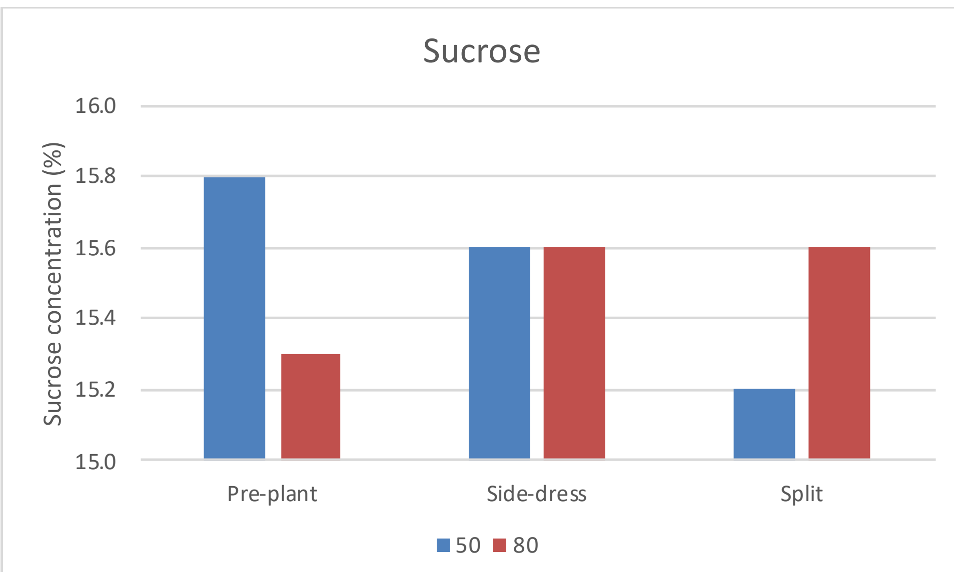

Figure 7. The effect of N application rate and timing/method on sucrose concentration at Redwood Falls site in 2019.

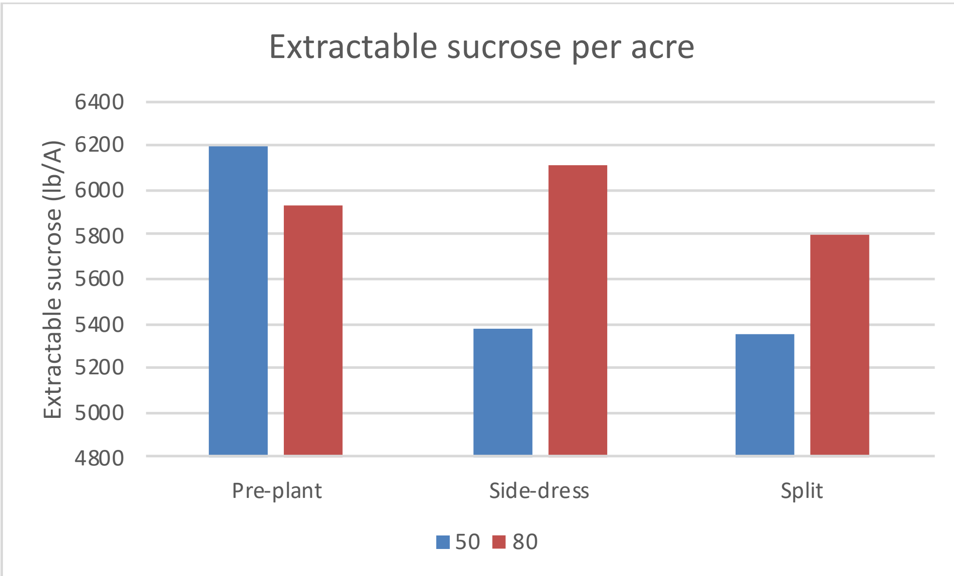

Figure 8. The effect of N application rate and timing/method on extractable sucrose per acre at Redwood Falls site in 2019.

Summary:

In 2019, weather conditions caused delayed planting and reduced production. The use of N fertilizer caused significant responses to root yield, sucrose concentration, extractable sucrose per ton, and extractable sucrose per acre. At the Redwood Falls site, the N response was quadratic with the optimum N application, soil test nitrate-N to 4 feet plus fertilizer was 123 and 121 lb N/A for root yield and extractable sucrose per acre. This site was planted in mid-May and was able to utilize some of the applied N. The Murdock location, planted at the end of May, responded negatively to N application for root yield, sucrose concentration, extractable sucrose per ton, and extractable sucrose per acre. The site had an initial soil test of 43 lb N/A in the surface 4 feet. The previous crop at Murdock was soybean. A N credit could also be possible. At that soil test level and if a soybean credit of 40 lb N/A acre was used, the response to N application could be small. Growing conditions were less than optimum because of the late planting date and the excessive moisture conditions during the growing season.

Use of different N application times/methods did affect root yield, sucrose concentration, and extractable sucrose per acre at the Redwood Falls site. In comparing pre-plant, side-dress, and split application method, the pre-plant time produced similar root yield to the other methods and was more efficient in using N fertilizer for extractable sucrose per acre.