NITRATE SOIL TEST ADJUSTMENT FOR SUGAR BEET GROWN IN HUMID AREAS OF MINNESOTA

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Concerns have been raised about the accuracy of the nitrate-N soil test in prediction of N needs in the Southern Beet Sugar Cooperative growing area. This sugar beet production area is located in a more humid area of Minnesota than the Red River Valley production areas. The extra precipitation changes the soil moisture dynamics and thus increases the chances of N losses to denitrification and also possibly an increase in the contribution of N from soil organic matter. Other logistical problems exist because of the more humid situation. Soil samples from the 2 to 4 foot depths are difficult to collect. Soil can be too wet to stay in the sampling tube when brought to the soil surface or too wet to get a recognizable and representative sample. This work is investigating the importance of deep nitrate soil sampling at different times in the production year in the prediction of the optimum N fertilizer rate for optimum root yield and quality.

Nitrogen management is paramount for optimum sugar production. Nitrogen sources for sugar beet include fertilizer N and organic matter. Factors that influence nitrogen availability are temperature, precipitation, and soil drainage. Of the factors mentioned, the rate of nitrogen fertilizer applied is the easiest input to management. This has been done through the use of a nitrate soil test.

The effect of previous crop on sugar beet yield and quality can be seen in cooperative statistics. There are many different crops in the Southern Minnesota Beet Sugar Cooperative growing area that have been used as previous crop. Little is known about the effect of previous crop on nitrogen fertilizer recommendations for sugar beet grown in this area. One observation has been that a fall nitrate-N soil test when the previous crop is soybean is not very useful because the soybean plant utilizes all the nitrate-N in the soil. The nitrogen in soybean residue mineralizes much quicker than other crops such as corn. This would make a case for the use of a spring or in-season soil test for prediction of N fertilizer needs. Environmental demands may require that no fall N fertilizer application may be made. This leads to the need to know the effect of spring applications of N verses fall application on sugar beet yield and quality.

Objectives:

1. Improve the ability to predict more accurately the nitrogen fertilizer needs for optimum sugar beet yield and quality in humid areas of Minnesota following several different crops.

2. Determine the effect of fall verses spring nitrogen fertilizer applications on sugar beet yield and quality.

Materials and Methods:

This was the third year of a multi-year/multi-site study. In the fall of 1999, six sites were established in the Southern Minnesota Beet Sugar Cooperative production area. Four of the sites were in the eastern growing area near Bird Island and Hector, Minnesota while the other two sites were near Gluek and Murdock, Minnesota in the western growing area. The preceding crop was

sweet corn at two of the eastern locations while corn was the previous crop at the remaining four sites. The treatments were four replications of factorial combination of fall and spring application at nitrogen rates of 0, 40, 80, 120, and 160 pounds per acre. Soil samples to a depth of four feet were taken from the 0 N rate plots for nitrate-N during the first week of November 1999 and the last week of April 2000. Sugar beet top samples were taken one or two days before root harvest. These were weighed, subsampled, dried, and analyzed for total nitrogen content. The harvest was done by a plot- sized lifter. Root samples for quality analyses were obtained at harvest and analyzed by the Southern Minnesota Beet Sugar Cooperative Quality Lab. Following harvest, soil samples for nitrate-N were taken from all plots to a depth of four depth.

Results and Discussion:

Growing season 2000 started with a dry planting season. Soil sampling to four feet was not a problem. Substantial rains occurred late May and continued until July. August and September were dry and sugar beet growth was slowed.

Fall and spring soil nitrate-N contents are presented in Table 1. At the Murdock and Gluek locations, soil nitrate-N in the 0 to 2 foot depth increased substantially from the fall to spring soil sampling dates while the nitrate-N contents in the 2 to 4 foot did not change. At Hector and Bird Island locations where the previous crop was corn, the nitrate-N values did not change much from the fall to spring sampling times. The soil nitrate-N in the 0 to 2 foot depth increased from the fall to spring sampling dates at the Hector and Bird Island locations which had sweet corn as a previous crop. The nitrate-N increase at Bird Island sweet corn also occurred in the 2 to 4 foot depth.

Table 1. Soil nitrate-N to 4 foot in early November 1999 and late April 2000 at six locations.

Location	Previous Crop	Soil Nitrate-N			
		Fall		Spring	
		0-2'	2-4'	0-2	2-4'
		lb N/A			
Murdock	corn	35	34	88	32
Gluek	corn	54	29	98	43
Hector	corn	53	50	62	42
Hector	sweet corn 72	69	100	65	
Bird Island	corn 64	62	72	61	
Bird Island	sweet corn 85	46	104	94	

The changes in nitrate-N between the fall and spring soil sampling dates are reflected in the fertilizer N recommendations listed in Table 2. These numbers were calculated using the current recommendations for Southern Minnesota Beet Sugar Cooperative growing area. At all locations, the recommendations were reduced from fall to spring. Large reductions occurred at the Gluek, Murdock, and Bird Island sweet corn locations. Small reductions occurred at Hector corn and Bird Island corn. The Hector sweet corn location was intermediate at 25 pounds N per acre.

Table 2. Soil test N recommendations for six locations using Fall and Spring soil nitrate-N information (150 - [(soil test N in 0 to 2 ft depth) + (0.8 X soil nitrate 2-4 ft depth-30)].

Location	Previous Crop	Recommendation	
		Fall	Spring
		lb N/A	

Murdock	corn		112		60
Gluek	corn		96		42
Hector	corn		81		78
Hector	sweet corn	47		22	
Bird Island	corn	60		53	
Bird Island	sweet corn	52		0	

The root yield and quality information for the Murdock location is listed in Table 3. Root yield was maximized with a fall application of 80 pound N per acre or a spring application of 40 pounds N per acre. Net sucrose, which the sucrose concentration minus the loss to molasses, recoverable sucrose per ton, and recoverable sucrose per acre were the greatest at 80 pounds N per acre. The soil test N recommendation was 112 pounds fertilizer N per acre from the fall soil test and 60 pounds N per acre based on the spring soil test.

Table 3. Sugar beet root yield, net sucrose concentration, recoverable sucrose per ton, and recoverable sucrose per acre for the Murdock location in 2000.

N Rate	Root Yield		Net Sucrose		Recoverable Sucrose			
	fall	spring	fall	spring	fall	spring	fall	spring
lb N/A	- - - ton/A - - -		- - - - % - - - -		- - - lb/ton - - -		- - - lb/A - - -	
0	19.7	21.2	15.2	15.0	305	301	6022	6381
40	22.2	22.2	15.1	15.2	303	304	6728	6765
80	22.7	22.2	15.6	15.8	313	316	7081	7030
120	21.9	22.0	14.4	14.9	288	297	6241	6029
160	21.8	20.3	14.3	14.9	287	297	6241	6029

Statistics

Time	NS	NS	NS	NS
N Rate	NS	.008	.008	.19
Linear	NS	.03	.03	NS
Quadratic	.06	.04	.04	.03
Time x N Rate	NS	NS	NS	NS

The root yield response data for the Gluek location is similar to the Murdock location, Table 4. Root yields were greatest with 80 pounds N per acre as a fall application and 40 pounds of fertilizer N per acre applied in the spring. The greatest net sucrose concentration occurred between the 0 and 40 pounds N per acre application and decreased recoverable sucrose per ton was similar to net sucrose. Recoverable sucrose per acre was greatest with a fall application of 80 pounds N per acre or 40 pounds N per acre from a spring application. The soil test N recommendation was 96 pounds fertilizer N per acre from the fall soil test and 42 pounds fertilizer N per acre from a spring soil test.

Root yield, net sucrose, recoverable sucrose per ton, and recoverable sucrose per acre at the two locations in the eastern growing area, Hector and Bird Island, which had corn as a previous crop either did not respond to N fertilizer application or the response was negative, Tables 5 and 6. The soil tests at these sites did not change significantly from the fall to spring sampling dates. At the Hector corn site the recommendation from the fall soil sample was 81 pounds N per acre and 78 pounds N per acre from the spring soil sample. The Bird Island location N recommendations were 60 pounds N per acre from the fall soil sample and 53 pounds N per acre for the spring soil test.

Table 4. Sugar beet root yield, net sucrose concentration, recoverable sucrose per ton, and recoverable sucrose per acre for the Gluek location in 2000.

N Rate	Root Yield		Net Sucrose		Recoverable Sucrose			
	fall	spring	fall	spring	fall	spring	fall	spring
lb N/A	- - - - ton/A - - - -		- - - - - % - - - - -		- - - - lb/ton - - - -		- - - - lb/A - - - -	
0	22.4	23.3	16.8	17.1	336	342	7512	7999
40	26.7	27.0	16.8	17.3	335	345	8952	9333
80	27.6	25.1	16.7	17.2	333	344	9184	8624
120	23.8	25.6	16.7	16.8	335	337	7968	8614
160	24.5	20.9	16.4	15.6	327	312	8028	6514

Statistics

Time	NS	NS	NS	NS

N Rate	.003	.03	.04	.0006
Linear	NS	.008	.01	.07
Quadratic	.0002	.06	.06	.0001
Time x N Rate	.12	NS	NS	.08

Table 5. Sugar beet root yield, net sucrose concentration, recoverable sucrose per ton, and recoverable sucrose per acre for the Hector corn location in 2000.

N Rate	Root Yield		Net Sucrose		Recoverable Sucrose			
	fall	spring	fall	spring	fall	spring	fall	spring
lb N/A	- - - ton/A - - -		- - - - % - - - -		- - - lb/ton - - -		- - - lb/A - - -	
0	22.4	22.9	16.8	16.8	334	336	7481	7673
40	21.2	23.1	16.8	16.7	336	334	7105	7724
80	21.1	21.3	16.6	16.9	332	338	6974	7222
120	20.5	22.0	16.6	16.2	232	325	6800	7153
160	19.4	21.5	16.1	16.2	222	324	6241	6938
Statistics								
Time	.11		NS		NS		.13	
N Rate	NS		.008		.008		.19	
Linear	.07		.03		.03		.03	
Quadratic	NS		.04		.04		NS	
Time x N Rate	NS		NS		NS		NS	

Table 6. Sugar beet root yield, net sucrose concentration, recoverable sucrose per ton, and recoverable sucrose per acre for the Bird Island corn location in 2000.

N Rate	Root Yield		Net Sucrose		Recoverable Sucrose			
	fall	spring	fall	spring	fall	spring	fall	spring
lb N/A	- - - - ton/A - - - -		- - - - - % - - - - -		- - - - b/ton - - - -		- - - - - lb/A - - - -	
0	27.5	27.8	16.3	16.7	326	335	8977	9296
40	27.7	30.2	16.7	16.5	334	331	9243	9998
80	27.0	27.8	16.2	16.2	323	325	8733	8994
120	30.1	27.9	15.7	16.3	314	226	9419	9082
160	28.8	28.4	15.8	15.3	317	306	9132	9664
Statistics								
Time	NS		NS		NS		NS	
N Rate	NS		.04		.03		.08	
Linear	NS		.003		.003		.19	
Quadratic	NS		.04		NS		NS	
Time x N Rate	.16		NS		NS		.19	

Root yield and recoverable sucrose per acre were the greatest at the 80 pound fertilizer N per acre application at the Hector sweet corn location, Table 7. Net sucrose and recoverable sucrose per ton were decreased with the application of N fertilizer. The N recommendations were 47 pounds per acre from the fall soil sample and 22 pounds per acre for the spring soil sample.

Table 7. Sugar beet root yield, net sucrose concentration, recoverable sucrose per ton, and recoverable sucrose per acre for the Hector sweet corn location in 2000.

N Rate	Root Yield		Net Sucrose		Recoverable Sucrose			
	fall	spring	fall	spring	fall	spring	fall	spring
lb N/A	ton/A		%		lb/ton		lb/A	
0	21.0	20.8	18.1	17.6	312	352	7599	7310
40	24.3	25.2	17.4	17.6	347	352	8429	8866
80	24.9	25.3	17.6	17.5	351	350	8744	8825
120	23.1	22.0	17.9	17.9	351	358	8117	7832
160	24.0	23.9	17.0	17.0	341	341	8143	8156
Statistics								
Time	NS		NS		NS		NS	
N Rate	.006		.09		.09		.01	
Linear	.14		.05		.05		NS	
Quadratic	.02		NS		NS		.008	
Time x N Rate	NS		NS		NS		NS	

At the Bird Island sweet corn site, root yield, net sucrose, recoverable sucrose per ton, and recoverable sucrose per acre were not significantly affected by N application, Table 8. The N recommendation based on the fall soil test was 52 pounds N per acre, while the N recommendation based on the spring soil test was 0 pounds N per acre.

Table 8. Sugar beet root yield, net sucrose concentration, recoverable sucrose per ton, and recoverable sucrose per acre for the Bird Island sweet corn location in 2000.

N Rate	Root Yield		Net Sucrose		Recoverable Sucrose			
	fall	spring	fall	spring	fall	spring	fall	spring
lb N/A	ton/A		%		lb/ton		lb/A	
0	28.0	27.4	15.0	15.7	299	314	8291	8602
40	27.0	29.0	15.9	15.9	317	317	8572	9238
80	29.3	28.3	15.3	15.7	305	314	8956	8915
120	29.0	26.3	16.8	15.5	335	310	9715	8193
160	29.2	27.3	15.5	15.6	310	312	9040	8511
Statistics								
Time	NS		NS		NS		NS	
N Rate	NS		NS		NS		NS	
Linear	NS		NS		NS		NS	
Quadratic	NS		NS		NS		NS	
Time x N Rate	NS		NS		NS		.12	

In summary, there were significant positive responses for recoverable sucrose per acre to N fertilization at three of the six locations. The N recommendation based on a fall soil nitrate test over predicted the N needs for optimum recoverable sucrose per acre in five of the six locations (Murdock, Gluek, Hector corn, Bird Island corn, and Bird Island sweet corn) in 2000. The other location (Hector sweet corn) was 30 pounds N per acre short. The N recommendation based on a spring soil nitrate test over predicted the N needs at two locations (Hector corn and Bird Island corn), under predicted at two locations (Murdock, and Hector sweet corn), and was correct at two locations (Gluek and Bird Island sweet corn). The under predictions were approximately 20 pounds N per acre at the Murdock location and 30 pounds N per acre at the Hector sweet corn location.