PREVIOUS CROP EFFECTS ON SUGARBEET RESPONSE TO NITROGEN FERTILIZER

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

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

Methods and Materials

Six sites have been established to achieve the objective of the study. These sites are located and established near Hector and Gluek in 2005, Buffalo Lake and Clara City in 2006, and New Auburn and Clara City in 2007. Each site was established a year before they were cropped to sugar beet. The site established near Gluek in 2005 was lost in 2006, the sugar beet year, to drought while the site near Clara City established in 2006 was lost in 2007, the sugar beet year, to disease. The Clara City and New Auburn sites established in 2007 were cropped to sugar beet in 2008. The results for the New Auburn site can not be reported because it was accidently planted to a Roundup tolerant sugar beet variety. In the initial set up year, four large replicated blocks (35 X 66 ft.) of corn, genetically modified corn (round up ready and Bt or BtRR corn), sweet corn, soybean, and spring wheat were grown. Each crop was fertilized according to U of MN guidelines. Deep soil samples for nitrate-N were taken late fall of the initial year to characterize the sites before being cropped to sugar beet. The large crop blocks were subdivided into 11 X 35 ft. subplots to accommodate six N rates (0, 30, 60, 90, 120, and 150 lb N per acre) that were applied late fall before the sugar beet crop was grown. In the second year, sugar beet was grown with root yield and quality measured.

During the sugar beet production at the Hector (2006) and Buffalo Lake (2007). sites, three replications of the previous crop treatments of the genetically modified corn and sweet corn and N rates of 0 and 90 pounds N per acre applied before sugar beet production were established to measure nitrogen mineralization during the season. At the Clara City (2008) the previous crops used for the measurement of N mineralization were conventional corn and sweet corn. This measurement involved the placement of 24 soil cores per plot that were encased in poly carbonate tube with a resin bag at a depth of 10 inches in the soil. The resin has the ability to trap soil ammonium and nitrate-N before it moves out of the soil core. The cores are placed in the sugar beet crop exposed to the same temperatures and moisture as the sugar beet crop. A four times during the growing season, initial, two times during the growing season, and at harvest, six cores are removed and analyzed for ammonium and nitrate-N. This gives an estimate of soil mineralization.

Results

Soil test results prior to sugar beet production:

The previous crops of spring wheat, sweet corn, conventional corn, BtRR corn, and soybean were fertilized according to University of Minnesota fertilizer recommendations. Soil nitrate-N to a depth of four feet was measured the fall before sugar beet production in each of the previous crops. The results are reported in Table 1. The residual soil nitrate-N at the Hector site, fall 2005, was on the average low at 31 pounds per acre. The residual soil nitrate-N was elevated for the soil when the previous crop was sweet corn or soybean. At the Buffalo Lake site, fall 2006, the residual soil nitrate-N was the least following spring wheat while the rest were very similar. The average residual soil nitrate-N for the Buffalo Lake site was 22 pounds per acre. The average residual nitrate-N at the Clara City site, fall 2007, was elevated to 95 pounds per acre. Where the previous crop was spring wheat, the residual soil nitrate-N was considerably less than the average, 59 pounds per acre, while the residual soil nitrate-N when the soybean was the previous crop, was greater than the average at 122 pounds per acre.

Table 1. The soil residual nitrate-N to a depth of four feet, as affected by the previous crop.

	Hector 2006	Buffalo Lake 2007	Clara City 2008
Previous crop	Soil residual nitrate-N to a depth of four feet, pounds per acre		
BtRR corn	25	18	94
Convention corn	21	33	100
Soybean	42	23	122
Sweet corn	41	31	99
Spring wheat	27	8	59
Site average	31	22	95

Sugar beet yield and quality:

In 2006, there was no previous crop by nitrogen rate interaction for any reported parameter, Table 2. The lack of an interaction means that nitrogen rate guidelines are not affected by the previous crop at this location. Root yield and extractable sucrose per acre were significantly affected by previous crop and nitrogen application rate, Table 3. Sugar beet grown after BtRR corn had the lowest root yield and extractable sucrose per acre, followed by corn. Sugar beet grown after soybean and sweet corn had similar root yield and extractable sucrose per acre while sugar beet grown after spring wheat had to largest. At this site the optimum root yield and extractable sucrose per acre were obtained at the 90 lb per acre nitrogen application, Table 4.

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

In 2006, there was no evidence to adjust nitrogen application rates for sugar beet because of previous crop.

Table 2. Statistical analysis for root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2006.

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

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

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

Table 4. The means for the effect of nitrogen fertilizer application on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2006.

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

In 2007, there was only one parameter with a N rate by previous crop interaction, extractable sucrose per acre, Table 5. Root yield was significantly affected by the previous crop and N rate. Root yields were affected with the least yield from the greatest root yield as follows: BtRR corn similar to corn < soybean < sweet corn < spring wheat, Table 6. Increasing N rate increased root yield up to 120 pounds N per acre, Table 7. The residual nitrate-N in 2007 was between 20 and 35 pounds nitrate-N per acre in the surface four feet.

Purity was decreased on the average by the application of nitrogen fertilizer, Tables 5 and 6. Previous crop did not affect purity in 2007, Tables 5 and 7. Extractable sucrose per ton of sugar beet refined integrates the sucrose concentration and the impurities in the sugar beet. Extractable sucrose per ton was not significantly affected by previous crop or N rate application, Table 5, 6, and 7.

Extractable sucrose per acre was affected by previous crop and N rate in 2007, Table 5. There was also an interaction between previous crop and N rate. The interaction is graphed in Figure 1. The main reason for the interaction is because of the response of extractable sucrose per acre to N rate application when soybean is the previous crop. In general, the extractable sucrose per acre increased with increasing N application in 2007. Extractable sucrose per acre was the least for sugar beet grown after BtRR corn and corn. Soybean was greater than the corn except at the 150 pound N per acre application. Sweet corn and spring wheat were the best.

In 2007, there was not evidence that N applications needed to be adjusted by previous crop.

Table 5. Statistical analysis for root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2007.

	Root yield	Purity	Extractable sucrose per ton	Extractable sucrose per acre
Previous crop	0.0011	NS	NS	0.02
N rate	0.0001	0.06	NS	0.0001
Previous crop X Nrate	NS	NS	NS	0.06
C.V. (%)	6.6	1.4	3.9	6.9

Table 6. The means for the effect of previous crop on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2007.

	Root yield	Purity	Extractable sucrose	
Previous crop	ton/A	%	lb/ton	lb/acre
BTRR corn	30.6	90.9	259	7927
Corn	30.7	90.5	256	7887
Soybean	33.7	89.7	254	8512
Sweet corn	34.6	89.8	252	8739
Spring wheat	35.2	90.4	259	9087

Table 7. The means for the effect of nitrogen fertilizer application on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2007.

N rate	Root yield	Purity	Extractable sucrose	
lb/A	ton/A	%	lb/ton	lb/acre
0	30.8	90.9	259	7967
30	31.3	89.9	254	7975
60	33.3	90.4	255	8431
90	33.0	89.8	255	8414
120	34.2	90.4	258	8833
150	34.5	90.2	255	8797

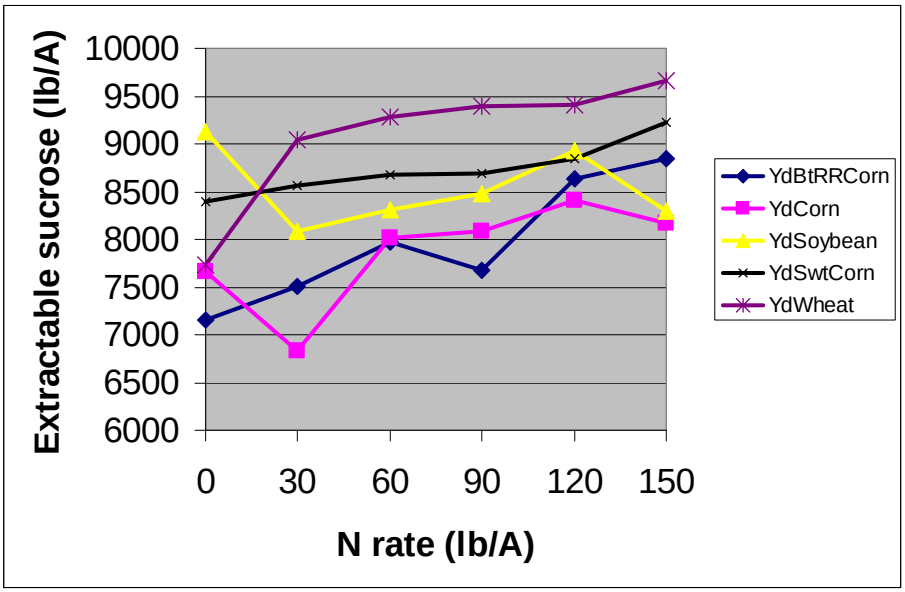

Figure 1. Extractable sucrose as affected by previous crop and N rate application in 2007.

In 2008, there were no differences in root yield, purity, and extractable sucrose cause by the previous crop or nitrogen rate, Tables 8, 9, and 10. These results were caused by the relatively high residual soil nitrate-N values , 95 pounds N per acre 0-4ft., in the fall of 2007 at this site.

Table 8. Statistical analysis for root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2008.

	Root yield	Purity	Extractable sucrose per ton	Extractable sucrose per acre
Previous crop	NS	NS	NS	NS
N rate	0.08	NS	NS	NS
Previous crop X Nrate	NS	NS	NS	NS
C.V. (%)	7.6	1.3	6.0	8.9

Table 9. The means for the effect of previous crop on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2008.

	Root yield	Purity	Extractable sucrose	
Previous crop	ton/A	%	lb/ton	lb/acre
BTRR corn	29.6	90.7	306	9058
Corn	30.2	90.4	301	9106
Soybean	29.1	90.5	310	9005
Sweet corn	30.8	90.3	300	9213
Spring wheat	30.1	90.4	305	9179

Table 10. The means for the effect of nitrogen fertilizer application on root yield, purity, extractable sucrose per ton, and extractable sucrose per acre in 2008.

N rate	Root yield	Purity	Extractable sucrose	
lb/A	ton/A	%	lb/ton	lb/acre
0	29.5	90.9	307	9052
30	29.9	90.3	300	8953
60	30.2	90.3	301	9109
90	30.7	90.3	307	9447
120	28.8	90.5	306	8817
150	30.6	90.5	304	9291

Soil nitrogen mineralization:

In-season nitrogen mineralization during sugar beet production was measured in 2006 and 2007 for the treatments with BtRR corn and sweet corn as previous crop at the 0 and 90 pounds N per acre applications and on conventional corn and sweet corn as previous crop at 0 and 90 pounds N per acre applications in 2008. The results for 2006 are presented in Figure 2.

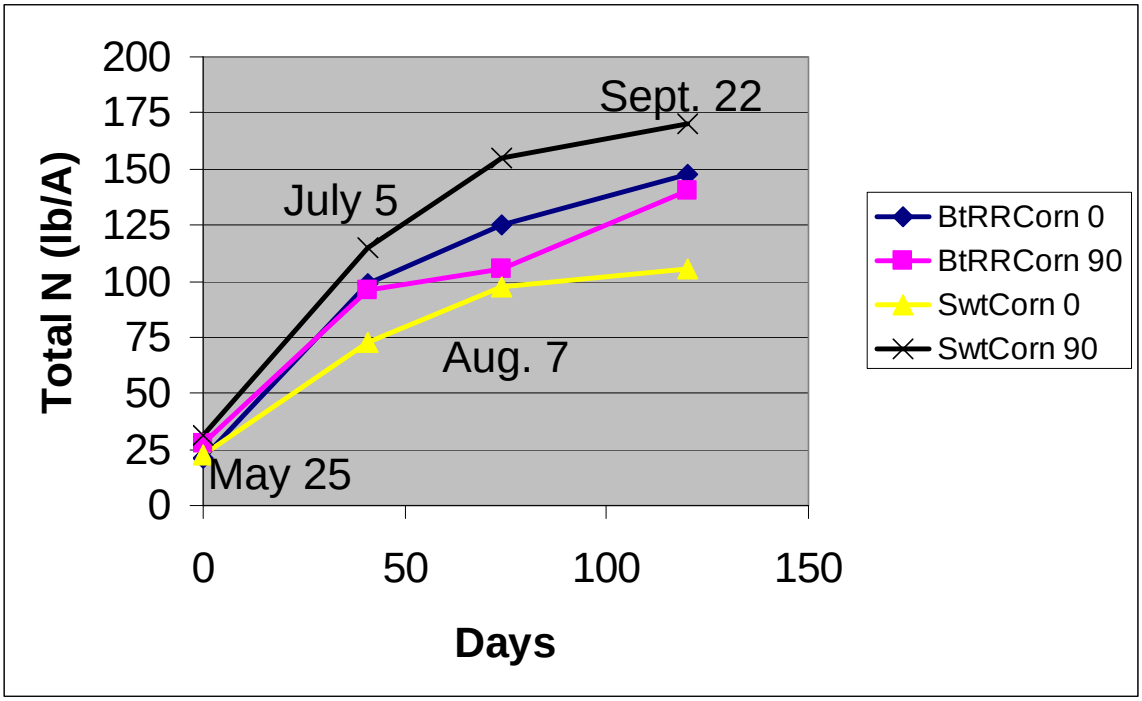

Figure 2. Total N in the surface 10 inches in a sugar beet crop in 2006 with a previous crop of BtRR corn and sweet corn with 0 and 90 pounds N applied.

In 2006, the addition of 90 pounds N per acre to sugar beet with a previous crop of BtRR corn did not affect the amount of N mineralization or the amount of mineral N measured. The addition of 90 pounds N per acre to sugar beet with a previous crop of sweet corn increased the amount of mineral N. The amount of mineral N during the growing season for BtRR corn was between the amounts found for the 0 and 90 pound N per acre with sweet corn as previous crop. The difference in mineralized N at the end of the season between sweet corn 0 pounds N per acre and sweet corn and 90 pounds N per acre was 56 pounds per acre, Table 11. This difference is because of the slower mineralization by the soil where sweet corn was a previous crop and 0 pounds of N per acre was applied. The differences in mineralized N between the other treatments in 2006 were not large.

Table 11. Mineralization rates during 2006, 2007, and 2008 for soil with sugar beet grown after BtRR or conventional corn and sweet corn with 0 and 90 pounds N per acre.

	N rate	Sept. 22 – May 25, 2006	Sept. 27 – May 25, 2007	Sept. 29 – May 27, 2008
Previous crop	pounds N/acre			
BtRR or Conventional corn	0	126	49	100
BtRR or Conventional corn	90	114	61	100
Sweet corn	0	83	100	188
Sweet corn	90	139	114	134

In 2007, the mineralization was larger for the sweet corn compared to the BtRR corn, Figure 3. Compared to 2006, mineralization for less for the BtRR corn in 2007. This could be from the drier weather in 2007 compared to 2006. The mineralization for the soil where sweet corn was the previous crop was similar to 2006.

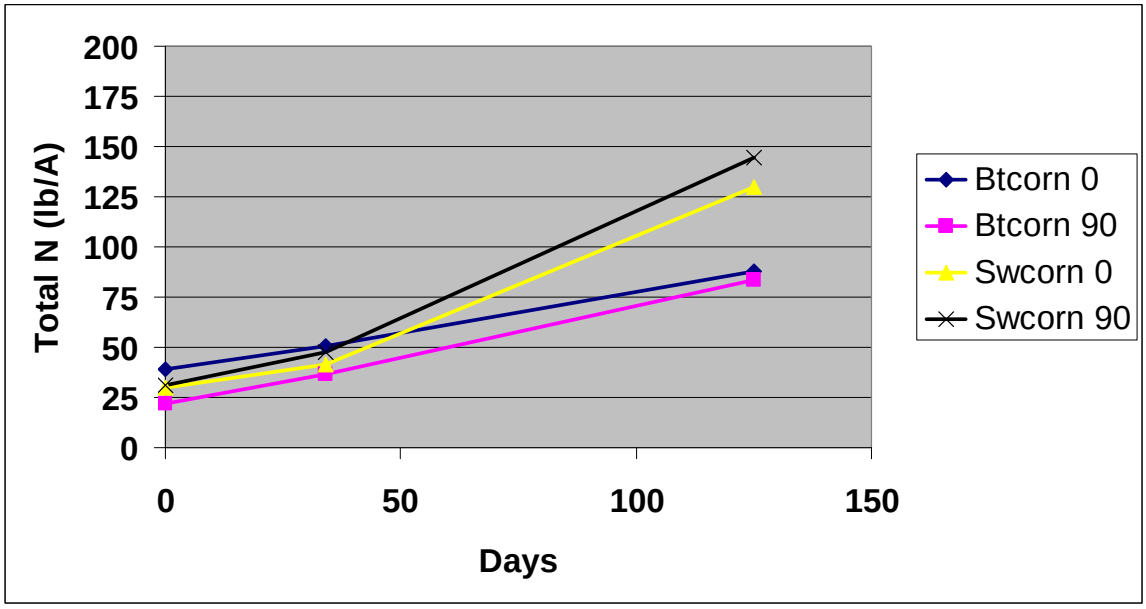

Figure 3. Total N in the surface 10 inches in a sugar beet crop in 2007 with a previous crop of BtRR corn and sweet corn with 0 and 90 pounds N applied.

In 2008, the mineralization was greater than 2007 for both sweet corn and the conventional corn, Figure 4. The soil where the previous crop was sweet corn mineralized more nitrogen than when conventional corn was the previous crop. There were few differences between the application of 0 and 90 pounds N per acre.

In general, N mineralization from the soil in this study was significant. The mineralization occurred during the whole growing season each year and thus could be a major contributor to the quality concerns encountered in the Southern Minnesota Beet Sugar Cooperative growing area.

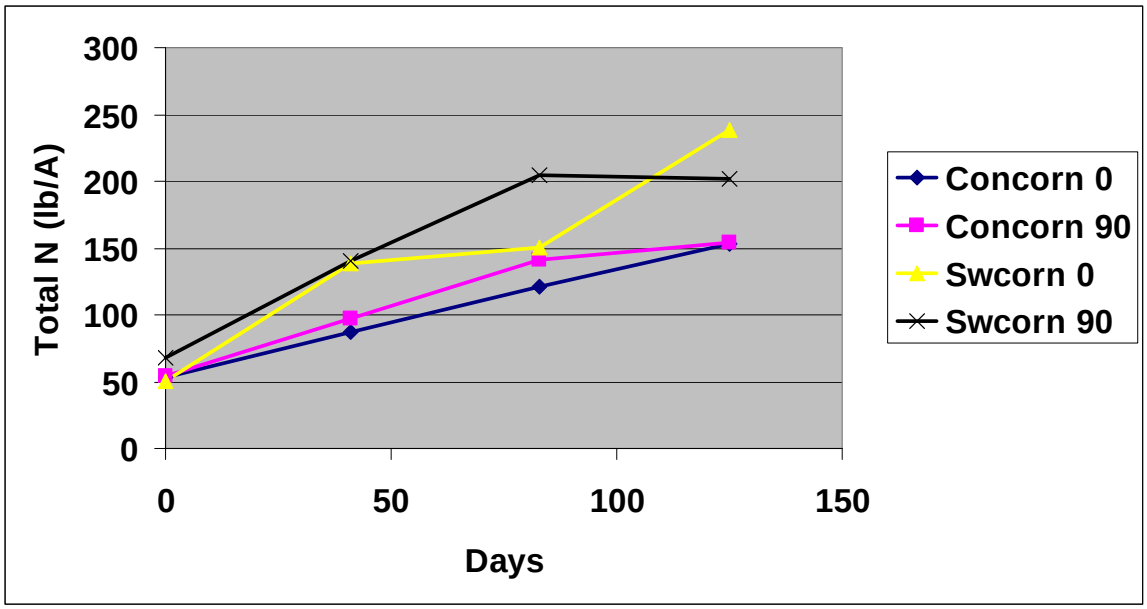

Figure 4. Total N in the surface 10 inches in a sugar beet crop in 2008 with a previous crop of corn and sweet corn with 0 and 90 pounds N applied.

Summary

Root yield and extractable sucrose per acre were affected by the previous crop and nitrogen application in 2006 and 2007. Corn and genetically modified corn had least root yield and extractable sucrose. Spring wheat had the greatest root yield and extractable sucrose per acre in each year. In 2008, previous crop and nitrogen application did not affect any parameter measured. This was because of the high soil residual nitrate, 95 lb N/A. The previous crop did not affect the optimum nitrogen application rate in any year of this study. Mineralization of nitrogen from organic matter was affected by the amount of N fertilizer applied when sweet corn was the previous corn in 2006. The sweet corn with 90 lb N/A applied had the greater mineralization then BrRR corn in 2006. Nitrogen rate did not affect the amount of N mineralized from either previous crop in 2007 and 2008. In all three years, the amount of N mineralized was greater when sweet corn was the previous compared to BtRR or conventional corn.