WHOLE ROTATION NITROGEN MANAGEMENT FOR SUGAR BEET PRODUCTION

John A. Lamb and Mark W. Bredehoeft
Department of Soil, Water, and Climate, University of Minnesota, St. Paul, Minnesota and Southern Minnesota Beet Sugar Cooperative, Renville, Minnesota

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

Materials and Methods:

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

Results:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

	Maynard	Hector	Raymond	Maynard	Hector	Raymond
Source	Root sucrose			Extractable sucrose per ton		
Nrate yr 2	0.08	0.44	0.78	0.19	0.17	0.83
Nrate yr 3	0.05	0.02	0.01	0.01	0.01	0.01

Yr 2*Yr 3	0.25	0.65	0.21	0.25	0.51	0.17
C.V. (%)	3.5	2.8	3.2	4.3	3.6	4.0

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

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

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

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

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

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

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

200	20	18	16

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

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

Conclusions:

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