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NITROGEN MANAGEMENT ON A FIELD SCALE

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The goal of sugar beet producers in Minnesota and North Dakota is to produce the most sucrose in the most economically way. To accomplish this, the growers must grow the best quality beets possible. One production practice which influences sugar beet quality is nitrogen fertilization. If a grower under applies nitrogen, the sugar beet root yield is not optimized for maximum recoverable sucrose, while if nitrogen fertilizer is over applied the concentration of sucrose in the beet is reduced and the concentration of impurities is increased. Sugar beet production fields in southern Minnesota have variable nitrogen needs for optimum recoverable sucrose. The use of variable rate application of nitrogen fertilizer in a production field could produce superior recoverable sucrose yields when compared to a blanket application of one rate across the whole field. Variable rate application technology allows the grower to apply less than average amount of N fertilizer on areas of the field with greater than field average soil nitrate-N and larger amounts of N fertilizer on areas of the field which have less than average residual nitrate-N soil tests.

The use of variable rate technology comes at a financial cost. To vary the application rate of nitrogen an application map must be generated. Currently to generate a map, an intense soil sampling for nitrate-N is required. This is time consuming and expensive. There is a need to develop a less intensive sampling protocol which would still characterize the majority of variability in the field. The methods to do this would be to include using spatial information such as yield maps from previous crops, elevation, drainage tiles, soil survey, satellite images, and soil test results. This information may be used to delineate management areas from which to take soil samples from. These management zones would require considerably fewer soil samples when compared to grid cell sampling protocol and thus be less expensive while maintaining a similar effectiveness.

Little information exists on the feasibility of variable nitrogen application for sugar beet production in southern Minnesota. Most research on the effect of variable rate application of nitrogen on sugar beets has been done in the Red River Valley of Minnesota and North Dakota. Recently additional research on the development and use of management zones has been conducted in the Red River Valley of Minnesota and North Dakota. This research indicates that elevation is very useful in delineating management zones. The soils, crop rotation, and annual precipitation are different in Southern Minnesota than in the Red River Valley of Minnesota and North Dakota. These differences could influence what factors are most appropriate for management zone delineation in southern Minnesota.

The effect of variable rate nitrogen on sugar beet yield and quality has been the subject of a few research projects. Cattanach et al. 1996 indicated that the use of variable rate application of N fertilizer in a sugar beet field could increase profitability by $70 per acre when compared to the yield and quality of a sugar beet field that was treated with a single N rate. Hollands 1996 reported that elevation differences in the Red River Valley landscape, even though small, were an important factor which could be used to determine zones for nitrate-N soil sampling. Franzen et al. 1996 reported the five soil samples were able to describe the nitrate-N status of a forty acre field as well as 40 samples taken at a density of one sample per acre in a grid pattern. These zones were delineated by elevation. Little work with variable rate application of N fertilizer for sugar beet production has been done in the Southern Minnesota Beet Sugar Cooperative growing area. Lamb and Rehm 1999 reported that the use of different density of grid sampling for nitrate-N did not affect root yield or quality. The same study also indicated that the use of variable nitrogen application based on grid sampling at any density was not advantageous for sugar beet yield and quality when compared to the use of a constant rate application.

Objectives:

1. *determine* if management zones for variable rate N fertilizer application will result in better root yield and quality than the use of a single N fertilizer rate for the whole field.

2. *determine* what information is necessary to best delineate management zones in a southern Minnesota landscape.

Materials and Methods:

To meet the above objectives, a three year study was initiated in 2001 in a Southern Minnesota Beet Sugar Cooperative grower's field near Danube, Minnesota. The 32 acre field was in a soybean-corn-sugar beet rotation. The treatments for the study were the following four nitrogen application strategies: 1. no N fertilizer applied to determine the need for N fertilization, 2. N applied based on a nitrate-N soil test for the whole field, 3. N applied at a rate based on a nitrate-N soil test from a management zones determined from the soil survey, and 4. like 3, N would be applied based on soil tests from the management zones. The management zones in treatment 4 would be based Veris soil conductance measurement, previous crop yield maps, and the previous corn crops N uptake. The basic difference between treatments three and four is the knowledge used to create the management zones.

The first and second year of this study was used to gather the information to delineate the management zones. The Veris conductance measurements were obtained in the Fall of first year of the study, 2001. Historic grain yield maps and grain yield maps from year one and year two were also utilized. Soil samples for nitrate-N were taken from each of the 96 70 by 140 feet plots in the fall of the corn year (year 2) and following the sugar beet production year (year 3). During year one and year two, plant samples will be taken for above ground growth and N uptake by the plant.. During the sugar beet production year, the treatments will be applied to 70 X 140 foot sized plots. The experimental design will be a randomized complete block with 24 replications in the field. Top yield, N content of the tops, and sugar beet root yield and quality samples was determined from each 70 X 140 foot plot. The sugar beet field was harvested by a lifter equipped with an on-the-go yield sensor.

Results and Discussion:

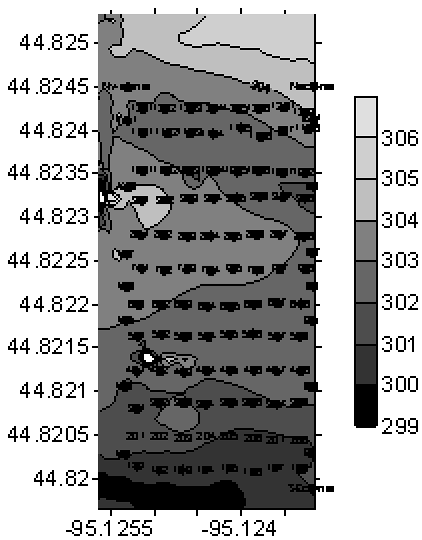


Figure 1. Elevation in meters at Renville Co. site.

Elevation: The location in Renville county had a mean elevation of 302 m (982 ft.) above sealevel, Figure 1. The difference in elevation between the lowest and highest point in the field was 7 m (21 ft). Within the field the landscape is rolling and typical of the landscape in the Southern Minnesota growing area.

Basal corn stalk nitrate: Basal corn stalk samples were taken in September 2002 from each plot, Figure 2. This plant test was developed at Iowa State University to assess the nitrogen status of a corn crop after the growing season. If the stalk nitrate is less than 250 ppm, the corn plant was under fertilized. The nitrogen status is marginal at 250 to 700 ppm. Optimum is 700 to 2000 ppm with excessive nitrogen when the basal stalk nitrate concentration is greater than 2000 ppm. At this location the basal stalk nitrate-N concentrations ranged from 24 to 4615 ppm. The mean concentration was 1297 ppm. On the average the nitrogen status of the previous corn crop was optimum. There were significant areas in the southwest and northern part of the field that were in the marginal or lower category.

Veris electrical conductivity (EC): The electrical conductivity map was acquired Fall 2001 after soybean harvest, Figure 3. This technology measures changes in the soil's electrical conductivity can be affected by soil texture, soil moisture content, and soluble salts in the soil. This tool has been found to be useful in delineating management zones in other parts of the United States. This location has a range of EC from 0 to 75 units. The pattern is similar to the elevation of the field.
Yield maps: Yield maps were obtained with a combine equipped with a yield monitor in the soybean and corn years of production, Figure 4. The lighter gray colors reflect poor yielding areas while the best yielding areas are reflected by the dark gray areas. The average soybean grain yield was 45 bushels per acre. The better yielding areas are in the northern end (up in figure) and in the middle. The poorer yielding area are the southwestern corner (lower left corner in figure). The yield map for the 2002 corn shows the possible problems that can be encountered with yield monitors. The GPS signal was not of good quality when the left hand side of the field was harvested. At the time of this report, the yield has not been adjusted for this problem. The average corn yield in 2002 was 144 bushels per acre. The better yields in 2002 occurred in the northeast corner of the field.

Corn N uptake 2002: The total nitrogen in the above parts of corn at maturity for the research site is in Figure 5. The amount of nitrogen ranged from 74 to 210 pounds per acre. The areas with less N uptake are similar to the areas with the less basal stalk nitrate-N in figure 2. The average N uptake was 154 pounds per acre.

Management zones: Management zone were developed for treatments 3 and 4. Treatment 3 zones represent the soil survey for Renville County. This is a Order 2 survey conducted in the late 1980's and early 1990's. This field had six different mapping units in eight different areas. The six units are a Webster clay loam 0-2%, Harps-Seaforth-Okoboji 0-3%, Normania loam1-3%, Amiret-Swanlake complex 2-6%, Amiret-Swanlake-Hawick complex 2-6%, and Havelock clay loam 0-2%. These were formed in glacial till materials from the Des Moine lobe.

Treatment 4 zones were formed from the electrical conductivity, yield maps, and the corn N uptake information. This resulted in six different zones.

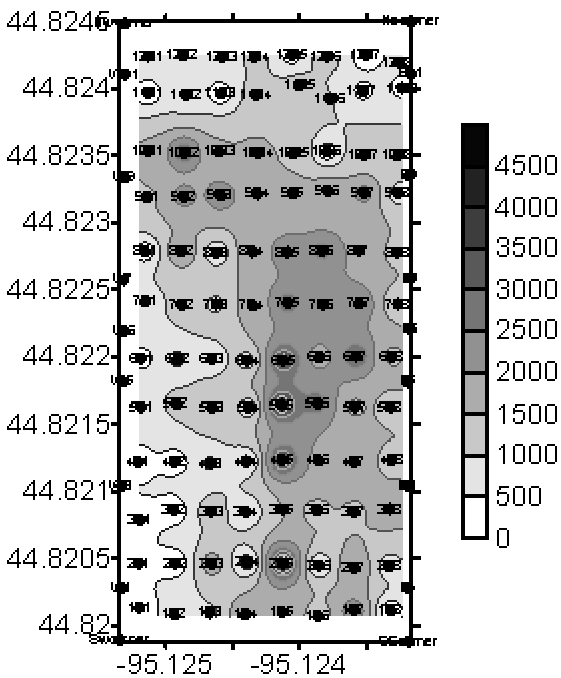


Figure 2. Corn basal stalk nitrate-N taken Fall 2002.

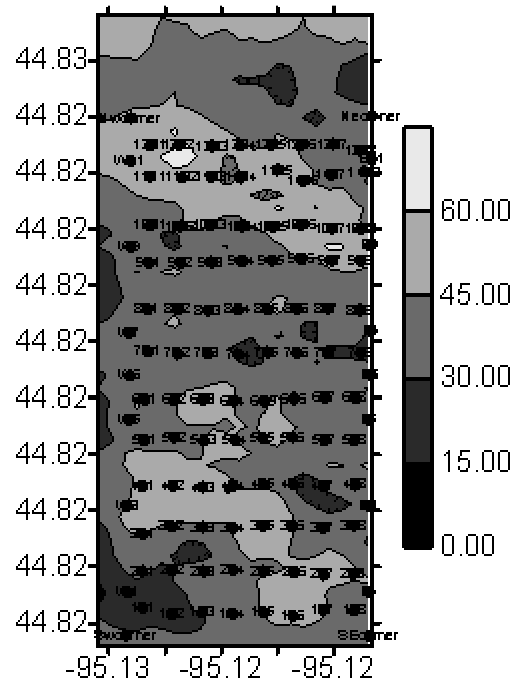


Figure 3. Veris electrical conductivity measured Fall 2001 after soybean production.

The soil nitrate-N to a depth of four feet from the fall of 2002 was used to derive the nitrogen fertilizer recommendations, Figure 7. The soil nitrate-N ranged from 30 to 130 pounds per acre. The recommendation of 130 pounds N as soil nitrate-N to four feet plus fertilizer N was used. The range in N fertilizer recommendation was from 0 to 100 pounds N per acre. The average amount for the whole field would have been 76 pounds N per acre.

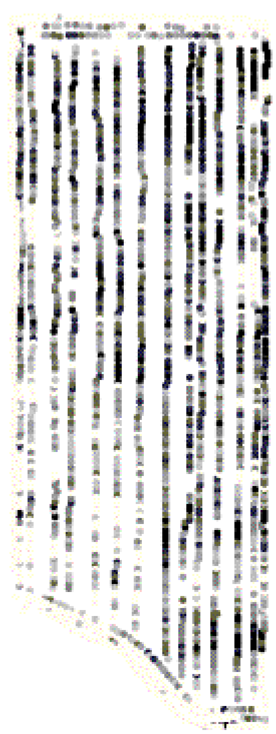
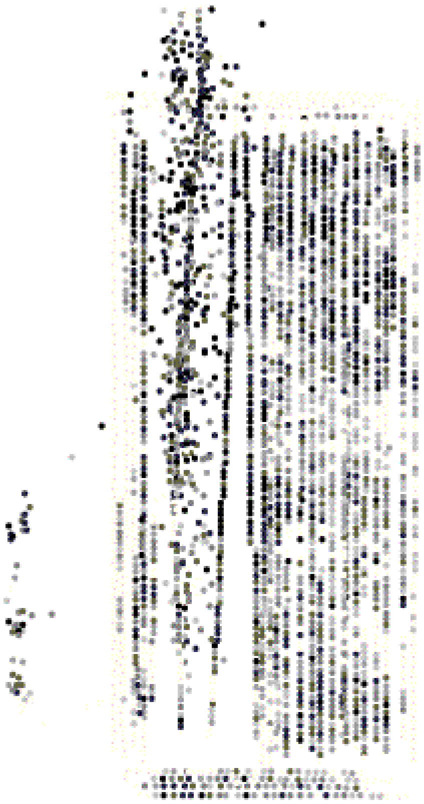


Figure 4. Yield maps for soybean 2001 (left) and corn 2002 (right).



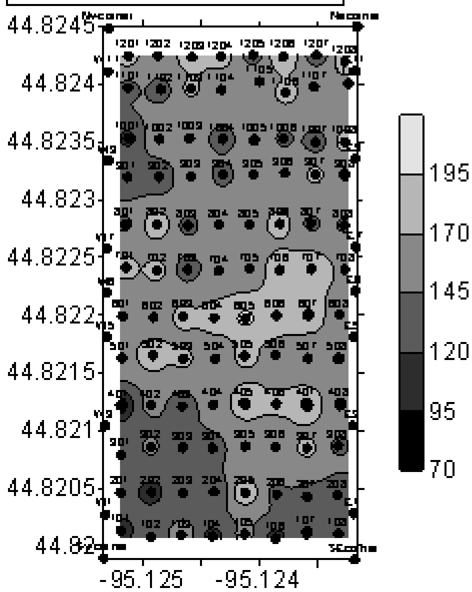


Figure 5. Corn N uptake in 2002.

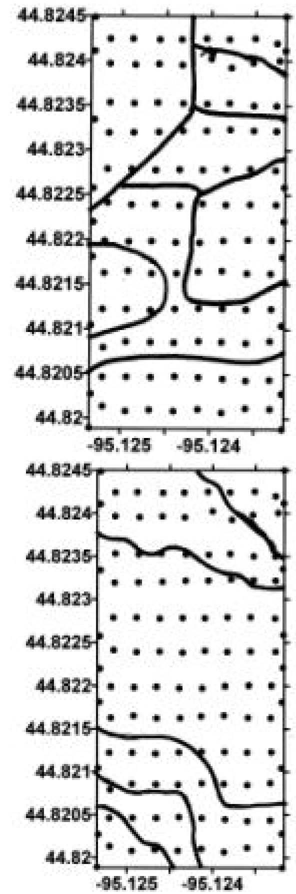


Figure 6. Management zone maps for treatment 3 (left) and treatment 4 (right) in 2003.

Fertilizer applied for each treatment: The amount of fertilizer N applied for each treatment is reported in table 1. Treatment 1 was a check and had no fertilizer applied. There is very little difference in the average amount of fertilizer applied in the other three treatments. This was about 76 pounds N per acre. With in the eight zones for treatment 3 the range from 59 to 93 pounds of N per acre. The six zones for treatment 6 had applications that ranged from in 72 to 93 pounds N per acre.

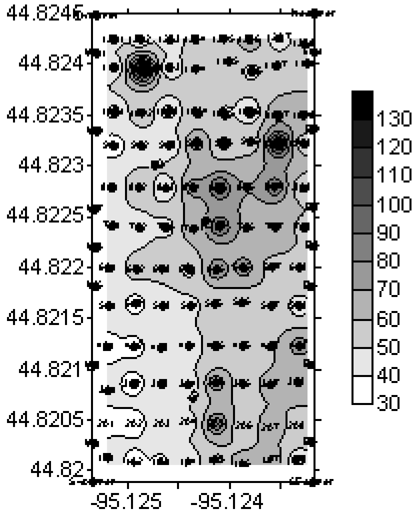


Figure 7. Soil nitrate-N to a depth of 4 feet, fall 2002.

Table 1. Nitrogen fertilizer applied in each zone.

Treatment (No N)	Treatment 2 (Conv.)		Treatment 3 (Zone 1)	Treatment 4 (Zone 2)
----- pounds N/acre -----		Zone number	----- pounds N/acre -----	
0	76	1	79	93
		2	78	84
		3	93	76
		4	67	74
		5	59	72
		6	72	76
		7	77	
		8	75	
		average	75	76

Sugar beet yield and quality: The results from the hand harvest is reported in table 2. Root yield was significantly affected by the treatments. The only difference large enough for root yield is the difference between the zone 1 treatment (soil survey) and the zone 2 treatment. The disturbing result is the lack of significant response to nitrogen application. The check root yield was 24.4 tons per acre compared to the conventional treatment of 24.2 tons per acre. The sucrose concentration was significantly reduce with the addition of fertilizer N in the conventional treatment and the zone 2 treatment when compared to the No N treatment. Recoverable white sucrose concentration was not affected by the treatments. The recoverable white sucrose per acre was significantly affected by treatments. The differences were between zone 1 and zone 2. Again there is not difference between the No N treatment and the other N application treatments.

Conclusions:

In review of the information gather from this study, the following conclusions can be drawn. It was disappointing that the use of nitrogen fertilizer did not increase root yield and recoverable white sucrose per acre. The use of nitrogen fertilizer did reduce the sucrose concentration. There were differences in the root yield and recoverable white sucrose between the two zone treatments. The use of a order 2 soil survey for creating zones did not yield as well as the use of zones based on crop and soil parameters. Neither zone treatment affected the measured parameters different than the conventional treatment based on the average soil nitrate-N for the field.

Table 2. Sugar beet root yield, sucrose concentration, recoverable white sucrose per ton, and recoverable white sucrose per acre in 2003.

	Root yield	Sucrose	Rec/ton	Rec white sucrose
N management	T/A	%	lb/Ton	lb/A
No N	24.4	18.0	277	6852
Conv.	24.2	17.6	274	6642
Zone 1 Soil survey	23.1	17.8	275	6364
Zone 2 EC, YM, Nup	25.5	17.7	275	7024
Statistics N management (P>F)	0.02	0.01	NS	0.08

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