Summary of Four Years of Research on Poor Quality Sugarbeets in a Sugarbeet, Spring Wheat, Potato Rotation

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Introduction

Successful sugarbeet production is the result of a combination of high sugarbeet yield, high beet sugar content and low levels of impurities. Mathematical formulas incorporating all of these features are used for grower sugarbeet delivery payments from the processing plants. Undesirable impurities are amino-N content, loss of sugar to molasses. Loss to molasses may be as low as 2% or as high as 20% of sugarbeet weight. Molasses is about 50% sucrose (Hobbis, 1978).

Nitrogen management is key to higher beet yields, high recoverable sugar and low levels of impurities. (Draycott, 1972; Hobbis, 1973). High soil N results in higher sugar beet yield, but it also results in lower recoverable sugar and higher levels of unrecoverable sugar and amino-N content, which increases processing costs. Table 1 illustrates the reduction in recoverable sugar and increase in amino-N content as N rate increases. It is therefore very important that enough N is available for high yields, but the N levels are low enough that late season plant energies encourage sugar storage and not continued foliar growth, which result in lower sugar content in the roots.

Table 1. Sugarbeet yield, recoverable sugar and amino-N content with N rate. Mean of six sugarbeet varieties. (Adapted from Smith et al., 1980.)

N rate lb/a	Yield tons/a	Sugar %	Gross sugar lb/a	Recoverable Sugar lb/a	Amino-N ppm
150	22.5	15.4	6,830	5,730	935
250	22.5	15.1	6,730	5,507	825
350	24.7	14.7	6,500	5,300	1116

One method to track whether high N levels are present in the plant is the use of a petiole nitrate test. Ulrich (1950) suggested a critical level of 1,000 ppm in the petiole that was important to maintain early in the season, but which should be allowed to drop below 1,000 ppm within about 11 weeks (in California) prior to harvest. In the northern plains, the rule is to let petiole nitrate levels drop below 1,000 ppm within about 6 weeks of harvest (Cattanach, 2001). Essentially what this threshold means is that sugarbeets need to be slightly N deficient during the final weeks of growth in order to increase sugar storage prior to harvest.

In order to limit the amount of N to the sugarbeet crop, but yet supply enough N to supply provide for yield demands, soil sampling and nitrate-N analysis is recommended prior to the sugarbeet year. In North Dakota and northwest Minnesota, sampling is usually conducted in the fall due to the long duration of winter, with deeply frozen soils and the limited N movement and N transformations possible under these conditions. Some spring sampling is also conducted, especially on sandy loam or coarser soils and on soils which periodically flood in the early spring. Nitrogen sampling is typically conducted on the 0-48 inch depth (Franzen and Cihacek, 1998). However, significant N can also be extracted from even deeper depths. Evidence of deep soil N extraction is provided by Rudolph et al. (1980) in which recoverable sugar per acre decreased as soil nitrate levels increased at the 0-66 inch depth. Smith (1980) suggested that deep soil sampling may be required to explain the influence of residual N in about 25% of Red River Valley fields. Deep sampling at the 40-48 inch depth is regularly practiced today by most beet growers.

Sugarbeet leaves may contain large amounts of N. Murphy and Smith (1967) found that sugarbeet leaves may contain high levels of nitrate-N. Moraghan and Smith (1994) presented a range of N levels present in sugarbeet tops at from 64-300 lb/a at harvest. Draycott (1972) pointed out the manurial value of sugarbeet tops due to their high N content. Crohain and Rixhon (1967) showed that crops subsequent to sugarbeet may benefit from N released from sugarbeet top residue. The entire rotation is therefore important nutritionally, given that certain crops might contribute N to the sugarbeet crop not seen in normal soil sampling, and crops subsequent to sugarbeet may benefit from N mineralized during sugarbeet top decomposition. It is possible from these studies to envision soil analysis from a field following sugarbeets with low levels of residual soil nitrate-N, but with sugarbeet leaves containing hundreds of pounds of N.

Abshahi et al. (1984) followed the application of N_{15}-isotope labeled fertilizer N through a sugarbeet crop and into the following wheat crop. Using sugarbeet residues, application of fertilizer N to wheat was optimized with 55 lb N/acre compared to 110 lb N/acre with no sugarbeet residues. They concluded that sugarbeet residues may contain high levels of N and should be considered a possible N source for subsequent crops.

Moraghan and Smith (1996) built on this idea and applied sugarbeet tops as one would apply a manure application. Two types of sugarbeet top applications were made prior to a spring wheat crop. One type contained lower sugarbeet N content (14.8 ppm), and the other a higher N content (34.8 ppm). The residues were applied at rates of 60 lb/acre and 240 lb/acre respectively. The high sugarbeet N residues contributed N similar to the yield response of 120-180 lb/a of N as urea, illustrating that sugarbeet tops should be considered a potential N source to subsequent crops. The study suggested that yellow or light-green tops at harvest be considered as contributing 20 lb/a N to subsequent crops and green canopied sugarbeets at harvest as contributing at least 60 lb/a N. From these studies, it is clear that nitrogen nutrition in sugarbeets must consider the entire rotation given the cyclic nature of nitrogen uptake, utilization and mineralization of residues from and to the sugarbeet crop.

Sugarbeet growers in the Drayton and St. Thomas districts collectively have been historically lower in recoverable sugar and higher in impurities than the Red River Valley average. Payments to growers on a per acre basis have also been lower. The rotation which predominated the lower payment acres appeared to be a rotation which included potatoes. Growers did not know why their sugarbeets were lower in quality. Soil testing prior to sugarbeets was usually used as a basis for N fertilization, with sampling depths of 42-48 inches common. It was generally believed that soil N was not a reason for the low quality sugarbeets, since unusually high soil N levels were generally not seen following potatoes. Some guesses as to the source of the problem included a water table high in excess N, a nutrient imbalance other than N, or some unexplained soil N variability that might be found with grid sampling.

A study was made with the following objectives:

1. To determine the reason for the low quality sugarbeets.

2. To study methods to improve the quality of sugarbeets.
3. To introduce those methods to growers so that sugarbeet quality could improve.

The Study-

1997

Exploring conventional thinking-

All of the work during the four years was conducted on four fields operated by Pete Carson, located southwest of St. Thomas. The fields were in a sugarbeet, spring wheat, potato rotation, in that order. The first year of the project, the fields were either in sugarbeet or potato (Table 2). Fertilization of the sugarbeets and the spring wheat during the study was controlled and applied by Pete Carson. Fertilization of the potatoes was left to the renters.

Table 2. Rotation of the fields during the four years of research.

Field	Acres	Years			
		1997	1998	1999	2000
29 E	40	Potato	Sugarbeet	Spring wheat	Potato
29 W	50	Sugarbeet	Spring wheat	Potato	Sugarbeet
34 N	40	Potato	Sugarbeet	Spring wheat	Potato
34 S	38	Sugarbeet	Spring wheat	Potato	Sugarbeet

The fields going into sugarbeet were sampled in the fall of 1996 using a four-acre grid, which was a density common in the Red River Valley at that time. N recommendations varied from 0-106 lb N/acre in field 34 S , and from 10-114 lb N/acre in field 29 W. Grid areas were randomly assigned N fertilization rates based on either the grid value or a composite soil test value. Variable-rate N was applied as anhydrous ammonia by the cooperator in the spring of 1997 prior to seeding. Multiple yield and quality samples were taken from each grid at harvest. There was no difference in yield and quality between the variably-applied grids and the composite fertilized grids.

Exploring the Source of the Problem

Clearly, the problem of low sugarbeet quality would not be as simple as addressing it through variable-rate N alone. This meant that in all probability, N sources from somewhere were so high that varying the rate of N in a particular grid had no effect. This idea was further reinforced by the low sugars (16.3-16.7%) and high impurities (nitrate grade 3.18-3.67 and % sugar loss to molasses 1.48-1.53) found in the harvest samples.

The high nitrogen availability to the sugarbeet crop was also reinforced by additional sampling of petioles during the 1997 growing season, and sugarbeet top analysis in the fall at harvest.

During the summer of 1997, the potato and sugarbeet fields, were divided into ½ acre grids for most subsequent plant and soil sampling. Petiole sampling was conducted four times during the summer. The petiole analysis for nitrate was compared to top total N levels at harvest and soil N levels at each of the four dates. Soil samples to 6 feet were taken at harvest in the same grid from both the sugarbeet and potato fields. It was unknown to what extent potato culls might also contribute any N to the 1998 sugarbeet crop, so culls were also collected from a 10 foot square area and analyzed for total N content.

Soil samples following sugarbeets showed low levels of soil N to six feet in depth in all areas except where sugarbeet growth was low due to excess water that season (Figure 1.) However, sugarbeet top analysis showed very high levels of N. Some tops were as high as 400 lb N/acre. Assuming a carbon/nitrogen ratio of about 10-1 (which later turned out to be a valid assumption in year 2000 work) this would be the N credit equivalent of tilling under a 4 ton alfalfa crop (Figure 2). It was estimated that about 2/3 of the top total N would be available to the subsequent wheat crop.

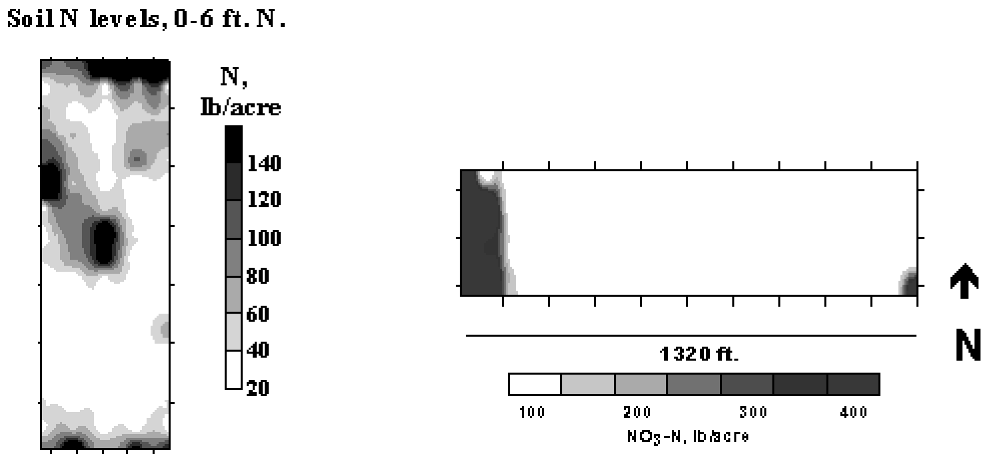


Figure 1. Field 29W (left) and 34 S nitrate-N levels to 6 feet following 1997 sugarbeets.

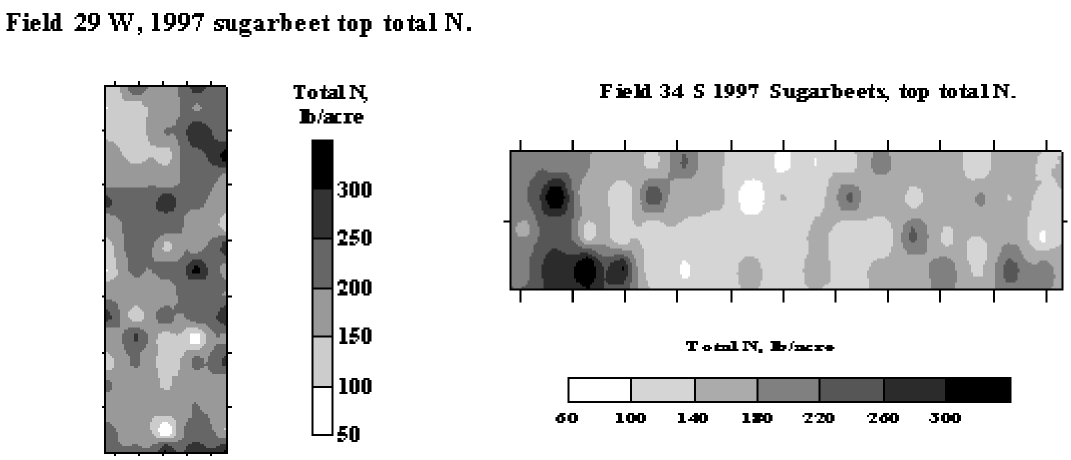


Figure 2. Fields 29 W and 34 S, sugarbeet top total N, 1997.

It was becoming clearer following the sugarbeet top analysis that one possible source of the excessive N in the rotation was the sugarbeet tops. Growers had not yet taken to practice the on-going research by Moraghan and Smith regarding the value of sugarbeet tops. Even if they had, the N levels in some of the sugarbeet tops on the experimental fields were above even that proposed by those other studies. Beyond that, practical methods to estimate the amount of N credit and the boundaries of the credit zones in the field needed to be established.

Two possible methods emerged from the 1997 and 1998 work. One was the use of satellite and/or aerial photographs to identify more and less vigorous areas, which would identify differences in top N level, but would not tend to quantify the amount of N, and the other was to use this along with petiole sampling of the sugarbeets to estimate better the actual value of the top N content.

Aerial photos of the 1997 fields showed areas of higher vigor and greater green in areas with higher N content (Figure 3). This supports the idea that remote imagery may help to speed collection of plant leaf or petiole samples in problem fields, to better estimate N contribution to subsequent crops, thereby reducing soil N levels over time and improving beet sugar yield.

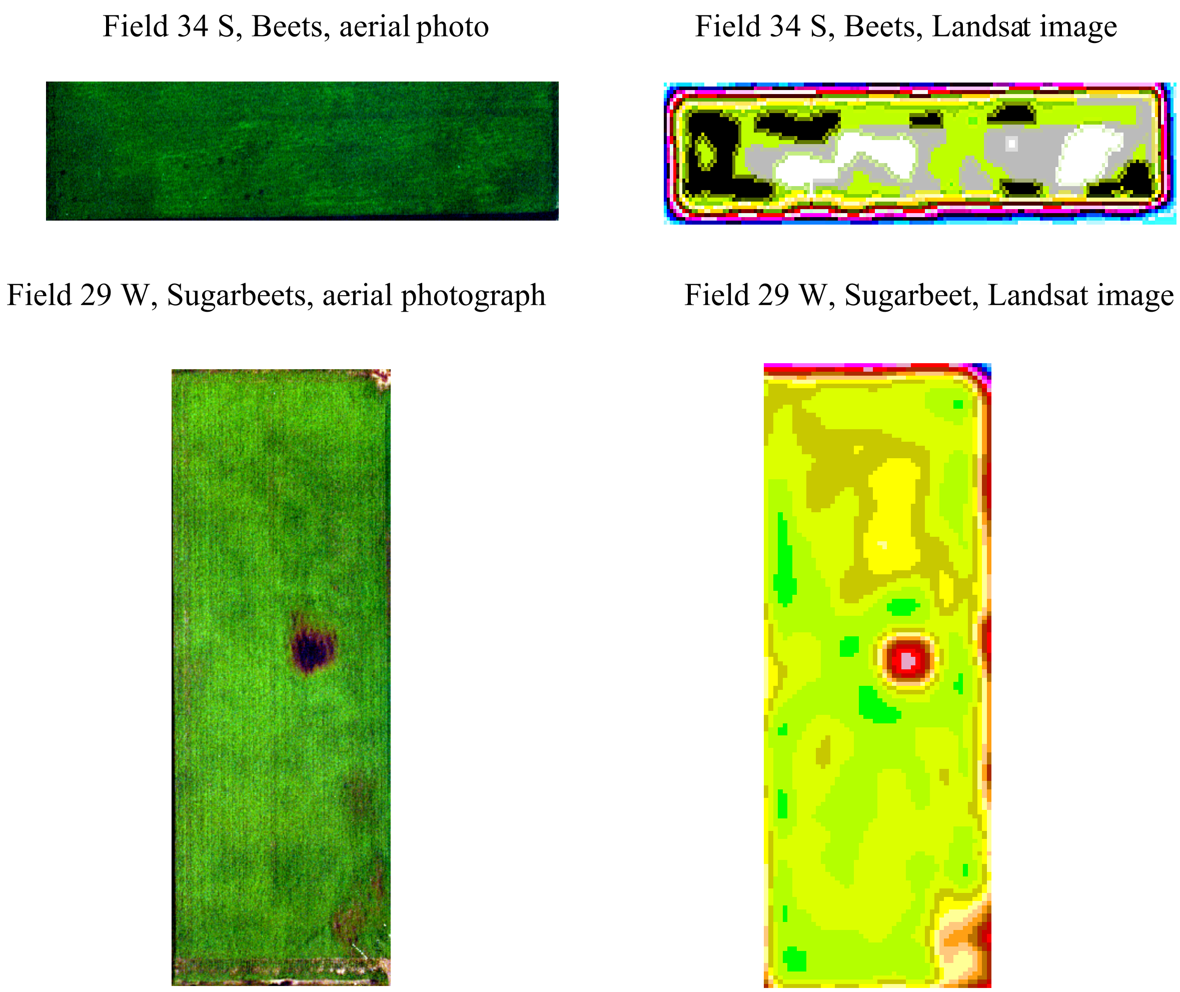


Figure 3. Fields 29 W and 34 S, sugarbeets, 1997, aerial and satellite images.

Aerial photographs were separated into red and green imagery, then gray-scaled so that the chroma for each pixel could be grouped and compared with the ½ acre grid data from plant and soil analysis. Table 2 shows how well imagery was correlated with soil and plant analysis.

Table 2. Sugarbeet imagery correlation with soil N analysis and plant analysis.

Field	Date	Color	Soil 2' N	Soil 4' N	Soil 6' N	Pet N*	Top N**
29 W aerial	8/27/97	Green	0.17	0.13	0.07 NS	0.02 NS	0.32
		Red	0.06 NS	0.01 NS	0.05 NS	0.08 NS	0.24
34 S aerial	8/27/97	Green	0.04 NS	0.08 NS	0.08 NS	0.04 NS	0.04 NS
		Red	0.09 NS	0.09 NS	0.12	0.04 NS	0.13
29 E aerial	9/04/98	Green	0.34	0.34	0.26	0.29	Hail
		Red	0.32	0.31	0.24	0.22	Hail
34 N aerial	8/20/98	Green	0.35	0.36	0.35	NA	0.01 NS
		Red	0.20	0.18	0.16	NA	0.09 NS
34 N Landsat	7/10/98	all	0.41	0.42	0.41	NA	0.21

* petiole analysis taken at a similar time as imagery, 1997 only.
** top N content, %.

Generally, the green band was more closely related to the soil and plant characteristics than the red band. In 1997, aerial photography was related to Top N content, but not petiole nitrate. In 1998, the field with available data from petiole nitrate sampling was correlated with imagery, but not Top N content. Landsat imagery in 1998 was correlated with Top N content.

These relationships are not strong enough to relate imagery directly with a value for Top N content for use with a previous crop N credit equation. However, given the crude method by which these values were calculated, more elegant mathematics may improve this relationship with the same set of data, and at the very least, it gives support that the greener, higher vigor areas are related to higher N levels in the plant tops. It enables a scout to walk directly to the most nearby area of the field with most green and least green foliage, and take a petiole or top sample for analysis in a much cheaper manner than grid sampling the entire field. Using only a couple samples per field representative of high and low vigor areas revealed by imagery, a good estimate might be obtained of N levels in the tops for the entire field.

In contrast, the relationship between petiole N content and sugarbeet and potato top N content was consistently high, especially at the late August, early September sampling dates in sugarbeets (Table 3).

Table 3. Relationship between sugarbeet and potato top N content (%) and petiole N content (%).

Petiole sampling date	Beets 97 34 S	Beets 97 29 W	Petiole sampling date	Beets 98 34 N	Petiole sampling date	Potato 97 29 E	Potato 97 34 N
7/22	0.38	0.00 NS	7/23	0.51	7/29	0.30	-----
8/08	0.60	0.00 NS	8/04	0.55	7/31	------	0.28
8/20	0.72	0.30	8/19	0.59			
9/04	0.65	0.44	8/31	0.66			

The biggest problem in determining a good estimate of sugarbeet leaf N content in the field is the quantity of material needed for a sample. There are two ways to solve this. One would be to obtain petiole samples near harvest and relate the analysis to top N content data. The other method might involve knowing where to sample at harvest, and after flailing an area of interest, obtain a grab sample of top material and have that analyzed directly. This study only started to look at this solution.

Potatoes precede sugarbeets in this rotation, so although the N content of sugarbeet leaves as a previous crop credit to wheat is important, it was also important to evaluate the residual N following potatoes which probably led to high N levels in the sugarbeet leaves to begin with. Levels of N in the 0-4 foot depth following potatoes was moderate, but if the fields had been sampled to this depth only and considerations were not made for foliage N and deeper N, some N would probably have been recommended for sugarbeets in 1998. However, high levels of N were found from the 4-6 foot depth. In addition, the high N content of the potato tops also prompted an N adjustment as a previous crop credit (Figure 4).

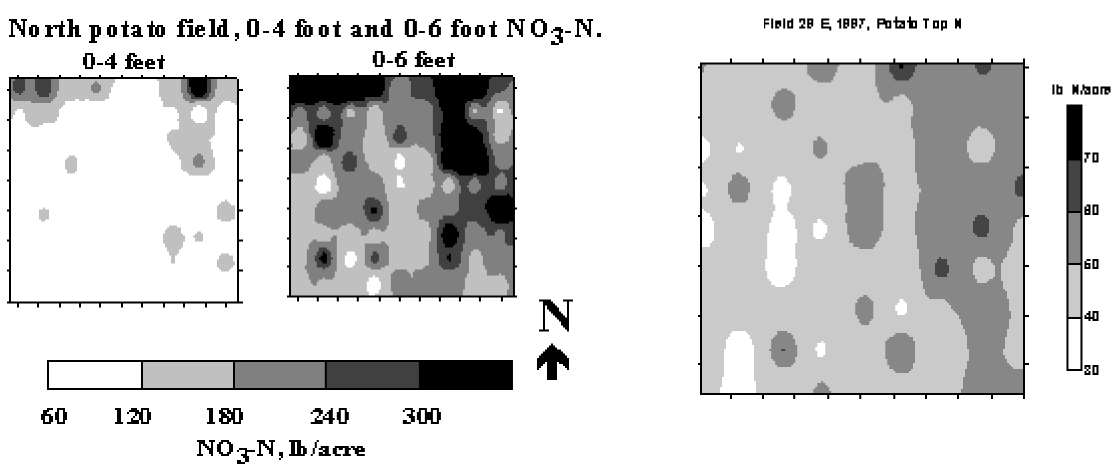


Figure 4. Field 29 E, potatoes, 1997, soil test N to 6 feet and potato top N levels.

Due to the soil test N to 4 feet from 60 to 120 lb N/acre, an added 30-50 lb N/acre from potato tops, and generally high N levels from 4-6 feet in depth, it was decided not to apply any additional N as fertilizer for the subsequent 1998 sugarbeet crop.

In addition, substantial N credits were given for sugarbeet tops to the subsequent spring wheat crop.

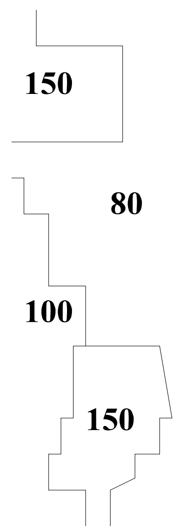


Figure 5. Field 29 W, following sugarbeets, fertilizer application map for spring wheat, 1998.

Conclusions from the First Study Year-

Following the first year of research, the following conclusions could be drawn.

1. The reason for the low quality sugarbeets was high N, not accounted for in the sugarbeet tops, the potato tops, and the 4-6 foot soil sampling depth.
2. Growers could begin to address the high N issue by giving credits to sugarbeet leaf color, and making further cuts is N rates to wheat through petiole or leaf top sampling near harvest.

Directed by remote imagery, limited 4-6 foot soil sampling could estimate how much deep N was present to begin to pump this N out of the soil using the sugarbeet crop. We did not have to credit more than a small amount of the 4-6 foot depth following potatoes to the sugarbeet crop. In fact, the 4-6 foot depth of nitrate-N probably does not contribute much to the development of the sugarbeet crop other than degrade quality during the last two months of the growing season. However, since we did find that sugarbeets tap into this depth and effectively suck it nearly dry of N, knowing it is there and monitoring the progress of remediation of these fields is a good reason to sample to these depths following potatoes.

Doubts remained

Despite the data that was shared with the growers following the first year of the study, it was determined to expand the scope of the study to determine when the sugarbeet residue N mineralization occurred.

The following spring after wheat emergence, an area about 8 feet long by 8 feet wide at each of the same ½ acre grid sites as the soil/plant sampling the previous year was killed by an application of Roundup. Five soil cores were obtained from each grid. In 1998, cores were taken at a soil depth of 0-6 inch and 6-12 inches for the growing season sampling, followed by a post-harvest sampling of 0-6 inch, 6-24 inch, 24-48 inch and 48-72 inch depth. In 1999, cores were taken from the 0-6 inch, 6-12 inch, and 12-24 inch depth, followed by a similar post-harvest sampling as in 1998. These soil samples were analyzed for NO_3-N.

The soil NO_3-N levels found in each year are the total NO_3-N found from the transformation of ammonia to nitrate, the mineralization of organic matter and the decomposition of sugarbeet tops. The nitrogen application map for the two fields studied in 1999 are shown in Figure 6.

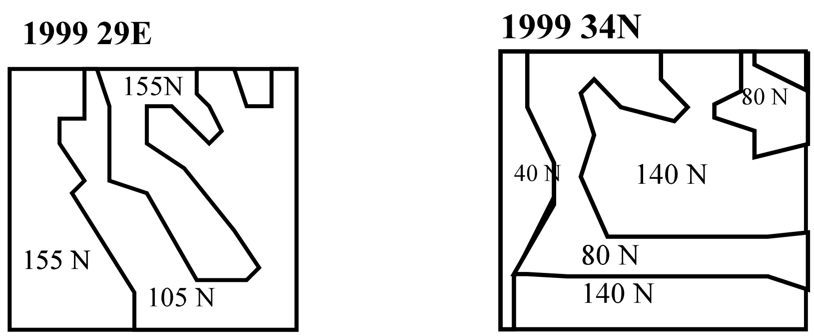


Figure 6. N application 1999.

Results from 1998

Field 29W

When comparing the 1998 first in-season 0-12 inch depth NO_3-N levels with the after-harvest 1997 0-12 inch depth levels, there were large differences in the amount of NO_3-N present (Table 4). In the fall of 1997 immediately following sugarbeets, mean NO_3-N levels were 19 lb/acre, compared with a mean of 130.9 for the 5/15/98 sampling. The mean ammonia-N fertilizer application rate was 102 lb/acre. The mean N reduction due to sugarbeet tops was 48 lb/acre. If all of the ammonia was converted to nitrate and beet tops supplied the N credit determined prior to its application, and all of the N from the previous fall found in soil test results was still in the top 12 inches of soil, the amount of N actually found should have been 169 lb/acre assuming no contribution of N from the organic matter. At the second sampling taken at 6/1/98, this number was more closely approximated by a mean NO_3-N level at the 0-12 inch depth of 159.7 lb/acre. The third sampling taken June 15 had a mean NO_3-N level of 88.4 lb/acre, while the fourth sampling, taken July 1 was 137.4 lb NO_3-N/acre. The mean NO_3-N level August 17 following wheat harvest was 101.3 in the 0-12 inch depth and a total of 144 lb/acre to a depth of 4 feet. The total NO_3-N available at each sampling date is displayed in Figure 7. The August sampling date following harvest is shown in Figure 8.

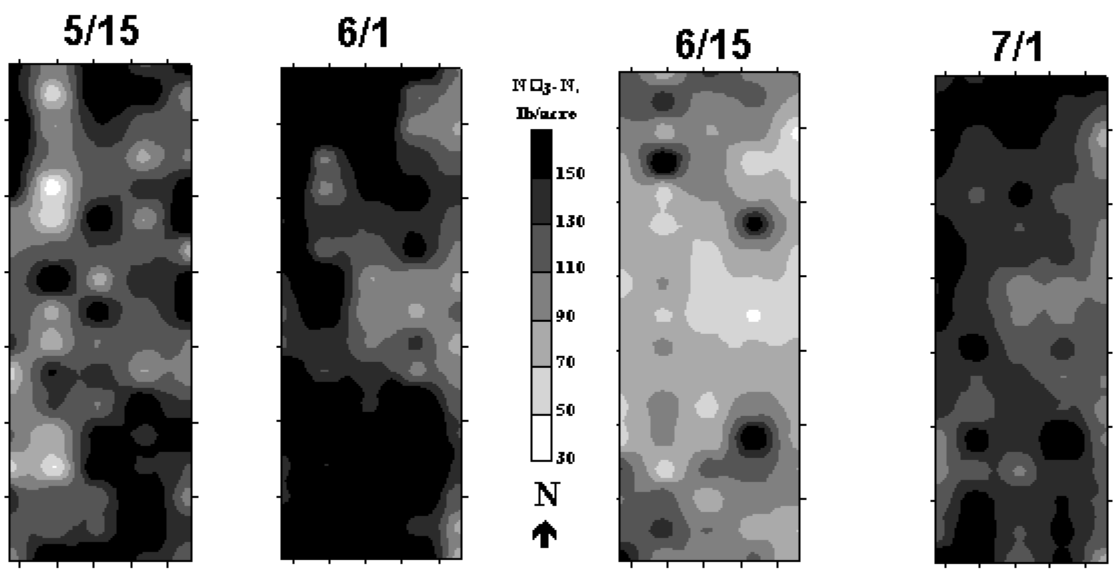


Figure 7. 0-2 foot NO_3-N levels, field 29W, 1998 over sampling dates. Note the peak N levels by 6/1/98 sampling date.

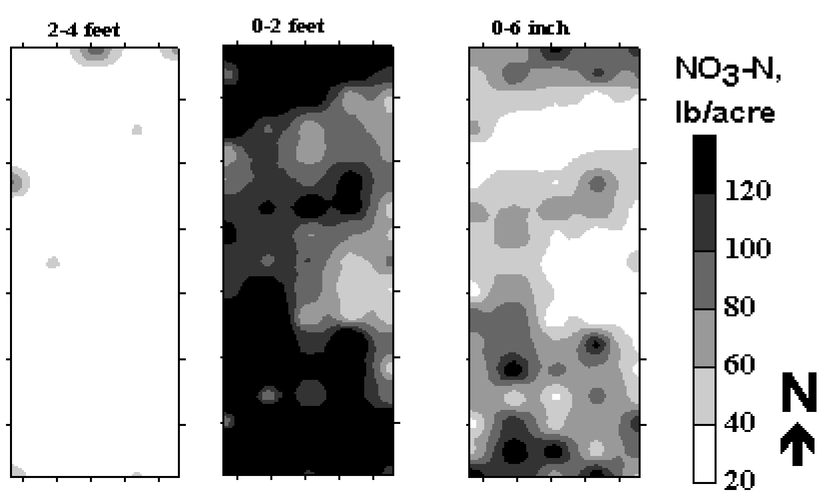


Figure 8. NO_3-N levels following spring wheat harvest, field 29W, 1998. A high level of N had leached below the 6 inch depth by harvest.

Another observation during the experiment was the value of N at the surface 0-6 inches compared to levels at depth. The 5/15 sampling was 112.3 lb/acre, the 6/1 sampling dropped to 94.4 lb/acre, and the 6/15 through harvest sampling was between 57.2 and 68.5 lb/acre. The 6-12 inch depth varied, perhaps as a result of rainfall patterns. From 5/15 through 6/1, 0.9 inches of rain fell, largely in two events at the beginning and end of the period. As a consequence of this, NO_3-N may have leached below the 6 inch sampling depth at the 6/1 sampling date. From 6/1 through 6/15, only 0.12 inches of rain fell, so evaporative processes may have pulled soil water again towards the surface and resulted in lower levels of NO_3-N at the 6-12 inch depth. The period from 6/15 to 7/1 was another rainy period (1.26 inches), with NO_3-N again increasing at the 6-12 inch depth.

Table 4. Field 29W, 1998 NO_3-N levels through the growing season.

Sampling date	Mean NO_3-N levels, lb/acre				
	0-6 inch	6-12 inch	0-1 foot	1-2 foot	2-4 foot
10/97	13.1	6.0 (est)	19.1 (est)	11.9 (est)	16.6
5/15/98	112.3	18.6	130.9		
6/1/98	94.4	65.3	159.7		
6/15/98	57.2	31.3	88.4		
7/1/98	68.5	68.9	137.4		
Harvest 8/17/98	61.8	39.3	101.2	21.3	21.4

The three fertilized zones, 150 lb N/acre, 100 lb N/acre and 80 lb N/acre, were examined more closely for NO_3-N levels at the 0-12 inch depth at the 6/1 sampling date at which soil N levels were maximized. These data are summarized in Table 2 and show that the area supported by the 150 lb N/acre rate contained 133 lb NO_3-N, while the 100 lb N/acre and 80 lb N/acre rates contained 115 lb and 113 lb NO_3-N/acre respectively. The areas supported by the lower N rates yielded as well as those with the higher fertilizer N rates (Table 5). Mean yields within each zone varied from 55 to 56.9 bu/acre. There were no significant differences between mean yields in each zone.

The two sugarbeet fields, 34 N and 29 E, received no N fertilizer for the 1998 crop. Field 29 E was destroyed by hail close to harvest, so no yield or quality measurements were made. However, the crop yield in 34 N was 22 ton/acre, with over 17% sugar. Based on a comparison by agriculturalists on neighboring fields in the township, this was comparable to tonnage, with about 1% greater sugar than other, conventionally fertilized fields.

Table 5. NO_3-N levels by zone, 6/1 sampling date and yields by zone. Field 29W, 1998.

Zone	NO_3-N, lb/acre	Yield, bu/acre
150 lb N/acre	133	56.4
100 lb N/acre	115	56.9
80 lb N/acre	113	55.0
Significance (yield only)		None

Results, Field 29E, 1999.

The significant snow melt and an additional 3.4 inches of rainfall between 4/1/99 and the first sampling date of 5/20/99 may have contributed to the deeper position of NO_3-N compared to the field studied in 1998. Of the total 131.7 lb NO_3-N in the top 0-2 foot depth, only 17.7 lb was at the 0-6 inch depth and more than half was found in the 12-24 inch depth (Table 7). The second sampling date (6/9/99) found an even greater amount at the 12-24 inch depth and a total NO_3-N content of about 20 lb/acre more than at the 5/20/99 date. A total of about 2 inches of rain fell between these two sampling dates in four 0.4 to 0.5 inch events.

Table 7. Field 29E, 1999 NO_3-N levels by depth and by date of sampling.

Sampling date	Mean NO_3-N levels, lb/acre				
	0-6 inch	6-12 inch	0-1 foot	1-2 foot	2-4 foot
10/98	10.3	4.0 (est)	14.3 (est)	7.7 (est)	12.0
5/20/99	17.7	47.1	64.8	66.9	
6/9/99	29.3	37.0	66.3	85.1	
Harvest, 8/27/99	25.0	30.0 (est)	55.0	59.0 (est)	44.5

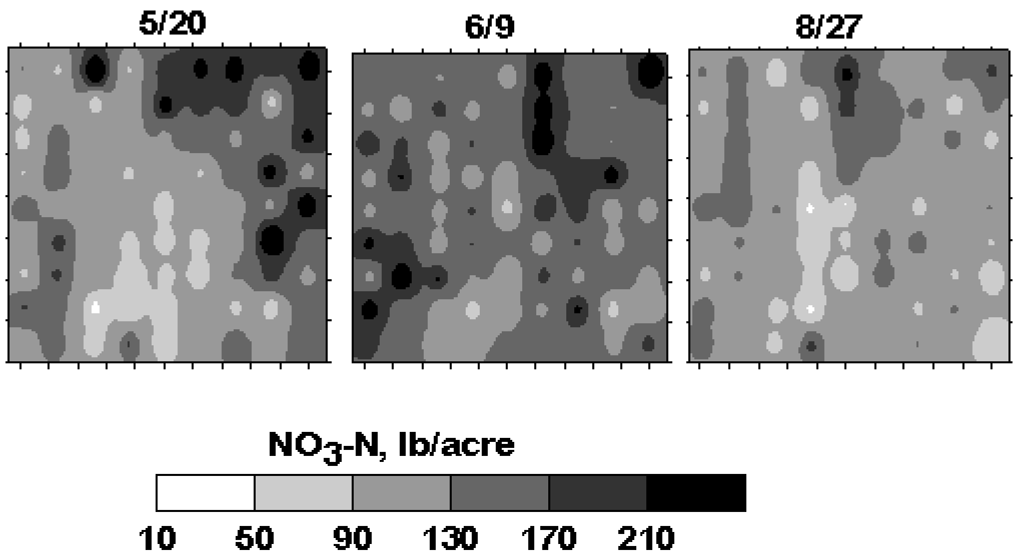


Figure 9. Field 29E, 1999, 0-2 foot NO_3-N by sampling date.

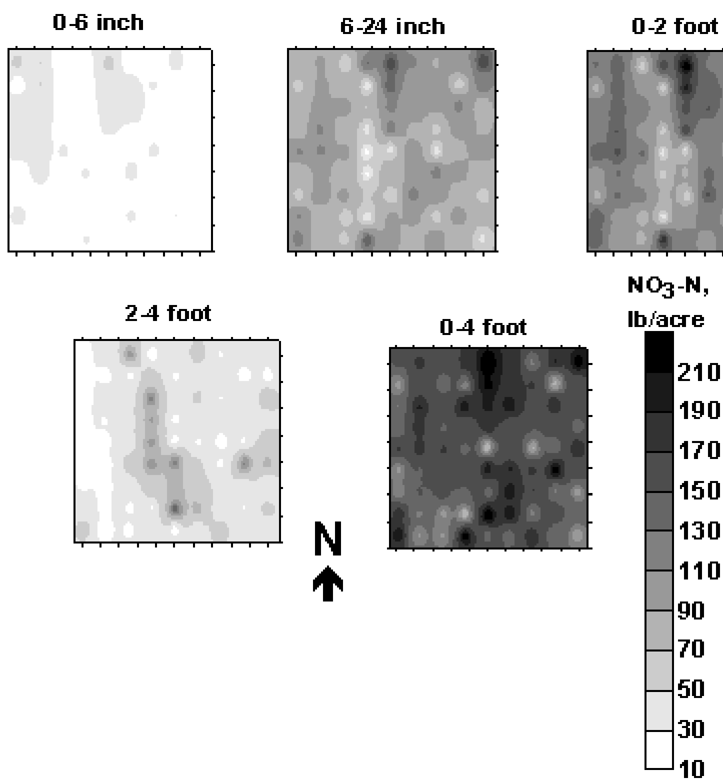


Figure 10. Field 29E, NO_3-N levels following spring wheat harvest, 8/27/99.

Approximately 3 inches of rain fell between the 6/9 sampling date and the 8/27 after harvest sampling date. NO_3-N continued to move downward in the soil, especially out of the 6-12 inch depth. Figure 9 shows a general increase in the 0-2 foot NO_3-N from 5/20 to 6/9, followed by a general decrease from 6/9 to 8/27. The 44.5 lb/acre at the 2-4 foot depth is an increase of 32.5 lb/acre over the fall 1998 levels following sugarbeets.

Table 8. NO_3-N levels by zone, 6/9 sampling date and yields by zone. Field 29E, 1999.

Zone	NO_3-N, lb/acre	Yield, bu/acre
155 lb N rate	155.3	83.4
105 lb N rate	147.7	80.4
Significance (yield only)		Yes

Despite a 50 lb/acre N credit given due to sugarbeet top greenness in the fall of 1998, NO_3-N levels were only about 7 lb/acre less at the 6/9 sampling date. As in 1998 in field 29W, even though some small increases in total NO_3-N following the May sampling dates, a very large proportion of N was available for the spring wheat crop at the earliest sampling date. The higher N rate translated into three bu/acre more response. The higher yield may not be related to higher N availability, but may be related to other favorable soil factors which are inherent in that zone compared to the higher sugarbeet top color zone.

Field 34N

Field 34 N behaved similar to field 29E in the manner of NO_3-N position and movement during the growing season. Table 5 shows that N was released early in the season and moved downward in the profile due to early spring rains and snow-melt. It shows that more than half of the NO_3-N was present at the 12-24 inch depth at the first and subsequent sampling dates.

Table 9. Field 34N, 1999 NO_3-N levels by depth and by date of sampling.

Sampling date	Mean NO_3-N levels, lb/acre				
	0-6 inch	6-12 inch	0-1 foot	1-2 foot	2-4 foot
10/98	9.5	6.0 (est)	15.5 (est)	12.1(est)	27.2
5/20/99	18.3	49.8	68.1	90.7	
6/9/99	33.3	38.2	71.4	74.9	
Harvest, 8/27/99	29.6	29.4 (est)	59.0	58.9 (est)	39.6

Soil NO_3-N levels are shown in Figures 11 and 12 to be high at the 0-2 foot depth at the first two sampling dates, then decrease at harvest. At harvest, the levels are relatively low at the surface, increase with depth, with the 2-4 foot depth containing significant levels compared to the fall 1998 sampling.

Figure 11. Field 34N, 1999, 0-2 foot depth by sampling date.

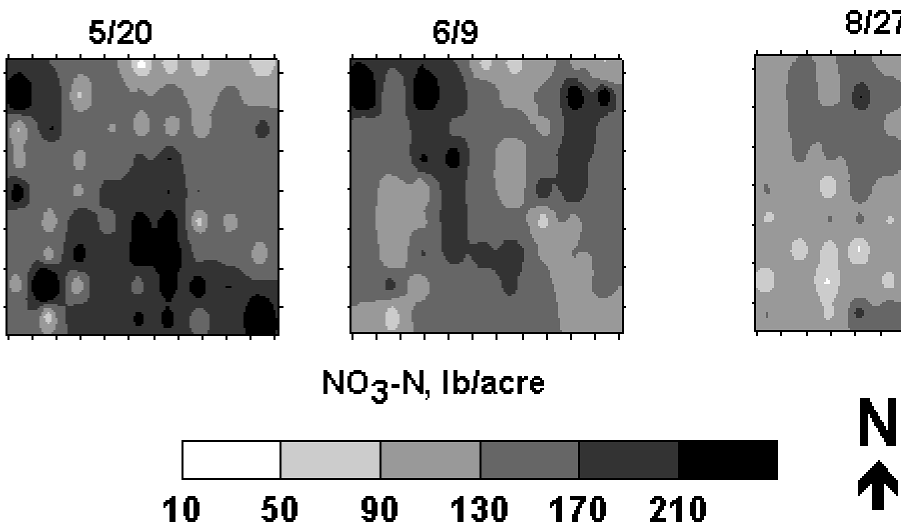


Figure 12. St. Thomas field 34N 1999 NO_3-N levels, 8/27/99.

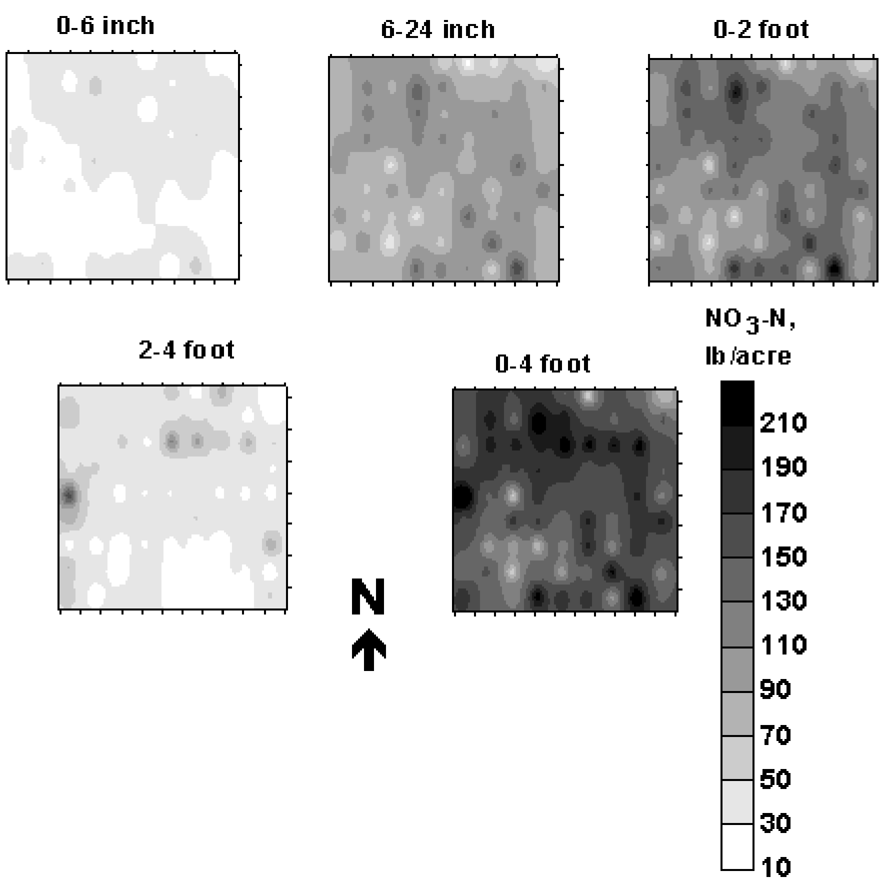


Table 8. NO_3-N levels by zone, 6/9 sampling date and yields by zone. Field 34N, 1999.

Zone	NO_3-N, lb/acre	Yield, bu/acre
140 lb N rate	170.2	85.2
80 lb N rate	150.8	87.2
40 lb N rate	161.9	83.7
Significance (yield only)		None

In the zone described by the N rate reduction of 60 lb/acre, the 6/9 sampling at the 0-2 foot depth was reduced by 20 lb/acre compared to the 140 lb N rate. The zone described by the 100 lb/acre N rate reduction was reduced by only 9 lb/acre. Because earlier sampling did not reach below 2 feet, it is not know whether higher levels of N would have been found below the 2 foot depth relative to those found in the 140 rate zone. However, a reduction of 60 lb/acre in N rate translated into only a 20 lb/acre reduction in NO_3-N, giving support to the use of a rate reduction in the greener leaf color of the previous summer's photography and satellite imagery. There was no significant differences in yields regardless of N rate, indicating that N was adequate through the season for high yields in the field regardless of N credit. It also indicates that the N credit was justified, or the high yields would not have been possible.

Support for the use of credits, 1998 and 1999.

The studies on wheat following sugarbeets showed again that credits for sugarbeet leaf N could be made and growers should be confident that N availability occurs early in the growing season, so that crops such as spring wheat and others could easily benefit.

Putting the last doubts to rest- buried bag studies, 2000.

To further investigate the timing of probable N release from residues, a buried residue bag study was conducted in 2000 at both Fargo and St. Thomas. Samples of residue from canola, spring wheat, corn, potato, sugarbeet and sunflower of varying N contents were collected, dried, weighed and placed in one foot square fiberglass mesh bags. More complete methods are described in Hapka et al., 2001. The bags were buried in early November, 1999 at about a 2 inch depth in randomized split blocks at each location. Bags were disinterred on May 15, May 29, June 19 and July 3, 2000. Soil was washed off the residue bags. A screening of actual minute pieces of residue during washing revealed wash losses of less than 0.1 g of residue.

Rainfall at Fargo was higher than St. Thomas. The higher rainfall at Fargo is reflected in the increased degradation and rate of degradation of residue at this site compared to St. Thomas. Notable, however, is that although the season was dry at St. Thomas, high levels of residue, particularly potato and sugarbeet, degraded by the first sampling date.

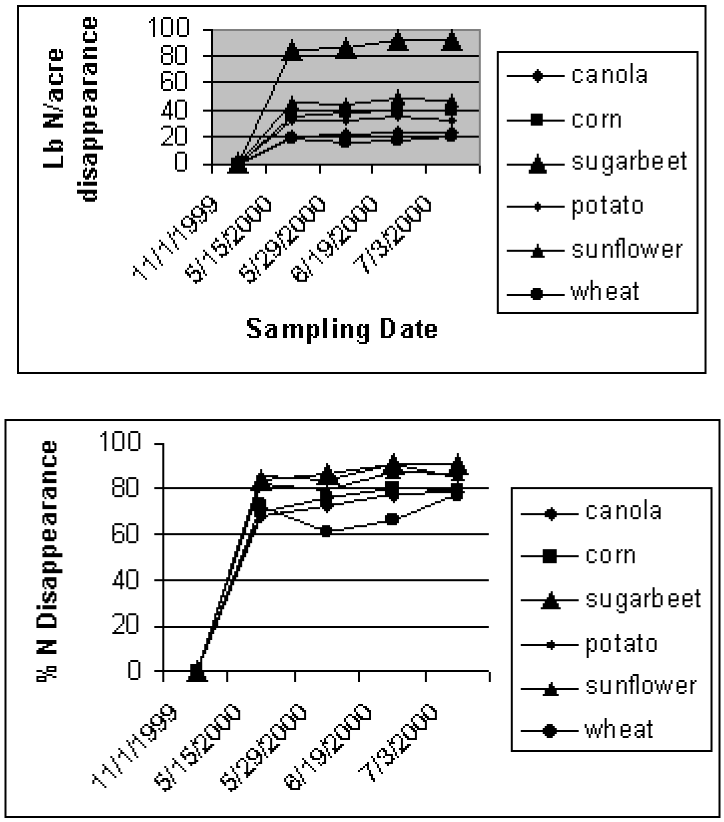
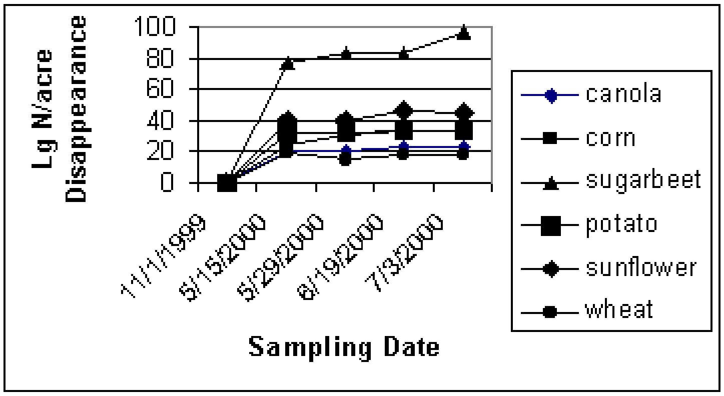


Figure 13. N disappearance from residue, Fargo.

From 50-85% of the residue had decomposed by the May 15 sampling date at both sites. Decomposition was faster at Fargo than St. Thomas, but even in a marginal drought situation at St. Thomas, significant decomposition and probable release of N from residue had taken place. Sugarbeet, potato and sunflower decomposition was most rapid, which was expected, since the C/N ratio of these residues was less than for corn, canola and wheat. Wheat decomposition was slowest, followed by canola and corn.

This study again supported the use of potato and sugarbeet residues, and perhaps sunflower as a previous crop N credit, similar to that given to annual legumes, and in the case of sugarbeet, crediting levels substantially higher than those given field pea or soybean is justified if total N levels are high enough in the residue.



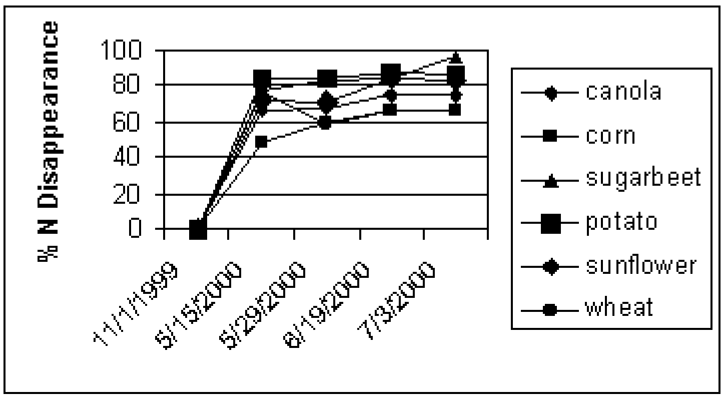
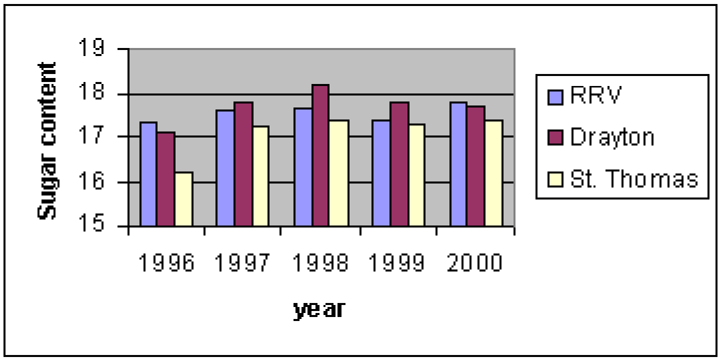


Figure 14. N disappearance from residue, St. Thomas.

Grower acceptance-

Changing grower management habits is never easy. The history of farming is one of conservative change. However, generally sugarbeet growers tend to be more innovative and willing to change management than the general farm population if the research is solid and overwhelming. Most of the conclusions reached in this study could have been adopted and adapted from previous work showing these concepts in North Dakota, Minnesota and elsewhere. However, sometimes there needs to be more local demonstrations than small plot studies which show the principles. One factor that seemed to help sway growers was the whole field nature of the study, where the entire field was measured, and not just samples taken from some areas within fields. Sugarbeet top research had certainly been thoroughly investigated prior and during this study, but its use through a rotation on a whole field basis in this study was probably a factor in management changes in the St. Thomas, Drayton areas.



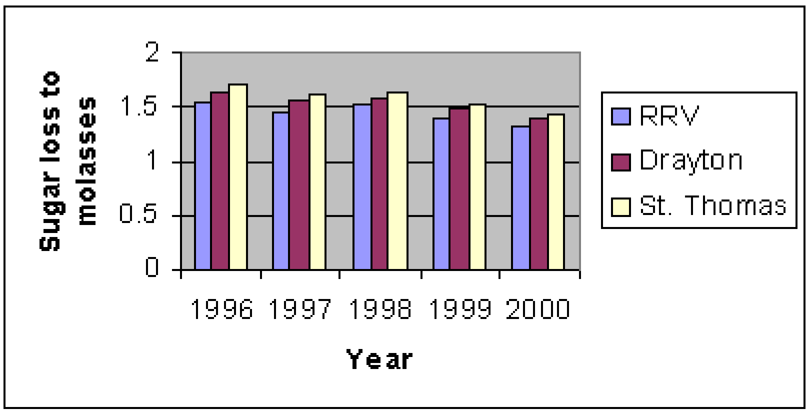


Figure 15. Sugar content and sugar loss to molasses from 1996 through 2000 for the Drayton and St. Thomas districts compared to the Red River Valley average.

At the beginning of the project, the difference between the sugar content and sugar loss to molasses was relatively high between Drayton and especially St. Thomas and the rest of the Red River Valley. As the project progressed, the beet quality at the two stations improved relative to the Valley average. Although St. Thomas is still below average, the magnitude of the difference has decreased.

Summary-

The reasons and the solutions for the problem are seen below in Figure16.

The problem

Sugarbeet year

Sugarbeets are fertilized based on a 0-4 foot sample following potatoes. At harvest, soil levels are low, and top N levels are high.

Wheat year

Due to low soil N levels, wheat is fertilized heavily. Nitrate from beet tops leaches below the 2 foot depth.

Potatoes

Excessive N from beet tops continues to leach below the 4 foot depth. Sugarbeets are again over-fertilized. Sugarbeet growers do not consider N contribution from potato tops. Sometimes, growers over-fertilize their potato crop

The solution

Sugarbeet year

Sugarbeets are fertilized based on the results of 0-4 foot sampling. Potato tops are considered as a previous N credit of 20-50 lb/acre and some consideration is made for the 4-6 foot N levels.

Wheat year

Wheat is fertilized based not only on a 0-2 foot sample, but on an estimate of N credits from sugarbeet tops. This year is the key to soil N draw-down.

Potato year

Potatoes are fertilized on a 0-2 foot depth, using conservative rates.

Using these principles, site-specific management of N will maximize the effect and lessen the risk of the program to each crop.

Figure 16. Problem and solution to the low quality sugarbeet problem.

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Acknowledgments

Thank you to the Sugarbeet Research and Education Board of Minnesota and North Dakota and Agrium for their financial support of this project.