

NITROGEN MANAGEMENT STRATEGIES FOR INCREASING SUGAR BEET ROOT QUALITY

Dr. John A. Lamb¹, Mark W. Bredehoeft², and Chris Dunsmore²

¹Department of Soil, Water, and Climate, University of Minnesota, St. Paul, Minnesota and ²Agricultural Research Department, Southern Minnesota Beet Sugar Cooperative, Renville, Minnesota

Justification of Research: Sugar beet growers are concerned about sugar beet root yield and quality. To remain competitive, the growers must fine tune their nitrogen fertilizer management to increase sugar beet quality and thus making a better economic situation for sugar production. Since 2002, the Southern Minnesota Beet Sugar Cooperative has had a goal of better quality. The purity of the root has increased from 87 % to 92 % during this time. This has occurred from a combination of refined varieties, harvest management, and nitrogen fertilizer application. The nitrogen fertilizer recommendation for this area has been reduced 50 lb/A since this time. This reduction has not reduced root yields. In fact, average root yields have increased from a cooperative average of 21 ton/A to 28 ton/A. The increase in percent sucrose in the root has not occurred. The reasons for this include, the large amount of soil organic matter (N) in this area, rainfall occurring just before harvest that increases N mineralization from the organic matter, and frost occurrence during the early harvest that causes the plant to re-grow and thus using the sucrose accumulated in the beet for an energy source. There is a need to explore and review other nitrogen fertilizer management practices. This proposed project will look at the effect of 'feeding' nitrogen to the sugar beet during the growing season by using a slow release nitrogen source or split applications. The slow release products may be able to supply enough nitrogen for root growth while not reducing the sucrose in the beet.

Summary of Literature Review: The current fertilizer guideline for growing sugar beet is a total of 130 lb N/A as soil nitrate-N to a depth of four feet and fertilizer nitrogen applied (Lamb et. al 2001a). This guideline was revised for the southern Minnesota and published in the 2010 Sugarbeet Production Guide to 100 lb N/A. There has been a considerable amount of research that has been done with nitrogen management since 1996, Lamb et al. 2006a, 2006b, 2005, 2004, 2003, 2001b, 2000, and 1999). Most of that work was to determine the optimum nitrogen rate for economic sugar beet production. Lamb and Moraghan 1993 reported on the effect of foliar applications during the growing season in addition to the initial pre-plant soil applications on sugar beet root yield and quality. They concluded that the later the foliar N application was made, the more the root quality reduced. Root yield was not affected.

Sims, 2010 reported new work on the use of a slow release nitrogen product called ESN by Agrium. The release of nitrogen is controlled by coating a urea prill with a polymer. The speed of release is governed by the polymer coating, amount moisture and temperature in the soil. It is thought that the slower release may be beneficial to sugar beet root growth and quality. In 2009, the use of ESN in the RRV did not perform any better than urea. This was one year of data.

Split applications of nitrogen to the soil have been investigated in the RRV and SMBSC growing areas in Minnesota, Lamb, 1986, 1987, 1988, and 1989. The results were neutral for root yield and quality when the nitrogen fertilizer was split applied a pre-plant and four weeks after emergence. The sugar beet varieties have changed since that time.

Objectives:

1. Determine if split applications of nitrogen or the use of slow release forms of nitrogen (ESN), can increase root quality.

Materials and Methods: An experiment was established at four locations in the Southern Minnesota Beet Sugar Cooperative growing area to meet the objective. One of the locations was abandoned because of wet planting conditions causing poor earlier growth. The study included the factorial combination of six nitrogen application rates (0, 30, 60, 90, 120, and 150 lb N/A) and two nitrogen sources (urea and ESN). The split applications of nitrogen at pre-plant and early July of urea at 60 and 120 lb N/A and split treatment of 60 and 120 lb N/A with the pre-plant, split applied as ESN and the July application as urea. Another method used was to split apply nitrogen as a liquid. Two nitrogen liquid products, NaChurs SRN and Kugler KQ-XRN were used as treatments. The preplant application was with 30 or 60 lb N/A as urea or ESN and the liquid applications occurred at the 10 and 20 leaf stage, July 8 and August 20, 2011, respectively. The liquids were applied at a rate of 2 gallons per acre delivering a total of 12 lb N/A. The SRN product is a 28 % liquid nitrogen product that is 7.8% urea-N and 20.2% slowly available water soluble nitrogen derived from urea triazone solution. Kugler KQ-XRN is a 28 % liquid nitrogen product with 72 % of its nitrogen as a proprietary formulation slow release nitrogen.

A summary of the treatments are in Table 1. The study had five replications. Petiole samples were taken mid-July from the each treatment and analyzed for nitrate-N. The sugar beet roots were harvested in October for root yield and quality determination. Root quality was determined at the Southern Minnesota Beet Sugar Cooperative quality laboratory in Renville, Minnesota.

Table 1. Treatments for ESN and Split N application trial in 2011.

| Trt | Pre-plant N (lb N/A) | Split application (lb N/A) | Total application (lb N/A) |
|-----|----------------------|----------------------------|----------------------------|
| 1 | 0 | 0 | 0 |
| 2 | Urea 30 | 0 | 30 |
| 3 | Urea 60 | 0 | 60 |
| 4 | Urea 90 | 0 | 90 |
| 5 | Urea 120 | 0 | 120 |
| 6 | Urea 150 | 0 | 150 |
| 7 | 0 | 0 | 0 |
| 8 | ESN 30 | 0 | 30 |
| 9 | ESN 60 | 0 | 60 |
| 10 | ESN 90 | 0 | 90 |
| 11 | ESN 120 | 0 | 120 |
| 12 | ESN 150 | 0 | 150 |
| 13 | ESN 30 + Urea 30 | 0 | 60 |
| 14 | ESN 60 + Urea 60 | 0 | 120 |
| 15 | ESN 15 + Urea 15 | Urea 30 | 60 |
| 16 | ESN 30 + Urea 30 | Urea 60 | 120 |
| 17 | Urea 30 | SRN 12 lb N/A foliar | 42 |
| 18 | Urea 60 | SRN 12 lb N/A foliar | 72 |
| 19 | ESN 30 | SRN 12 lb N/A foliar | 42 |
| 20 | ESN 60 | SRN 12 lb N/A foliar | 72 |
| 21 | Urea 30 | KQ-XRN 12 lb N/A foliar | 42 |
| 22 | Urea 60 | KQ-XRN 12 lb N/A foliar | 72 |

Results and Discussion:

Site 1176

N Rate study with urea and ESN: Root yield, extractable sucrose per ton, extractable sucrose per acre, and petiole nitrate-N in mid-July were significantly affected by nitrogen application rate, Table 2. Root yield was increased with 60 lb/A of N applied, Figure 1. With the soil test of 70 lb N/A, then the total N needed was 130 lb N/A for optimum root yield. The effect on root yield was similar whether we used urea or ESN as the preplant N source.

Extractable sucrose per ton was reduced from 290 lb/ton to 255 lb/ton with the addition of nitrogen fertilizer, Figure 1. The source of preplant N did not affect this decline in quality.

Because of the effect of N application on quality the optimum extractable sucrose per acre occurred with 30 to 60 lb N/A applied, Table 1. The source of N did not affect the extractable sucrose per acre. The

total N need for optimum extractable sucrose per acre was between 100 and 130 lb/A. This falls well in line with the current guidelines for Southern Minnesota Beet Sugar Cooperative growing area.

The most recently matured sugar beet petiole was sampled from 15 plants in each plot during mid-July in 2011. The addition of preplant applied nitrogen, either as urea or ESN, increased the amount of nitrate-N in the petiole at that time of sampling, Figure 1. This increase is an indicator that more nitrogen is getting into the plant for the addition of more fertilizer N. Since nitrogen is an purity, it also indicates why the extractable sucrose per ton was reduced with the N application.

Table 2. Statistical analysis of N rate and N source on root yield, extractable sucrose per ton, extractable sucrose per acre, and petiole nitrate-N concentration in mid-July at site 1176 in 2011.

| | Root yield | Extractable sucrose per ton | Extractable sucrose per acre | Petiole nitrate-N |
|-------------------|-------------------|-----------------------------|------------------------------|-------------------|
| Statistic | ----- P > F ----- | | | |
| N rate | 0.0006 | 0.001 | 0.03 | 0.0001 |
| N source | 0.21 | 0.81 | 0.42 | 0.54 |
| N rate X N source | 0.05 | 0.57 | 0.15 | 0.07 |
| C.V. (%) | 5.4 | 4.6 | 6.9 | 23.7 |

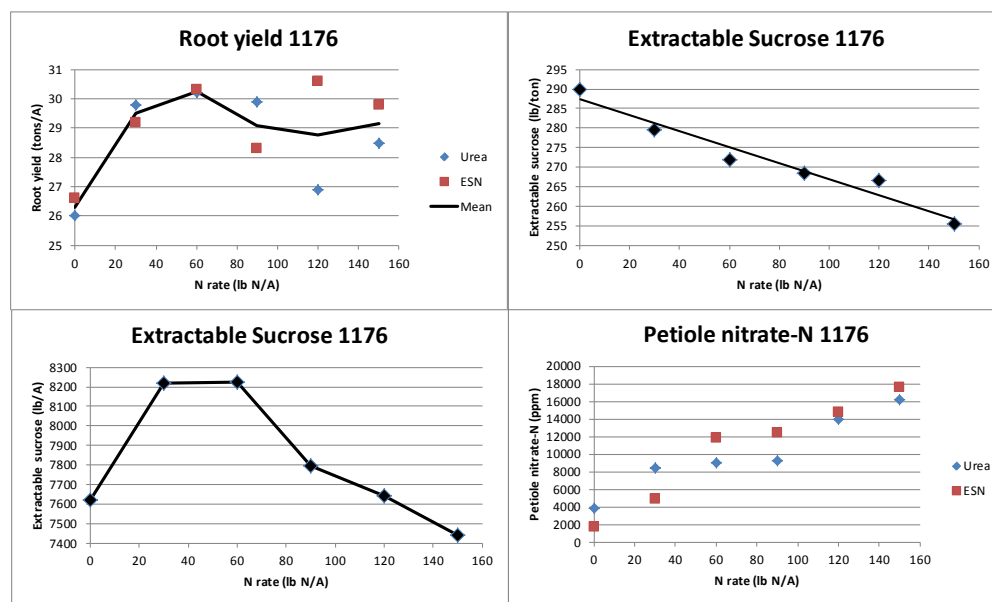


Figure 1. Root yield, extractable sucrose per ton, extractable sucrose per acre, and petiole nitrate-N concentration in mid-July 2011 at site 1176.

Evaluation of split applications: The use of split applications of nitrogen has been suggested as a way to grown large sugar beet roots while minimizing the detrimental effects of nitrogen on root quality. This evaluation was done using the 60 lb N/A treatments. The slow availability split applications of SRN and XRN actually had 72 lb N/A applied. The statistical analysis indicates that there was no difference in root yield, extractable sucrose per ton, and extractable sucrose per acre caused by the different products and split application management, Table 3 and Figure 2. Petiole nitrate-N concentration was affected by the treatments, Table 3 and Figure 2. The petiole nitrate-N concentration was the least with the split application of urea, preplant May 14 and July 7, 2011. The plants treated with preplant ESN did have the greatest petiole nitrate-N concentration. This was caused by the N in this treatment being all from ESN and the slow release characteristic of this product. The lower petiole nitrate-N concentration in the plants treated with the split application urea show a possible strategy to increase quality, but the root yield was not increased by the treatment.

Table 3. Statistical analysis of split applications with several N sources at the 60 lb N/A rate for root yield, extractable sucrose per ton, extractable sucrose per acre, and petiole nitrate-N concentration in mid-July at site 1176 in 2011.

| | Root yield | Extractable sucrose per ton | Extractable sucrose per acre | Petiole nitrate-N |
|-----------|-------------------|-----------------------------|------------------------------|-------------------|
| Statistic | ----- P > F ----- | | | |
| Product | 0.33 | 0.58 | 0.28 | 0.008 |
| C.V. (%) | 4.7 | 4.4 | 5.5 | 31.0 |

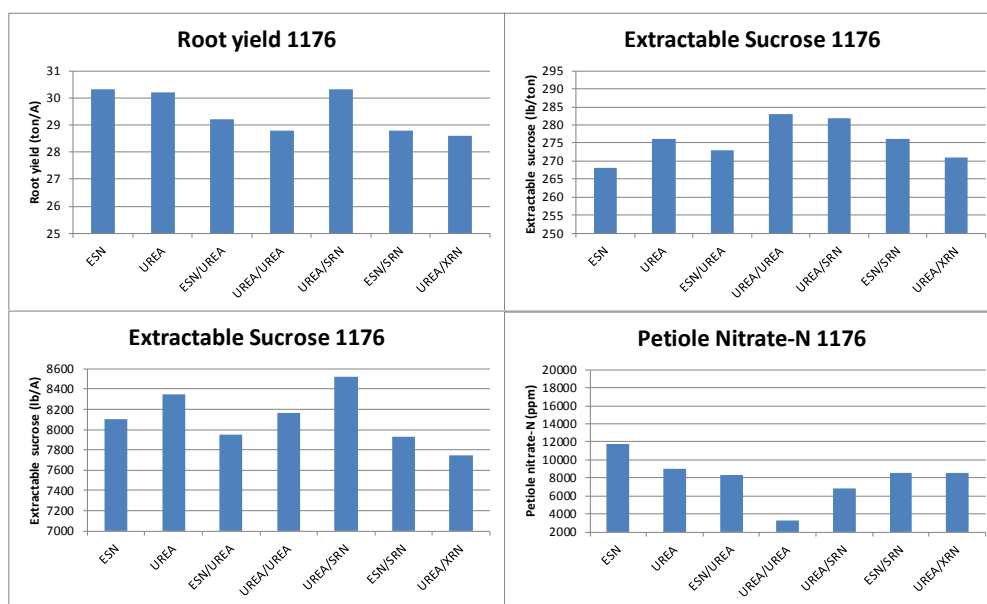


Figure 2. Root yield, extractable sucrose per ton, extractable sucrose per acre, and petiole nitrate-N concentration in mid-July 2011 at site 1176 as affected by different split applications and products at 60 lb N/A.

Site 1274

N Rate study with urea and ESN: Root yield and extractable sucrose per acre responses to the addition of ESN and Urea fertilizer caused an interaction, Table 4, and Figure 3. The addition of N as urea increased both root yield and extractable sucrose per acre with increasing amounts added. The optimum N rate when urea was the N source for root yield was 120 lb N/A while the optimum N rate for extractable sucrose per acre was 90 lb N/A. This result would have put the optimum N rate plus soil test N at this site at 160 lb N/A. This is on the high side of the current guideline. The use of ESN had the opposite effect and the root yield decrease with the addition of N as ESN. The addition of N as either ESN or Urea decreased the amount of extractable sucrose per ton. As the amount of N applied increased above 30 lb N/A, the extractable sucrose per ton decreased 1 lb/ton for every 3.4 lb N applied.

Table 4. Statistical analysis of N rate and N source on root yield, extractable sucrose per ton, and extractable sucrose per acre at site 1274 in 2012.

| | Root yield | Extractable sucrose per ton | Extractable sucrose per acre |
|-------------------|-------------------|-----------------------------|------------------------------|
| Statistic | ----- P > F ----- | | |
| N rate | 0.22 | 0.0001 | 0.62 |
| N source | 0.81 | 0.45 | 0.49 |
| N rate X N source | 0.0001 | 0.51 | 0.008 |
| C.V. (%) | 7.9 | 3.6 | 9.2 |

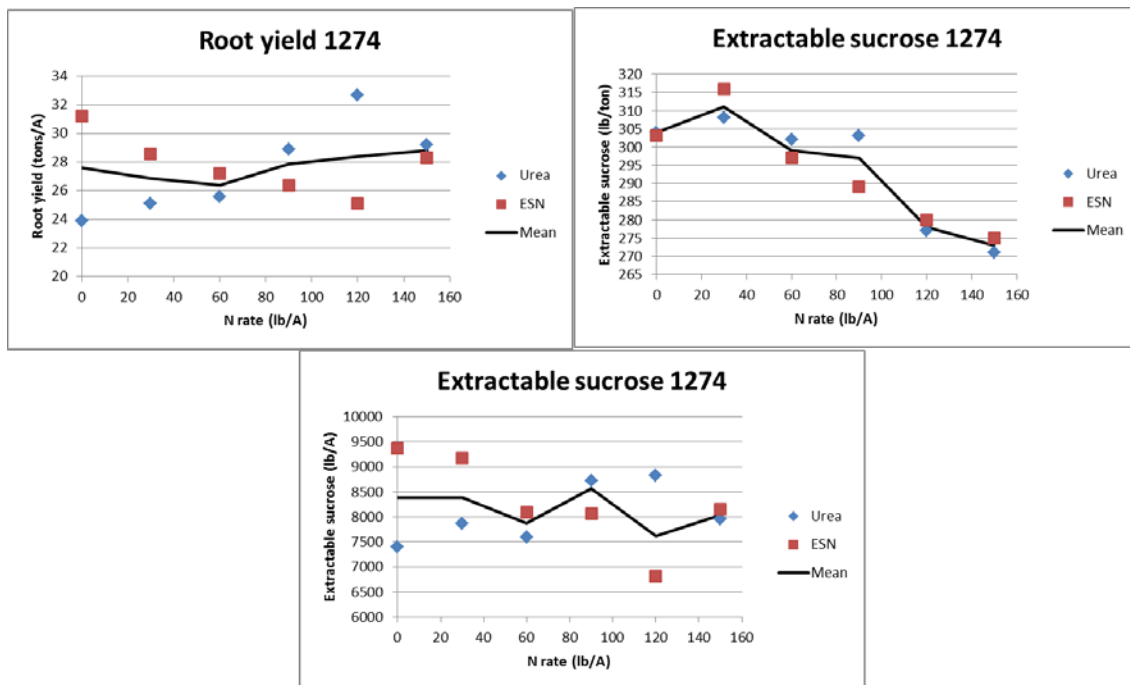


Figure 3. Root yield, extractable sucrose per ton, and extractable sucrose per acre in 2012 at site 1274.

Evaluation of split applications: The use of split applications and slow release products did not significantly affect root yield, extractable sucrose per ton, or extractable sucrose per acre, Table 5, Figure 4. Because of the dry summer, there was considerable variability in the measurements of root yield and extractable sucrose at this site.

Table 5. Statistical analysis of split applications with several N sources at the 60 lb N/A rate for root yield, extractable sucrose per ton, and extractable sucrose per acre at site 1274 in 2012.

| | Root yield | Extractable sucrose per ton | Extractable sucrose per acre |
|-----------|------------|-----------------------------|------------------------------|
| Statistic | | ----- P > F ----- | |
| Product | 0.23 | 0.54 | 0.60 |
| C.V. (%) | 10.7 | 4.7 | 13.7 |

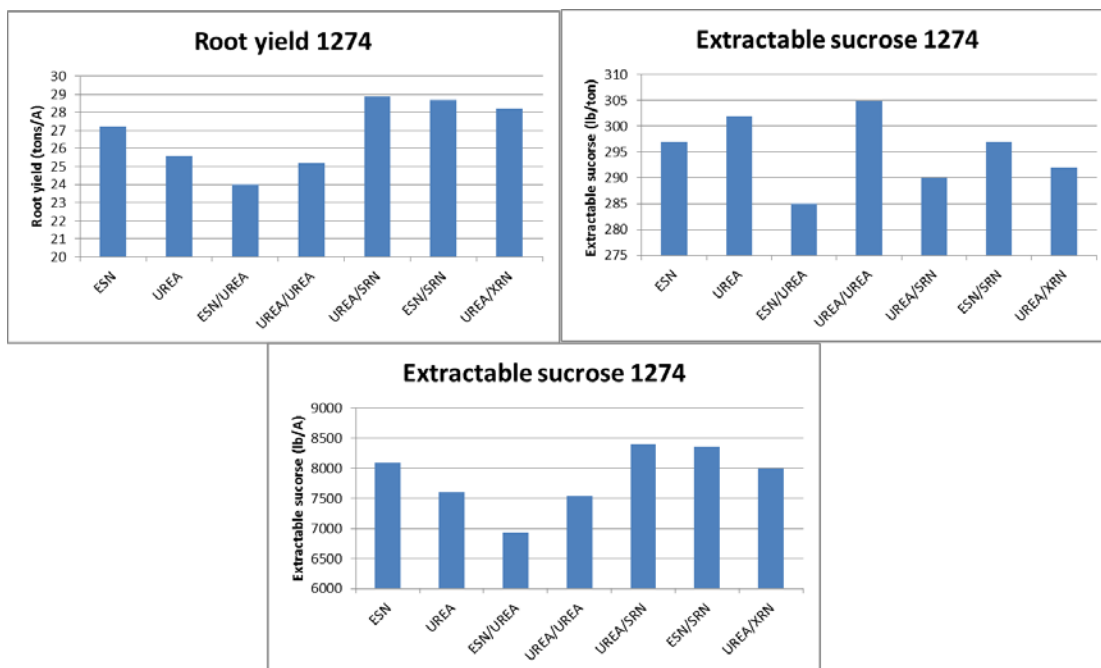


Figure 4. Root yield, extractable sucrose per ton, and extractable sucrose per acre in 2012 at site 1274 as affected by different split applications and products at 60 lb N/A.

Site 1275

N Rate study with urea and ESN: Root yield, extractable sucrose per ton, and extractable sucrose per acre were significantly affected by nitrogen application rate and had an interaction with the source of N, Table 6, Figure 5. When urea was the N source, root yield was increased with 60 lb/A and 150 lb/A of N applied, Figure 5. The effect of dry weather caused some strange root yields at the 90 and 120 lb N/A of urea treatments. The ESN treatment, did not affect root yields. The response for root yield was similar for the extractable sucrose per acre. The extractable sucrose per ton was reduced by increasing N rates as urea. The reduction was 1 lb/ton per each 3.75 lb N/A application. With the soil test of 48 lb N/A, the optimum N application should have been between 50 and 70 lb N/A.

Table 6. Statistical analysis of N rate and N source on root yield, extractable sucrose per ton, and extractable sucrose per acre at site 1275 in 2012.

| | Root yield | Extractable sucrose per ton | Extractable sucrose per acre |
|-------------------|-------------------|-----------------------------|------------------------------|
| Statistic | ----- P > F ----- | | |
| N rate | 0.0002 | 0.0007 | 0.02 |
| N source | 0.76 | 0.62 | 0.45 |
| N rate X N source | 0.01 | 0.01 | 0.02 |
| C.V. (%) | 8.18 | 3.4 | 8.5 |

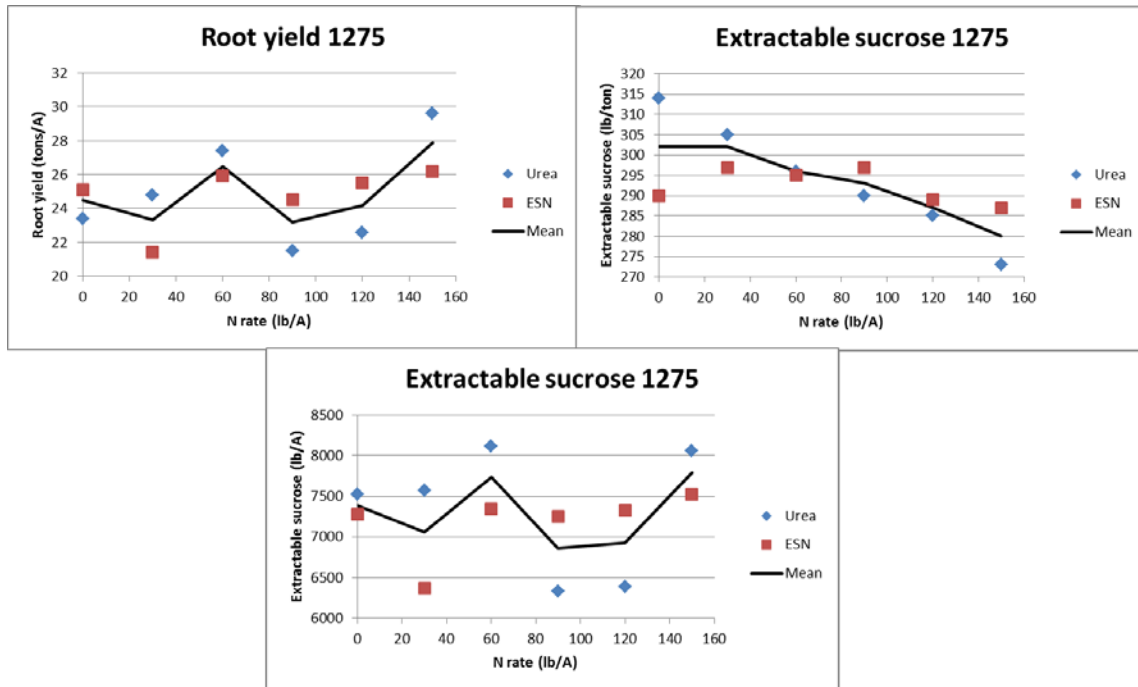


Figure 5. Root yield, extractable sucrose per ton, and extractable sucrose per acre in 2012 at site 1275.

Evaluation of split applications: As in the other two sites, the use of split applications of nitrogen was done using the 60 lb N/A treatments. The slow availability split applications of SRN and XRN actually had 72 lb N/A applied. The statistical analysis indicates that there was no difference in root yield, extractable sucrose per ton, and extractable sucrose per acre caused by the different products and split application management, Table 7 and Figure 6.

Table 7. Statistical analysis of split applications with several N sources at the 60 lb N/A rate for root yield, extractable sucrose per ton, and extractable sucrose per acre at site 1275 in 2012.

| | Root yield | Extractable sucrose per ton | Extractable sucrose per acre |
|-----------|-------------------|-----------------------------|------------------------------|
| Statistic | ----- P > F ----- | | |
| Product | 0.22 | 0.32 | 0.32 |
| C.V. (%) | 8.3 | 3.9 | 9.2 |

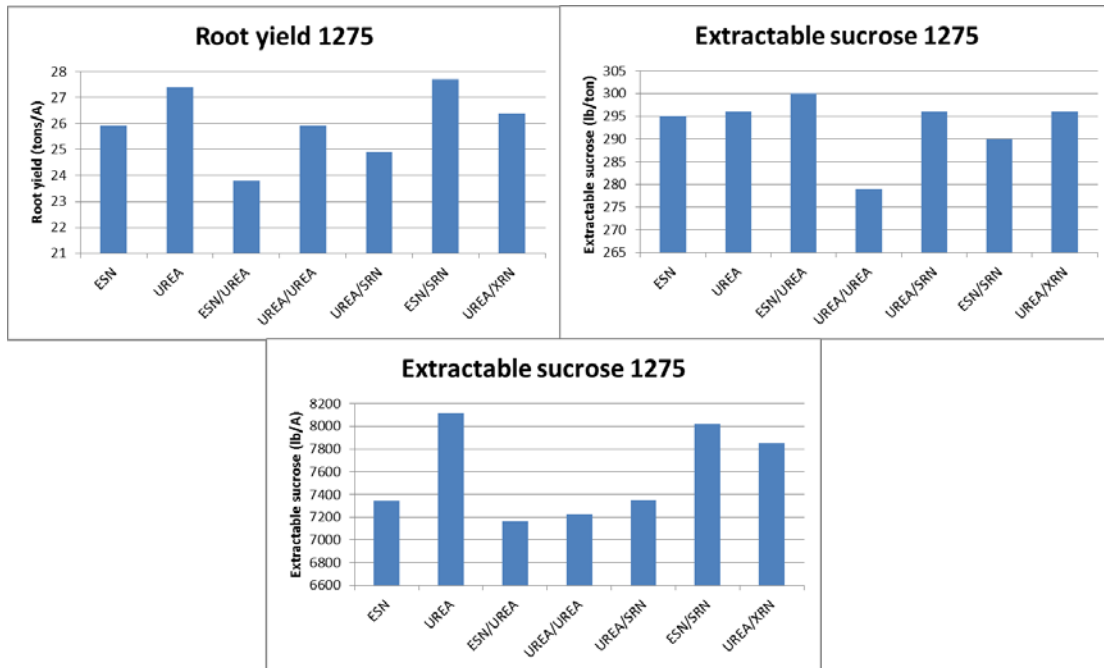


Figure 6. Root yield, extractable sucrose per ton, and extractable sucrose per acre in 2012 at site 1275 as affected by different split applications and products at 60 lb N/A.

Summary: The information from three sites has indicated that the use of ESN as a N source did not increase root yield or extractable sucrose per acre. It's use decreased sugar beet quality as measured by extractable sucrose per ton similarly to urea. In this study, there was also no advantage to the use of a split application of urea or the use of foliar slow release products to sugar beet production.

Literature Cited:

Lamb, J.A., M.W. Bredehoeft, and S.R. Roehl. 2006a. Nitrogen management with sugarbeet varieties as influenced by rhizomania. *In* 2005 Sugarbeet Res. and Ext. Rpts. 36:123-130.

Lamb, J.A., G.W. Rehm, and M.W. Bredehoeft. 2006b. Grid cell size for sugar beet nitrogen application in Southern Minnesota: Nutrient maps, root yield, root quality, and recoverable sucrose. *Comm. Plant and Soil Anal.* 37:143-154.

Lamb, J.A., M.W. Bredehoeft, and S.R. Roehl. 2005. Nitrogen management with sugarbeet varieties as influenced by rhizomania. *In* 2004b Sugarbeet Res. and Ext. Rpts. 35:91-99.

Lamb, J.A., M.W. Bredehoeft, and S.R. Roehl. 2004. Nitrogen management on a field scale. *In* 2004 Sugarbeet Res. and Ext. Rpts. 34:110-115.

Lamb, J.A., M.W. Bredehoeft, and S.R. Roehl. 2003. Nitrogen recommendation research in Southern Minnesota. *In* 2002 Sugarbeet Res. and Ext. Rpts. 33:89-91.

Lamb, J.A., A.L. Sims, L.J. Smith, and G.W. Rehm. 2001a. Fertilizing Sugar Beet in Minnesota and North Dakota. *Univ. Minn. Ext. Ser.* FO-07715-C 2001

Lamb, J.A., G.W. Rehm, M.W. Bredehoeft, S.R. Roehl, and J.A. Fischer. 2001b. Nitrate soil test adjustment for sugar beet grown in humid areas of Minnesota. *In* 2000 Sugarbeet Res. and Ext. Rpts. 31:98-102.

- Lamb, J.A., G.W. Rehm, M.W. Bredehoeft, S.R. Roehl, and J.A. Fischer. 2000. Nitrate soil test adjustment for sugar beet grown in humid areas of Minnesota. In 1999 Sugarbeet Res. and Ext. Rpts. 30:136-139.
- Lamb, J.A., G.W. Rehm, and M.W. Bredehoeft. 1999. Nitrate soil test adjustment for sugarbeet grown in humid areas of Minnesota. In 1998 Sugarbeet Res. and Ext. Rpts. 29:118-124.
- Lamb, J.A., and J.T. Moraghan. 1993. Comparison of foliar and preplant applied nitrogen fertilizer for sugar beet. *Agron. J.* 85:290-295.
- Lamb, J.A. 1989. Timing of nitrogen application on sugarbeet. In 1988 Sugarbeet Res. and Ext. Rpts. 19:85-88.
- Lamb, J.A. 1988. Timing of nitrogen application on sugarbeet. In 1987 Sugarbeet Res. and Ext. Rpts. 18:98-99.
- Lamb, J.A. 1987. Timing of nitrogen on sugarbeet. In 1986 Sugarbeet Res. and Ext. Rpts. 17:73-74.
- Lamb, J.A. 1986. Timing of nitrogen application on sugarbeets. In 1985 Sugarbeet Res. and Ext. Rpts. 16:96-97.
- Sims, A.L. 2010. Challenging current nitrogen recommendations: Sugar beet response to nitrogen in different RRV locations and soils – Report 2. In 2009 Sugarbeet Res. and Ext. Rpts. 40:87-98.