NITROGEN MANAGEMENT STRATEGIES FOR INCREASING SUGAR BEET ROOT QUALITY

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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 a polymer coating on the urea prill. 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 six 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 for 2011 and one site in 2012.

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
23	*ESN 45 + Urea 45*	*0*	*90*
24	*Urea 30*	*Urea 30*	*60*
25	*Urea 60*	*Urea 60*	*120*
26	*ESN 30*	*Urea 30*	*60*
27	*ESN 30*	*Urea 60*	*90*

Results and Discussion:

Site 1176

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, 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 pre-plant 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.

Table 2. Statistical analysis for the effect of N product and rate for root yield and extractable sucrose, 2011-2013.

	Root yield					Extractable sucrose per ton					Extractable sucrose per acre				
Term	1176	1274	1275	1273	1276	1176	1274	1275	1273	1276	1176	1274	1275	1273	1276
	-- P > F --														
N rate	0.01	0.15	0.01	0.18	0.01	0.01	0.01	0.01	0.08	0.01	0.03	0.05	0.02	0.12	0.07
Product	0.21	0.30	0.76	0.74	0.24	0.81	0.45	0.62	0.11	0.17	0.43	0.08	0.45	0.86	0.75
N*P	0.04	0.04	0.02	0.21	0.85	0.57	0.51	0.01	0.17	0.98	0.15	0.09	0.02	0.28	0.75
C.V. %	5.5	14.5	8.2	9.8	9.0	4.6	3.6	3.4	3.7	9.5	6.9	13.2	8.5	11.5	4.0

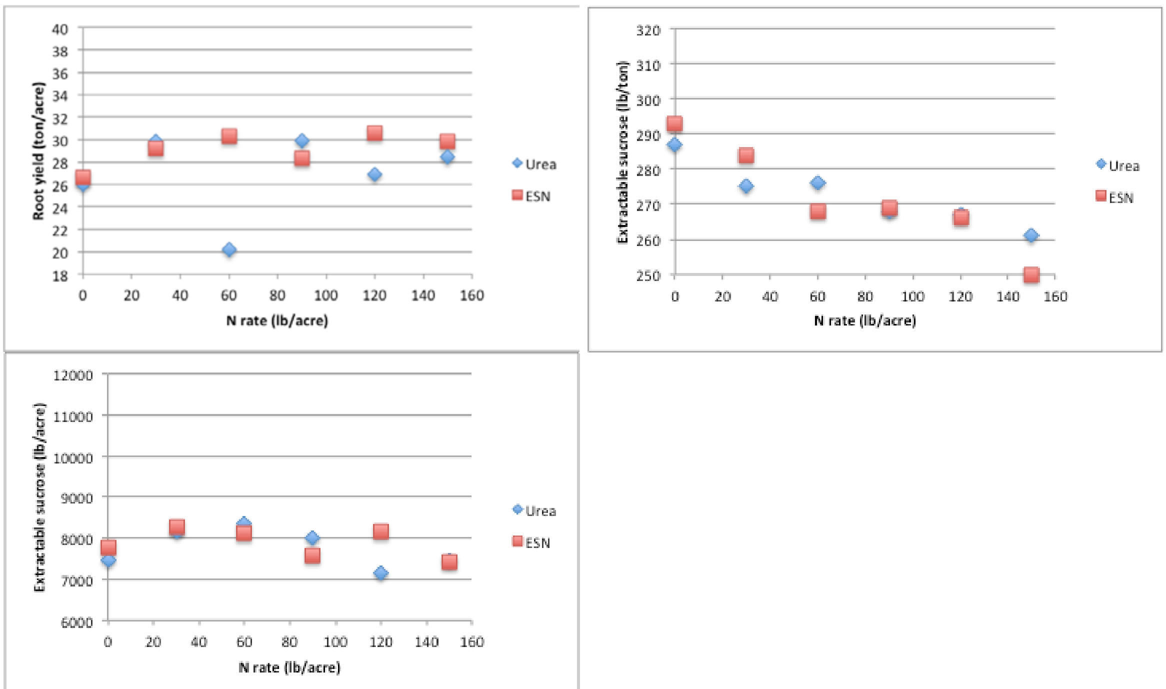

Figure 1. The effect of N source and rate on root yield, extractable sucrose per ton, and extractable sucrose per acre at site 1176 in 2011.

<u>Evaluation of split applications</u>: 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 use of 60 lb N/A did have an significant effect on root yield, extractable sucrose per ton, and extractable sucrose per acre when compared to the check. The application of N increased root yield and extractable sucrose per acre while is decreased the extractable sucrose per ton. The statistical analysis on the treatements applied at 60 lb N/A indicates 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.

Table 3. Nitrogen sources and management effects on root yield and extractable sucrose at site 1176 in 2011.

Treatment	Pre-plant source	Pre-plant N rate	Split source	Split N rate	Root yield	Extractable sucrose	
		lb N/A		lb N/A	Ton/A	lb/ton	lb/A
Check	-	0	-	0	26.3	290	7619
Urea	Urea	60	-	0	30.2	276	8349
ESN	ESN	60	-	0	30.3	268	8101
ESNUrea	ESN/U	60	-	0	29.3	273	7947
ESNUsplit	ESN/U	30	Urea	30	28.9	283	8162
UXRN	Urea	60	XRN	12 (2 gal)	28.6	271	7747
USRN	Urea	60	SRN	12 (2 gal)	30.3	281	8516
ESNSRN	ESN	60	SRN	12 (2 gal)	28.8	276	7927
Statistics							
Check vs rest					0.0001	0.009	0.02
Product					0.33	0.57	0.27
C.V. (%)					5.6	4.6	5.5

Site 1274

<u>N Rate study with urea and ESN:</u> Root yield and extractable sucrose per acre responses to the addition of ESN and Urea fertilizer caused an interaction, Table 2, and Figure 2. 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 decreased with the addition of N. 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.

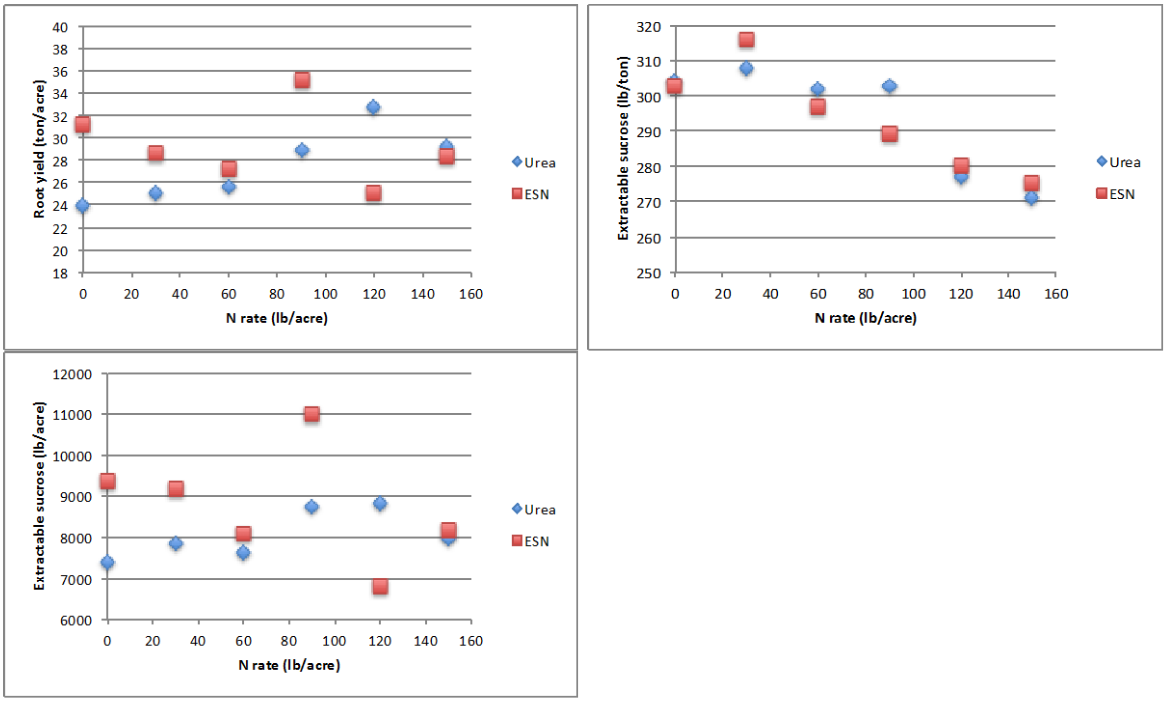

Figure 2. Root yield, extractable sucrose per ton, and extractable sucrose per acre in 2012 at site 1274.

<u>Evaluation of split applications</u>: 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 4. Because of the dry summer, there was considerable variability in the measurements of root yield and extractable sucrose at this site.

Table 4. Nitrogen sources and management effects on root yield and extractable sucrose at site 1274 in 2012.

Treatment	Pre-plant source	Pre-plant N rate	Split source	Split N rate	Root yield	Extractable sucrose	
		lb N/A		lb N/A	Ton/A	lb/ton	lb/A
Check	-	0	-	0	27.6	304	8384
Urea	Urea	60	-	0	25.6	302	7598
ESN	ESN	60	-	0	27.2	297	8091
ESNUrea	ESN/U	60	-	0	24.0	285	6935
Ureasplit	Urea	30	Urea	30	26.9	300	8009
ESNsplit	ESN	30	Urea	30	26.0	308	8175
ESNUsplit	ESN/U	30	Urea	30	25.2	305	7541
UXRN	Urea	60	XRN	12 (2 gal)	28.2	292	7998
USRN	Urea	60	SRN	12 (2 gal)	28.9	290	8401
ESNSRN	ESN	60	SRN	12 (2 gal)	28.7	297	8357
Statistics							
Check vs rest					0.67	0.29	0.37
Product					0.19	0.45	0.58
C.V. (%)					8.9	4.4	11.0

Site 1275

<u>N Rate study with urea and ESN:</u> 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 2, Figure 3. When urea was the N source, root yield was increased with 60 lb/A and 150 lb/A of N applied, Figure 3. 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.

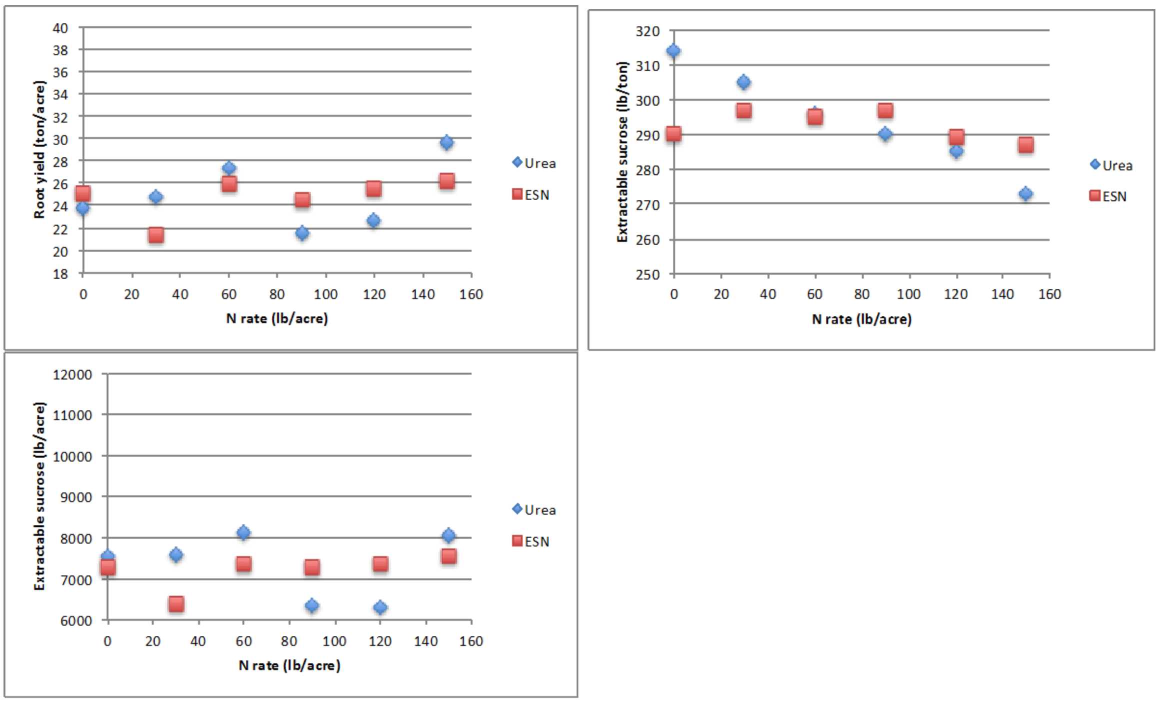

Figure 3. Root yield, extractable sucrose per ton, and extractable sucrose per acre in 2012 at site 1275.

<u>Evaluation of split applications</u>: 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 use of 60 lb N/A did significantly increase root yield compared to the root yield for the check. The use of 60 lb N/A also decreased the extractable sucrose per ton compared to the check. 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 5.

Table 5. Nitrogen sources and management effects on root yield and extractable sucrose at site 1275 in 2012.

Treatment	Pre-plant source	Pre-plant N rate	Split source	Split N rate	Root yield	Extractable sucrose	
		lb N/A		lb N/A	Ton/A	lb/ton	lb/A
Check	-	0	-	0	24.5	302	7387
Urea	Urea	60	-	0	27.4	296	8120
ESN	ESN	60	-	0	25.9	295	7347
ESNUrea	ESN/U	60	-	0	23.8	300	7160
ESNUsplit	ESN/U	30	Urea	30	25.9	279	7227
UXRN	Urea	60	XRN	12 (2 gal)	26.4	296	7853
USRN	Urea	60	SRN	12 (2 gal)	24.9	296	7354
ESNSRN	ESN	60	SRN	12 (2 gal)	27.7	290	8025
Statistics							
Check vs rest					0.10	0.05	0.42
Product					0.23	0.32	0.32
C.V. (%)					58.4	3.5	9.3

Site 1373

<u>N Rate study with urea and ESN:</u> Root yield and extractable sucrose per acre were not significantly affected by nitrogen application rate or the N source applied, Table 2, Figure 4. Extractable sucrose per ton was only affected by the addition of N. The source did not affect the result. The addition of N decreased the extractable sucrose per ton at site 1373 in 2013. The reduction was 1 lb/ton per each 0.05 lb N/A application. With the soil test of 50 lb N/A, the optimum N application should have been between 50 and 70 lb N/A.

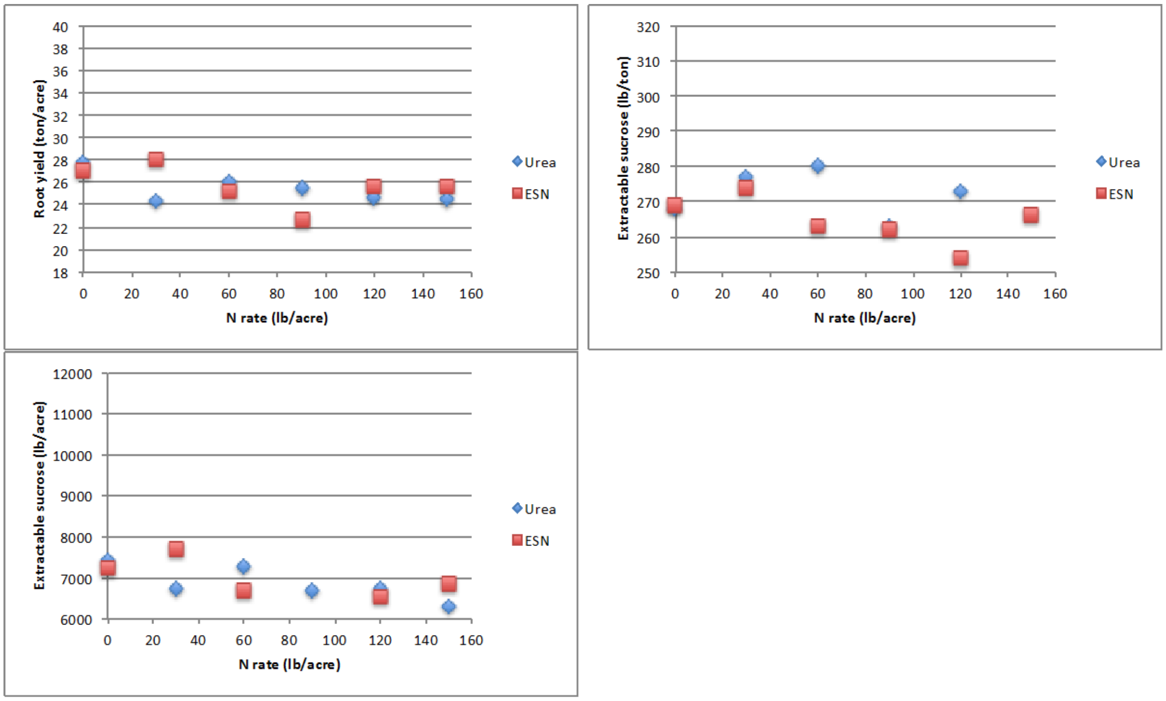

Figure 4. Root yield, extractable sucrose per ton, and extractable sucrose per acre in 2013 at site 1373.

<u>Evaluation of split applications</u>: As in the other 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. There was no response in root yield, extractable sucrose per ton, or extractable sucrose per acre to the addition of 60 lb N/A, Table 6. 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 6.

Table 6. Nitrogen sources and management effects on root yield and extractable sucrose at site 1373 in 2013.

Treatment	Pre-plant source	Pre-plant N rate	Split source	Split N rate	Root yield	Extractable sucrose	
		lb N/A		lb N/A	Ton/A	lb/ton	lb/A
Check	-	0	-	0	27.4	268	7330
Urea	Urea	60	-	0	26.0	280	7269
ESN	ESN	60	-	0	25.2	263	6687
ESNUrea	ESN/U	60	-	0	28.8	274	7896
Ureasplit	Urea	30	Urea	30	28.5	271	7864
ESNsplit	ESN	30	Urea	30	28.0	263	7362
ESNUsplit	ESN/U	30	Urea	30	23.9	272	6498
UXRN	Urea	60	XRN	12 (2 gal)	27.6	287	8481
USRN	Urea	60	SRN	12 (2 gal)	28.2	264	7321
ESNSRN	ESN	60	SRN	12 (2 gal)	22.5	276	6230
Statistics							
Check vs rest					0.47	0.39	0.90
Product					0.23	0.21	0.25
C.V. (%)					10.4	4.2	11.0

Site 1376

N Rate study with urea and ESN: Unlike the other 4 sites in this study, site 1376 was irrigated. The soil surface was a loam with a gravelly subsurface. Root yield, extractable sucrose per ton, and extractable sucrose per acre were significantly affected by nitrogen application rate, Table 2, Figure 5. The addition of nitrogen increased root yield and extractable sucrose per acre up to the 150 lb N/A application rate. The decrease in extractable sucrose per ton was not severe. The addition of N up to 90 lb/A did not reduce extractable sucrose per ton. Applications greater than 90 lb N/A caused a 10 lb sucrose per ton between the 90 and 150 lb N/A N application rates. Usually an irrigated loam over gravel soil has very little residual nitrate-N. The increase in root yield and extractable sucrose per acre was not unexpected.

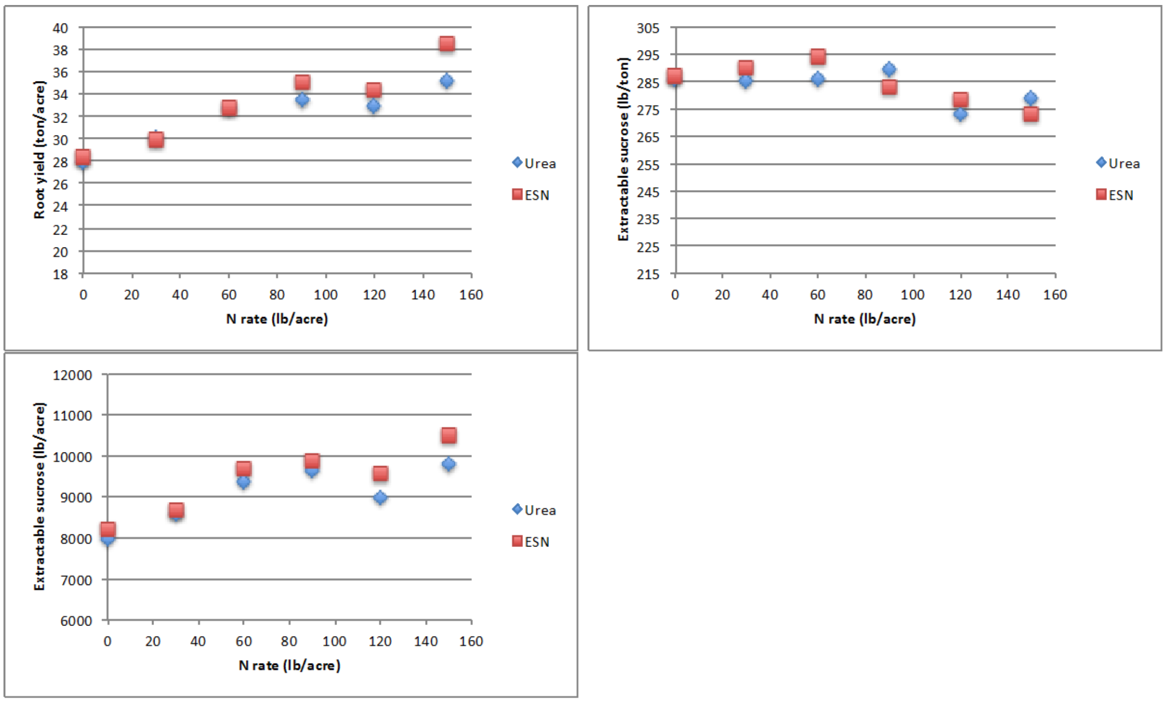

Figure 5. Root yield, extractable sucrose per ton, and extractable sucrose per acre in 2013 at site 1376.

Evaluation of split applications: As in the other 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. There was a significant increase in root yield and extractable sucrose per acre from the use of 60 lb N/A, Table 7. The extractable sucrose per ton was not effected by the application of N or the product or management used. At this site, the ESN/Urea mix applied at pre-plant had greater root yield and extractable sucrose per acre than the Urea and ESN pre-plant treatments. The ESN/Urea split application was superior compared to the other split applications. This was the only site that had significant difference caused by the different sources or management splits. It was also the only irrigated site in this study. Split applications have been shown to be superior in irrigated situations because of the increased leaching potential. This may be why certain treatments were superior.

Table 7. Nitrogen sources and management effects on root yield and extractable sucrose at site 1376 in 2013.

Treatment	Pre-plant source	Pre-plant N rate	Split source	Split N rate	Root yield	Extractable sucrose	
		lb N/A		lb N/A	Ton/A	lb/ton	lb/A
Check	-	0	-	0	28.2	286	8089
Urea	Urea	60	-	0	32.8	284	9368
ESN	ESN	60	-	0	32.8	294	9662
ESNUrea	ESN/U	60	-	0	35.5	293	10349
Ureasplit	Urea	30	Urea	30	33.1	296	9791
ESNsplit	ESN	30	Urea	30	34.4	290	9979
ESNUsplit	ESN/U	30	Urea	30	32.6	299	9756
UXRN	Urea	60	XRN	12 (2 gal)	33.0	283	9325
USRN	Urea	60	SRN	12 (2 gal)	29.5	285	8413
ESNSRN	ESN	60	SRN	12 (2 gal)	33.0	290	9576
Statistics							
Check vs rest					0.0008	0.17	0.0001
Product					0.09	0.13	0.05
C.V. (%)					8.0	2.8	8.2

Summary: The information from five 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, at four of the five sites, 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. The irrigated site did have some yield differences because of some of the management practices. This could be from the sandy nature of the subsoil at this site.

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