DO WE NEED TO REVISIT CURRENT NITROGEN RECOMMENDATIONS FOR THE NEW HIGH YIELDING SUGAR BEET VARIETIES?

A. Chatterjee[1], K. Subedi[1], H. Mickelson[2], N. Cattanach[1], D.W. Franzen[1], L. Sharma[3]
[1] Department of Soil Science, North Dakota State University, Fargo, ND
[2]Scientist, Northwest Research and Outreach Center, University of Minnesota, Crookston, MN
[3]Assistant Professor Extension & Sustainable Agriculture, University of Maine Cooperative Extension, Presque Isle, Maine

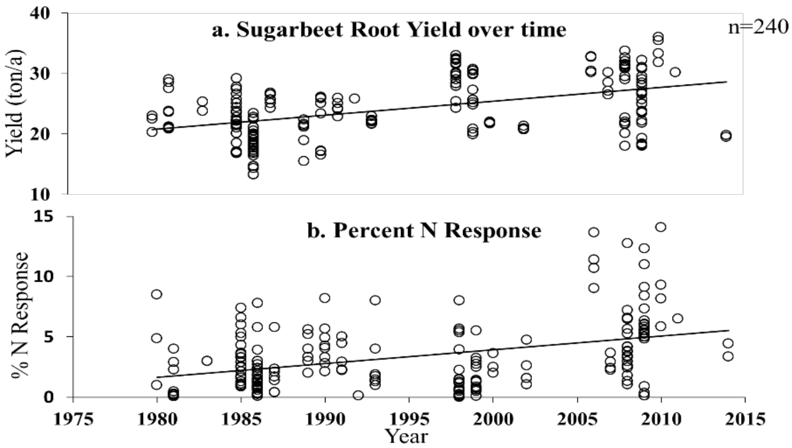

Figure 1. (Top) Changes in beet yield in the Red River Valley during 1980 to 2015; (bottom) Percent N response = {(Y_N-Y_0)/N}*100, where Y= yield in response to N addition, Y_0 = yield without N, and N = amount of fertilizer N

Current sugarbeet nitrogen (N) recommendations were developed in 2001 (Lamb et al. 2001), since then sugarbeet root yields have been substantially increased from an average of 21 to 28 ton per acre mostly due to introduction of high yielding disease resistant varieties (Sims 2010, Lamb et al. 2012) (Fig. 1). Fertilizer N management is a critical factor in sugarbeet production. Root yield, extractable sucrose per ton and purity percentage are greatly affected by the N application rate (Lamb et al 2013). Under-application of N fertilizer can result in reduced root yield while over-application can result in decreased sugar content and recoverable sucrose percentage, increased production cost and contamination of ground and surface water (Tarkalson, 2012). Economic return depends on both yield and quality. Increasing fertilizer N may increase the yield but at the cost of increasing soluble non sucrose constituents such as potassium (K), sodium (Na), and soluble nitrogen (N) which prevent sucrose from crystallizing and reduce processed sugar yield (Pollach et al., 1996). We have conducted on-farm trials to recalibrate the fertilizer N application rates of sugarbeet to maximize the yield and sugar content.

Table 1. Initial soil properties and relevant information of experimental sites

	Crookston, MN	Ada, MN	Hickson, ND	Sabin, MN
Previous Crop	Wheat	Wheat	Sugarbeet	Soybean
Soil Series	Wheatville	Glyndon	Fargo	Wyndmere
EC (ds m^{-1})	0.41	0.31	0.61	0.62
pH	7.9	8.2	7.5	8.2
Initial Soil N 2ft lb/ac	16	47	53	47
Olsen P (ppm)	6	22	13	10
Extractable K_2O (ppm)	215	100	445	113
Planting	April 30	April 27	3 May	April 23
Harvesting	24 September	21 September	15 September	21 September

During 2015 growing, trials were conducted at four sites, Crookston MN, Ada MN, Hickson ND and, Sabin MN across the Red River Valley. Initial soil nutrient availability and other background information are presented in table 1. At each site, five N application rates (0,100, 130, 160, 190 lb N/acre) in the form of urea were arranged in randomized complete block design with four replications. For 160 and 190 lb N/ac rates, 130 lb/ac was applied pre-plant and rest 30 and 60 lb N/ac was top dressed in last week of May. Application of N above 130 lb/ac was reported to have negative effects on sugarbeet seed germination.

Table 2. Monthly total precipitation and average monthly temperature during growing season.

	Crookston, MN		Ada, MN		Hickson, ND		Sabin, MN	
Mo	**Precip. (in)**	**Temp (^{0}F)**	**Precip. (in)**	**Temp (^{0}F)**	**Precip. (in)**	**Temp (^{0}F)**	**Precip. (in)**	**Temp (^{0}F)**
Apr	0.58	44.0	0.78	44.6	0.50	46.4	0.50	46.4
May	2.71	65.3	4.75	53.6	5.70	55.4	5.70	55.4
Jun	3.77	64.2	3.98	64.4	2.31	66.2	2.31	66.2
Jul	5.04	70.0	2.61	69.8	1.86	71.6	1.86	71.6
Aug	1.12	65.8	1.05	66.2	1.10	68.0	1.10	68.0
Sept	1.16	62.6	0.50	62.6	0.55	64.4	0.55	64.4

Each experimental plot was 11 ft wide consisted of six rows with row spacing of 22 inches. Each plot were 30 ft in length except in Crookston site, where plots were 35 ft in length. The sugar beet cultivar (Crystal 093) was planted at the depth of 1.25 inches with 5 inch seed spacing.

The center two rows of each plot were mechanically harvested for yield determination and a sub sample of 10-15 roots were analyzed for quality at American Crystal Sugar Quality Tare Lab, East Grand Forks, MN. Profile soil samples of 4 ft with depth increments of 0-6", 6-12", 12-24", 24-36" and 36-48" were collected after harvest. Soil samples were analyzed for residual inorganic N- ammonium (NH_4^+) and nitrate (NO_3^-) concentrations. Normalized Difference in Vegetation Index (NDVI) were collected for center two rows of each plot using a handheld NDVI sensor (Crop Circle) on 2nd July and 10th July during the growing season and again on the day of harvest. Statistical analyses were performed using PROC GLM procedure for RCBD in SAS 9.4 (SAS Institute, 2010).

Table 3. Sugarbeet root yield (t/ac) in response to N fertilizer application rates at four sites in the Red River Valley.

Treatments	Crookston, MN		Ada, MN		Hickson, ND		Sabin, MN	
	Yield (t/ac)	Sugar%	Yield (t/ac)	Sugar%	Yield (t/ac)	Sugar%	Yield (t/ac)	Sugar%
Control	21.5c	17.43	34.3b	16.33	23.9	17.00	31.2	17.48
100 lb/acre	26.7ab	17.40	38.5 b	16.43	23.6	16.82	33.4	17.55
130 lb/acre	26.9ab	17.23	39.9a	16.50	24.9	16.89	34.9	17.60
160 lb/acre	29.9a	16.90	38.8a	16.08	23.8	15.98	34.9	17.48
190 lb/acre	26.2b	16.95	39.2a	16.15	24.6	16.21	35.7	17.65
LSD (α = 0.05)	3.5	ns	2.9	ns	ns	ns	ns	ns

Different lower case letters within the same column indicate significant difference at 95% significance level.*ns = non-significant

Table 4. Residual inorganic soil N ($NH_4^+ + NO_3^-$) lb/ac in the soil profile (4 feet) after harvest

Treatments	Crookston, MN	Ada, MN	Hickson, ND	Sabin, MN
Control	18.02a	84.90b	1.51	22.03ab
100 lb/acre	18.59a	94.11ab	1.45	20.16b
130 lb/acre	19.74a	128.9a	2.04	25.48ab
160 lb/acre	19.08a	108.2ab	1.49	19.92b
190 lb/acre	20.42a	123.3a	1.51	27.03a

Different lower case letters within the same column indicate significant difference at 95% significance level.

Sugarbeet yield and sugar content in response to different N application rates were presented in Table 3. Out of four sites, Ada and Crookston sites showed significant differences in yield response to N. At Crookston, the highest yield was achieved with 160 lb N/ac but it was statistically similar with 100 and 130 lb N/ac. Application of N at 190 lb/ac resulted in reduction of yield as compared to 160 lb N/ac. At Ada, the highest yield was obtained with 130 lb N/ac and was significantly higher than 100 lb N/ac; N application above 130 lb N/ac did not increase yield. At Hickson, the highest yield was observed at 130 lb N/ac; whereas in Sabin, application of 190 lb N/ac had the highest yield. We did not find any significant difference in sugar content in response to N application rates. These results indicate initial soil available N and mineralizable N have potential to supply sufficient N two out of four sites, particularly for soils with high organic matter and moderate availability of P and K.

After harvest soil N analyses showed a significant difference in profile N at Ada and Sabin sites. At Ada, 130 lb N/ac had the highest soil N. Light-textured soils had increased downward movement of soil N. However at Sabin, highest profile N at 190 lb N/ac indicates application of N might steadily increase soil N but it was not utilized by plant. Lowest available N at Hickson site might be due to loss of N or immobilization by microbial community. Use of NDVI measurement showed a promise for yield prediction at three out of four sites and significant exponential relationships indicate role of other variables (climate and/or crop and/or soil) in yield besides fertilizer N applications (Figure 2).

This is the first year of this trial and we are planning to conduct it during 2016 growing season. However, it is interesting that sugar content did not respond to any N application rate. It is possible that high rainfall during May resulted in loss of N due to denitrification and leaching. In the 2015 season the current N recommendation system appear to remain valid.

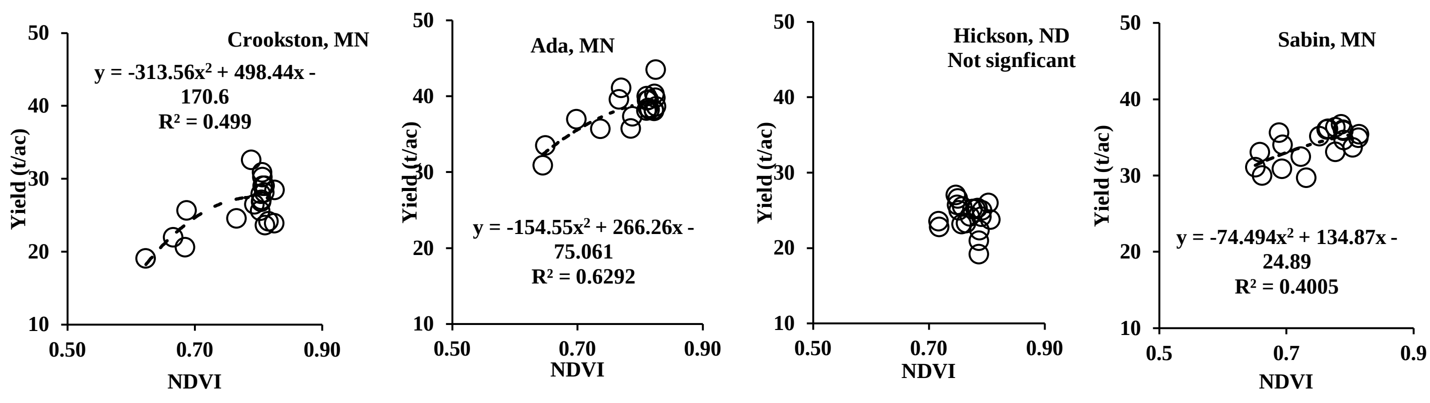

Figure 2. Regression analysis between yield (t/ac) and NDVI values of July 10 for all N treatments at four sites. Hickson site did not show any significant difference.

References:

Lamb, J. A. Sims, M. Bredehoeft, C. Dunsmore. 2010. Differences in nitrogen mineralization across a landscape. 2009 Sugarbeet Research and Extension Reports. Available online: www.sbreb.org

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

Lamb, J.A., M.W. Bredehoeft, C. Dunsmore, and N. Van. 2013. Nitrogen management strategies for increasing sugarbeet root quality. 2013. Sugarbeet Research and Extension Reports. Available online: www.sbreb.org.

Lamb, J.A., M.W. Bredehoeft, C. Dunsmore. 2012. Nitrogen management strategies for increasing sugar beet root quality. 2011 Sugarbeet Research and Extension Reports. Available online: www.sbreb.org.

Pollach, G., W. Hein and, G. Rosner. 1996. Definition of the ‘internal quality’ of sugarbeet. Zuckerindustrie 121:332-344.

Sims, A.L. 2010. Challenging current nitrogen recommendations: sugar beet response to nitrogen in different RRV locations and soils-report 2. 2009 Sugarbeet Research and Extension Reports. Available online: www.sbreb.org.

Tarkalson, D. 2011. Nitrogen requirements for sugarbeets: a summary of past and present research findings. 2012 Proceedings of Idaho nutrient management conference. 6:15-19.