Nitrogen Rate Effects on Sugarbeet Yield and Quality

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Proper application rates of N to sugarbeets continue to increase in importance with rising fertilizer costs, heightened awareness of potentially negative environmental effects, and industry transitions from tonnage-based payments to payments weighted toward crop quality. While multiple N rate trials have been conducted on this site and others in the Michigan beet growing region, their continued presence is crucial for refining N recommendations to maximize tonnage while maintaining or improving quality. Nitrogen fertility is a key component to profitability of sugarbeet growth and production with improved management benefiting the entire industry.

Interest has arisen in accounting for residual N contributed to the soil profile following sugarbeets. Nitrogen management is increasingly being viewed on a whole rotation scale, necessitating a better understanding of residual N. Applying N credits from previous sugarbeet rotations for use by subsequent crops can more accurately match N application rates with N requirements. More precise accounting of whole system N dynamics increases economic and environmental efficiency.

In addition to evaluating N rate effects on sugarbeet yield and quality, several methods to measure in-season N dynamics in above-ground biomass are examined for their viability to improve N management for the sugarbeet crop and for the whole rotation. Optical sensing instrumentation has emerged as a possible means to estimate N use efficiency, growing season N requirement, and yield potential for crops including corn and wheat. Vegetative indices are calculated from reflectance values of leaf tissue and are used to estimate photosynthetic potential and living cell mass.

Methodology

Sugarbeets (Beta 5833R) were planted to stand with a 6 row Monosem NG Plus at 4” in-row and 30” between-row spacing on April 18 into moist soil conditions. The previous crop was soybeans, and tillage consisted of fall (2005) moldboard plow and two spring passes with a field cultivator/finisher. Six N fertilizer treatments were arranged in a randomized complete block design with 4 replications (Table 1). Nitrogen starter fertilizer at 40 lb N ac^{-1} as urea (46-0-0) was banded 2”x 2” at planting for all N rates, except the 0 lb ac^{-1} control treatment. Sidedress rates of 40, 80, 120, and 160 lb N ac^{-1} as 28% UAN were injected between rows on June 2. An NTech Greenseeker (Ntech Industries, Inc., Ukiah, CA) optical sensor was used to measure normalized difference vegetative indices (NDVI) on sugarbeet above-ground biomass in mid-June, mid-July, and at harvest in mid-October. The NDVI is calculated by the optical sensor from the ratio of red to near-infrared reflectance in the plant canopy. The NDVI measurements are used to calculate the In-Season Estimation of Yield (INSEY), which is a function of the NDVI and cumulative growing degree days (GDD) from day of planting to day of sensing. Dividing NDVI by GDD results in INSEY, a value useful in yield prediction models. Leaf samples were collected at each sensing event for foliar N analysis. Just prior to harvest, sugarbeet tops were hand-collected and weighed from two 10’ lengths of the center two rows. Plots were harvested on October 16 with a two row research harvester, taking the center two rows for yield, with a 10-15 beet subsample collected for quality analysis.

Results

Sugarbeet yield averaged 30.2 ton ac^{-1} across all treatments receiving N fertilizer in 2007 and was similar for all treatments except the control, which averaged 22.3 ton ac^{-1} (Table 2). Percent sugar was significantly reduced only at the 200 lb N ac^{-1} fertilizer rate, though sugar tended to decline when fertilizer rate was greater than 40 lb N ac^{-1} (Fig. 1). Both percent clear juice purity (CJP) and amino N were impacted by N rate. The greatest CJP was reported for the 0, 40, and 160 lb N ac^{-1} fertilizer rates, while the 80 and 200 lb N ac^{-1} resulted in significantly less CJP than those treatments. While a decrease in CJP was expected at higher fertilizer rates, the presence of above adequate mineralized and residual N existing in the soil profile (as indicated by the non-responsiveness of yield at this site) likely influenced the results observed. Amino N concentration was greatest at fertilizer rates at or above 120 lb N ac^{-1}, indicating an increase in impurities as N rate increased (Table 2, Fig. 1).

Recoverable white sugar per ton (RWST) was similar for all treatments except the 200 lb N ac^{-1} rate, which resulted in less RWST (253.5 lb) relative to the other treatments (avg. 282.3 lb). Nitrogen rate did not significantly influence recoverable white sugar per acre (RWSA, Table 2). Both RWST and RWSA provide an indication of the amount of actual sugar produced and include factors of percent sugar and CJP. Although no significant differences were found for RWSA among treatments, these values tended to increase slightly with 40 to 80 lb N ac^{-1}, then remain relatively stable or decrease slightly at rates above 80 lb N ac^{-1} (Fig. 2).

Foliar N% was positively correlated with INSEY at sampling periods in mid-June and mid-July (Fig. 3), indicating that optical sensing may serve as a viable tool by which to access above-ground biomass N content. Foliar N% was greater for June sampling than July, indicating a greater concentration of N in leaf tissue early in the growing season. However, INSEY was greater for July sampling than June, reflecting an increase in relative top greenness as the season progressed. Optical sensor measurements obtained on day of harvest showed a positive correlation between NDVI (INSEY) and foliar N% or total top biomass N per acre (Fig. 4 and 5). As INSEY increased (reflecting an increase in NDVI, or relative greenness), plant tissue analysis indicated an increase in percent total N in the tops. These data support the possibility of using optical sensing instrumentation as an indicator of total N in beet tops and the subsequent implications of top N contributions to residual soil N for the following crop in the rotation.

Summary

Sugarbeet yield averaged 30.2 ton ac^{-1} across all treatments receiving N fertilizer in 2007 and was similar for all treatments except the control, which averaged 22.3 ton ac^{-1}. A decrease in CJP was expected at higher fertilizer rates, although the presence of above adequate mineralized and residual N existing in the soil profile (as indicated by the non-responsiveness of yield at this site) likely influenced the results observed, where CJP for beets receiving 80 lb N ac^{-1} was less than for those receiving 160 lb N ac^{-1}. While no significant differences in RWSA were found among the N fertilizer treatments, values tended to remain stable or decrease at rates above 80 lb N ac^{-1}. RWST was less for the 200 lb N ac^{-1} treatment compared with all other treatments including the control. Optical sensing at harvest was positively correlated with foliar N% and total top biomass N at topping, a trend that was evident as early as mid-June with NDVI measurements. Foliar N concentration was positively correlated with INSEY at sensing in June and July.

Table 1. Nitrogen rate treatments as starter and sidedress applications

Total N	Starter (urea)	Sidedress (28% UAN)
	- - - - - - - - - - - - - - - - lb N ac^{-1} - - - - - - - - - - - - - - - -	
0	-	-
40	40	-
80	40	40
120	40	80
160	40	120
200	40	160

Table 2. Sugarbeet yield and quality variables at incremental N fertilizer rates. Means with the same letter for a selected variable are not different at the α=0.05 level.

Treatment	Yield	Sugar	CJP	Amino N	RWST	RWSA
lb N ac^{-1}	ton ac^{-1}	%	%	mmol kg^{-1}	lb	lb
0	22.3b	18.6a	95.8a	4.49a	278.8a	6553.5
40	28.0a	19.3a	95.7a	5.35a	291.4a	7899.8
80	31.6a	18.9a	95.0bc	5.94ab	279.8a	8904.0
120	28.7a	18.9a	95.4ab	7.68bc	282.9a	8100.1
160	31.1a	18.6a	95.5a	8.42c	278.6a	8674.5
200	31.5a	17.4b	94.5c	9.64c	253.5b	7832.9
Pr>F	0.0015	0.0182	0.0024	0.0026	0.0082	NS

Figure 1. Percent sugar and amino N in relation to N fertilizer rate. Means with the same letter for a selected variable are not different at the α=0.05 level.

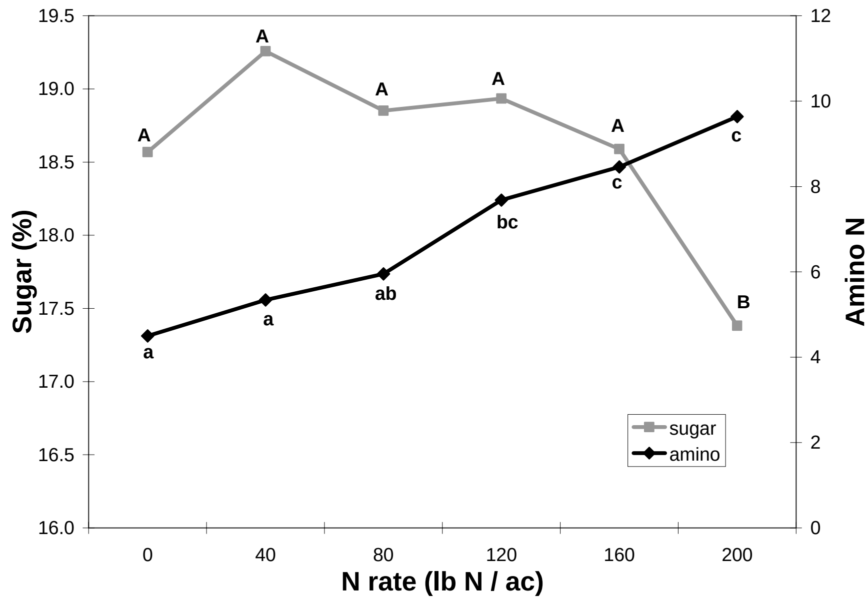

Figure 2. RWST and RWSA in relation to N fertilizer rate.

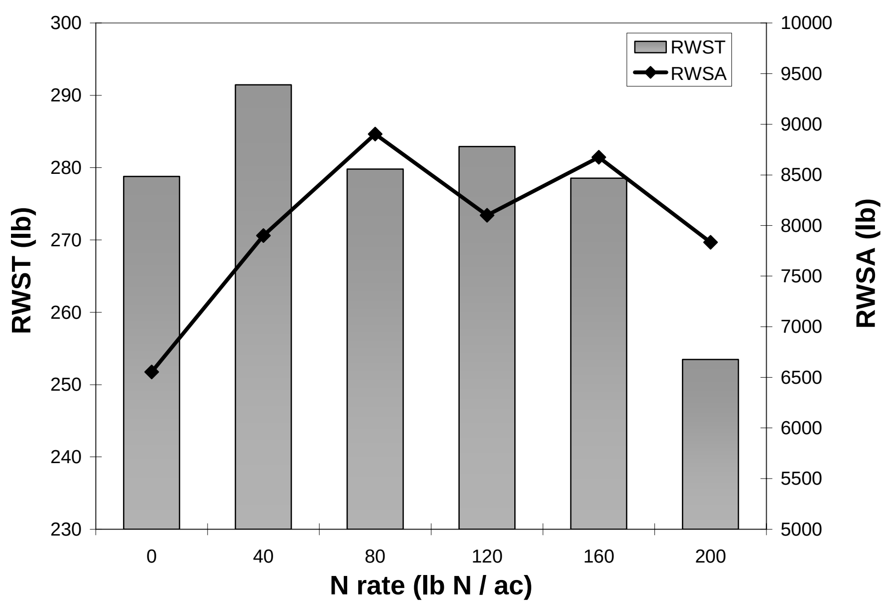

Figure 3. Correlation of INSEY and foliar N% for June and July observations.

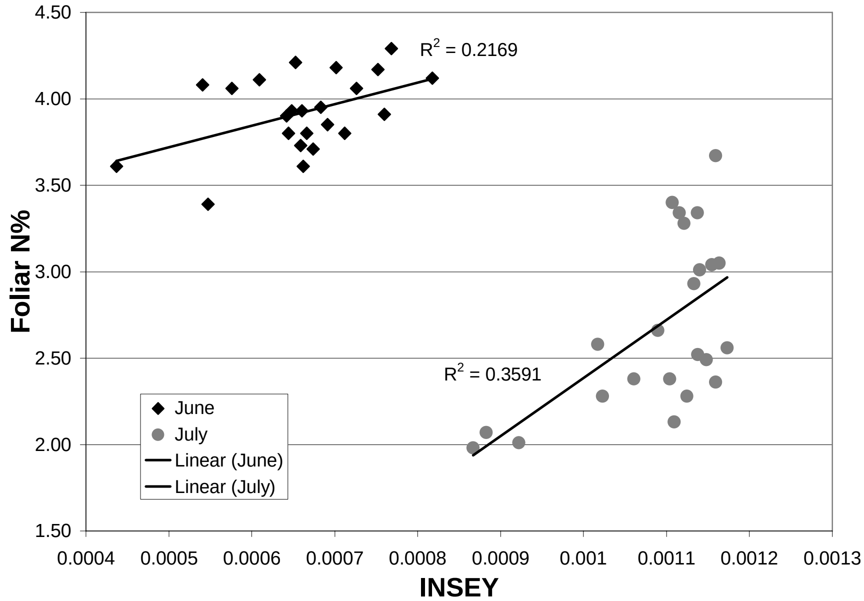

Figure 4. INSEY determined by NDVI prior to topping on day of harvest relative to foliar N% in sugarbeet tops.

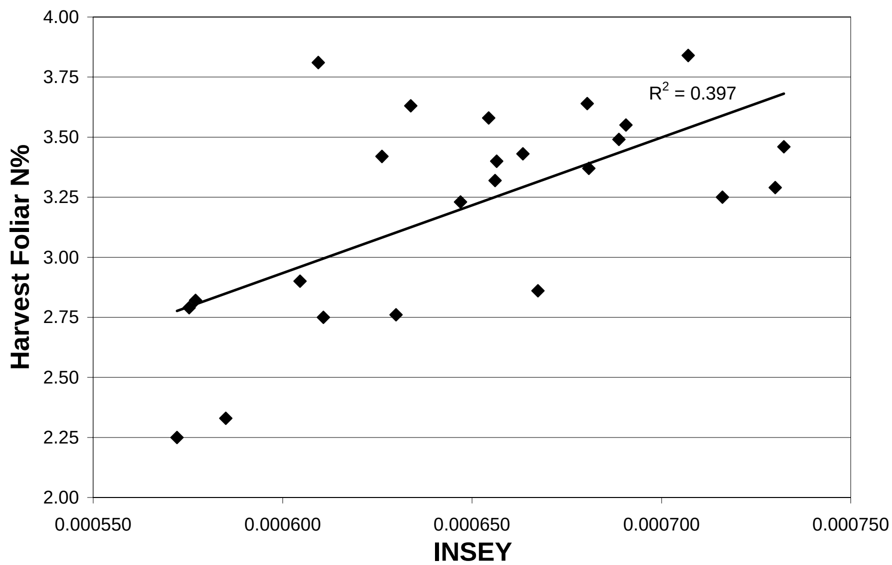

Figure 5. INSEY determined by NDVI prior to topping on day of harvest relative to total N in sugarbeet tops.