CROP CANOPY SENSOR FOR SUGARBEET PRODUCTION AND NITROGEN MANAGEMENT

Ron Gehl; Assistant Professor, Dept. of Soil Science, NC State University, and Tim Boring; Research Assistant, Dept. of Crop and Soil Sciences, Michigan State Univ.

Sugarbeet production efficiency depends on both root quantity and sugar quality – factors that are largely influenced by N fertilization. Considerable efforts have been made to develop indicators of sugarbeet N need. Recently, measurement of the absorption/reflectance characteristics of foliage has been adopted for N status assessment in various crops. Optical sensing instrumentation can be used to calculate vegetative indices, which are indicators of a plant's photosynthetic potential and above ground, green biomass. Research efforts have focused on the use of active sensors as a tool to estimate N use efficiency, N requirement, and yield potential for crops including corn and wheat.

Yearly sugarbeet production is limited by suitable storage days and processing plant capacity. In this limited window, profitability is directly related to recoverable sucrose. Calibration of a vegetative index for prediction of sugarbeet yield and quality during the growing season would be a valuable tool to assist in harvest scheduling. Additionally, recent increases in N fertilizer costs have prompted renewed interest in system-wide N accountability. Fifty to sixty percent of total sugarbeet N is located in tops, and the organic N returned to the soil from tops can mineralize considerably the spring following harvest, becoming available to the subsequent crop. Results of previous studies indicate the use of active sensors during the sugarbeet growing season shows promise as a means to predict root yield and quality, and to improve rotational N management by providing an indication of N return to the cropping system. With financial support provided by Michigan Sugar Company, a study was initiated in 2006 to evaluate the applicability of a Greenseeker (NTech Industries Inc., Ukiah, CA) optical sensor for estimating sugarbeet N requirement, root yield, root quality, and leaf residual N (top N).

Field experiments were established at three sites in 2006 and four sites in 2007. Treatments included six N rates ranging from 0 to 200 lb N/ac in 40 lb N/ac increments. Nitrogen starter fertilizer at 40 lb N/ac as urea was banded 2x2 at planting for all N rates except the 0 N control. Sidedress N as 28% UAN, comprising the remaining N rate, was injected between rows in early June. One site in 2006 and 2 sites in 2007 did not receive starter fertilizer. At those sites, all N fertilizer was applied at sidedress. Plots measured 6 rows wide by 40' and each treatment was replicated 3-4 times. Plots were managed by cooperating producers as part of the entire field, with the exception of N application and harvest. One site each year was on Saginaw Valley Bean and Beet Research Farm and was managed similarly to the other sites following general production practices of the region. Sugarbeet canopy NDVI was measured in mid-June, mid-July, mid-August, and at harvest using a hand-held Greenseeker optical sensor. The Greenseeker sensor calculates NDVI based on absorption/reflectance characteristics of plant tissue in the red and near-infrared bandwidths. Leaf tissue total biomass was determined immediately following Greenseeker scanning on the day of harvest, and subsamples were analyzed for total N. Root yield and quality were determined in each plot and were used to calculate RWST and RWSA.

Canopy NDVI was monitored throughout the season for assessment of crop N status. In 2006, NDVI measurements were similar for all N rates except the control in June, July and August. Mean NDVI values in September were greater for the 160 and 200 lb N/ac treatments compared with the 0 and 40 lb N/ac treatments. Similar trends were observed in 2007. As the season progressed, differences in relative greenness of the sugarbeet canopy among N rate treatments became more pronounced, as tops remained greener with increasing N rate. The differences in NDVI measured with the Greenseeker in the latter part of the growing season confirmed visual observations recorded at the field sites.

NDVI readings, regardless of N rate, tended to increase throughout the growing season as the sugarbeet canopy developed. The relatively low NDVI values and the lack of differentiation in NDVI among N treatments early in the season (June) is indicative that the use of active sensors for N management at that time may not be practical, particularly if small differences in canopy characteristics cannot be detected. Early season NDVI readings in particular are affected by soil background interference compared with later season readings, when the crop canopy begins to close and occupies a greater portion of the sensors field of vision. High soil background reflectance may be a significant challenge in sensing sugarbeet biomass at early growth stages and in appropriate time for corrective N management. Improved relationships observed between NDVI and leaf N from June to July in 2007 may be a result of increased canopy to soil ratios in the sensor field of vision.

Averaged across all sites and both years, sensor NDVI readings showed a strong relationship with root yield in July (R^2=64%) and August (R^2=82%) (Figure 1). Additionally, as early as mid-July, NDVI was strongly related to RWSA (R^2=69%) and this relationship improved at August sensing (R^2=77%) (Figure 2). Our results indicate that using a Greenseeker active sensor to generate NDVI measurements was useful for predicting root yield and recoverable sugar per acre with relatively good accuracy from mid-season through harvest. The difficulties correlating early season (prior to July) NDVI measurements with yield may be due to final determination of yield and quality occurring only later in the growing season.

Harvest NDVI was strongly related to sugarbeet top total N across all sites and N rates in 2006 and 2007 (R^2=85%, Figure 3). The ability to accurately predict total N in tops improves late in the season near harvest, particularly on the day of topping/harvest. Results indicate that NDVI measurements may be useful for determination of a N credit or delineation of N zones for improving N managements of the subsequent crop in the rotation. Using sensors for this purpose could have a significant impact on producers' input costs and reduce concerns regarding over-application of N fertilizers for Michigan sugarbeet cropping systems. However, for accurate prediction of top N using an active sensor, some tissue sampling will be necessary to calibrate the sensor. This calibration may be necessary on a field-by-field basis, or at the least by variety planted since top greenness is quite variable among varieties. Additional research is planned, at a larger field-scale, to attempt to address some of these issues.

Figure 1. Prediction of sugarbeet root yield using Greenseeker NDVI generated by sensing in mid-July and August.

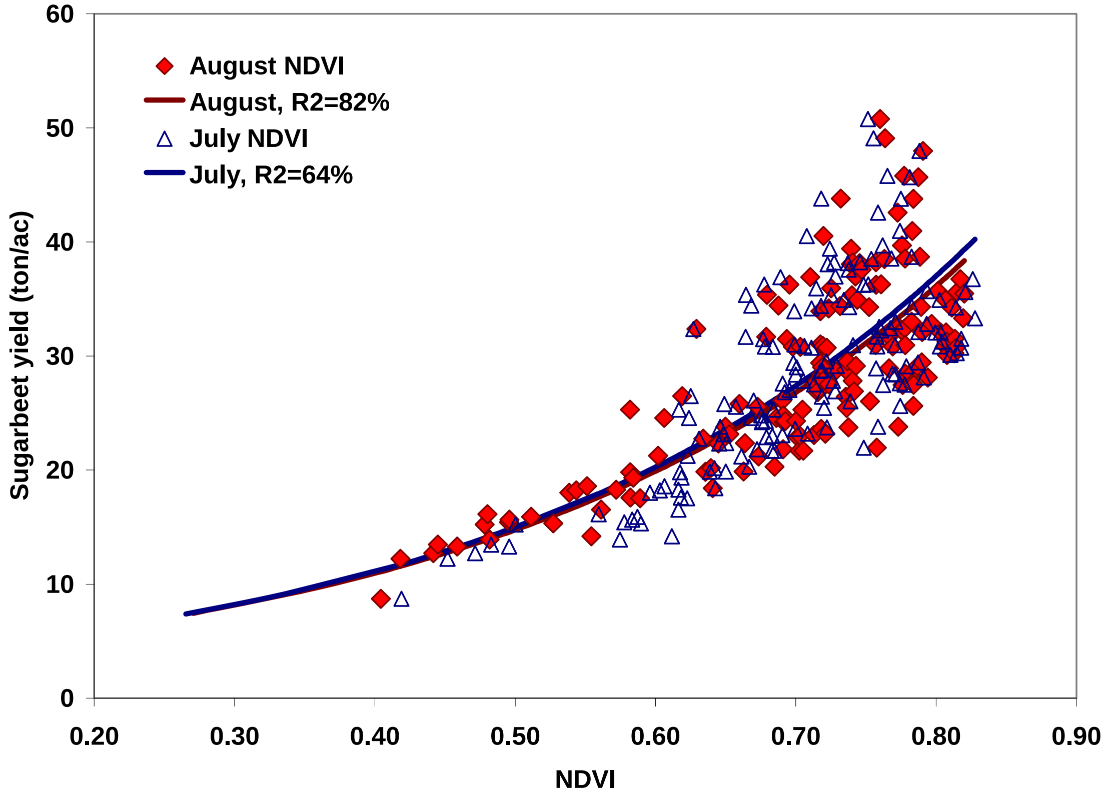

Figure 2. Prediction of sugarbeet RWSA using Greenseeker NDVI generated by sensing in mid-July and August.

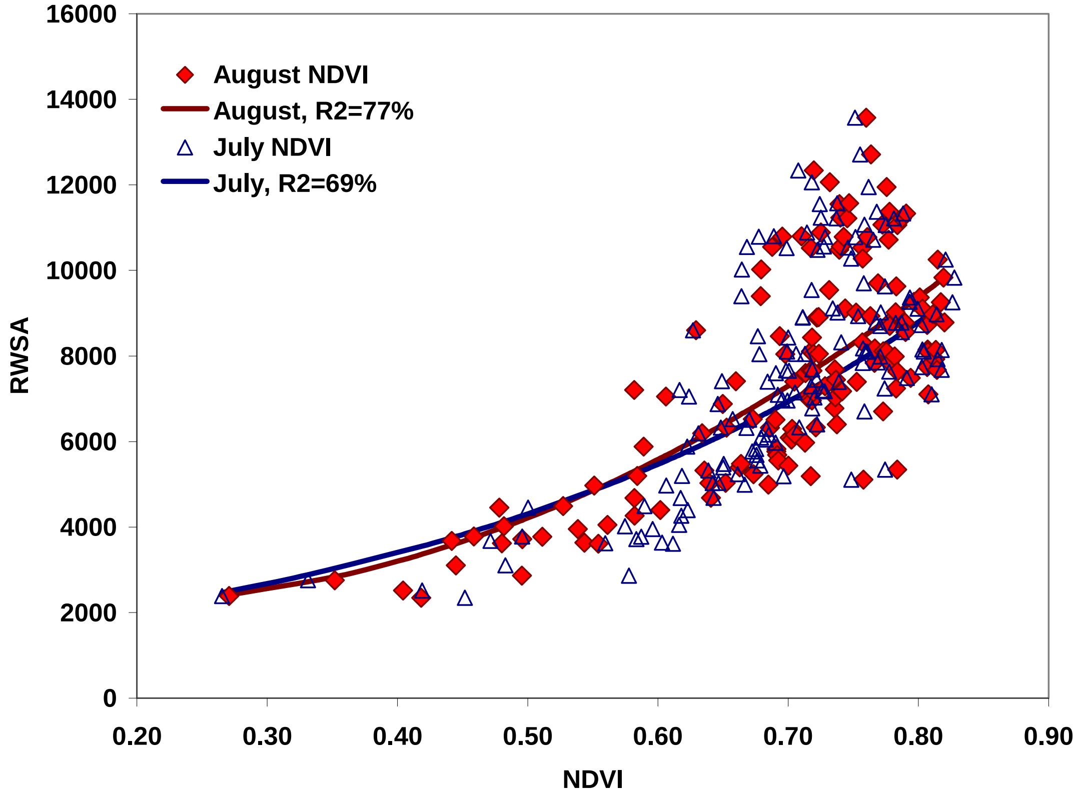

Figure 3. Prediction of total N in sugarbeet tops using Greenseeker NDVI generated by sensing on the day of topping/harvest.