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Estimation Of Sugar Beet Yield And Quality With UAV-Based Sensors

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Introduction

SUGAR BEET (*BETA VULGARIS* L.) production profitability is based on maximizing three parameters: beet yield, sucrose content, and sucrose recovery efficiency. Efficient nitrogen (N) and water management are key for maximizing sugar yield. N deficits in the soil can reduce root and sugar yield; however, overapplication of N can reduce sucrose content and increase nitrate impurities which lower sucrose recovery. Additionally, overapplication of N leads to vigorous canopy growth, while negatively impacting root development and sugar production. Due to The Amalgamated Sugar Company's (TASCO) recommendation to have all N applied and plant-available by the 6-leaf growth stage, it is imperative to determine the appropriate fertilizer N application rates for N responsive fields (in which a response to applied N is reflected in improved yield and/or quality) early in the season. Appropriate irrigation amount and timing optimize sugar beet yields while minimizing disease pressure, water costs, and N leaching. Excessive irrigation increases sugar beet root weight, but lowers sugar content. Defining the optimum water and N fertilizer levels should be done based on analyzing local data, utilizing locally grown varieties, and considering local management practices. Prediction of sugar beet yield and quality before harvest is important for making agronomic and marketing decisions.

Unmanned aerial vehicle (UAV)–based remote sensing is a promising tool for in-season N and water management and in-season prediction of sugar beet yield and quality, which in turn improves the economic returns to sugar beet growers and processors. The Normalized Difference Vegetation Index (NDVI) is commonly used in remote sensing of crops using UAVs. The NDVI estimates biomass by measuring the difference between near-infrared light (which plants reflect) and red light (which plants absorb).

Field Trials

Objectives:

1. To analyze the effects of water and N fertilizer rates on the yield and quality of sugar beets;
2. To assess the feasibility of predicting sugar beet root yield and estimated recoverable sucrose (ERS) using UAV-based NDVI.

Field trials, funded in part by the Snake River Sugarbeet Research and Seed Alliance, were conducted in Parma, Idaho, in 2019 and 2020 (Figure 1).

In April, sugar beets (BTS 2570) were planted at 22-inch row spacing, and 8-inch seed spacing into 40-ft-long plots each containing 4 rows. Treatments were arranged in a split-plot design with four replications. Urea (46-0-0) was applied at planting to achieve three N levels 100, 200, and 300 lb N/a (soil residual + added fertilizer). Plots were irrigated via a subsurface drip irrigation system based on daily ET (evapotranspiration) data from the Parma AgriMet weather station, adjusted using sugar beet crop-specific coefficients, at two levels: 100% and 50%. At forty and sixty days after planting (June and July, respectively), a Matrice 100 UAV (DJI, Los Angeles, California), equipped with the RedEdge-M Camera (MicaSense, Seattle, Washington), was used to obtain aerial imagery (Figure 2). MicaSense Atlas (MicaSense, Seattle) and Pix4Dmapper image analysis software (Pix4D, Prilly, Switzerland) were used to process the UAV-based data. In October, sugar beets were scalped to a 1.5-inch-sized disc and harvested; their root yield and ERS were measured.

The effects of N and irrigation rates on sugar beet root yield and ERS were assessed. The relationship between UAV-NDVI and sugar beet root yield and ERS were evaluated. Data were analyzed using SAS statistical software 9.4 (Littell et al. 1996). The effect of N rate on sugar beet root yield and ERS is reported in Table 1.

Figure 1. Sugar beets treated with 50% water + 100 lb N/a (left) and 100% water + 300 lb N/a (right), Parma, Idaho, June 10, 2019. ET = evapotranspiration.

Figure 2. Matrice 100 UAV equipped with the RedEdge-M Camera.

Table 1. Effect of N and irrigation rates on sugar beet root yield and estimated recoverable sugar (ERS), Parma, Idaho, 2019 and 2020.

Treatment	2019		2020	
	Root Yield, ton/a	ERS, lb/a	Root Yield, ton/a	ERS, lb/a
100 N + 50 ET	26.3 d	7,657 d	37.6 a	11,947 a
100 N + 100 ET	29.4 c	8,510 c	38.7 a	12,174 a
200 N + 50 ET	30.2 b	8,999 b	44.0 a	14,123 a
200 N + 100 ET	33.9 a	9,927 a	41.7 a	13,303 a
300 N + 50 ET	28.0 c	8,318 c	41.4 a	13,381 a
300 N + 100 ET	37.7 a	11,243 a	40.1 a	12,827 a

**Values within each column followed by the same letter are not statistically different (95% confidence level).*

Conclusion

- Application of 200 lb N/a in combination with 100% ET-based irrigation maximized both sugar beet root yield and ERS in 2019 but there was no effect of irrigation and N on sugar beet root yield and ERS in 2020. Increasing N to 300 lb N/a did not further increase sugar beet root yields and ERS in both years (Table 1).
- UAV-based data can be successfully used to accurately estimate sugar beet root yield (65%–91%) and ERS (75%–95%) in season. The accuracy of sugar beet root yield and ERS prediction from UAV spectral indices improves substantially from June to July (Figures 3 and 4).
- This work presents a proof of concept that UAV-based data can help estimate yield and ERS in season. The next step for developing grower recommendations is to build an algorithm through extensive, multi-site-year trials across growing conditions and varieties to ensure the accuracy of yield and ERS predictions.

Further Reading

Amalagamated Sugar. 2020. 2020 *Sugarbeet Grower's Guide Book*. Boise, ID: The Amalgamated Sugar Company (TASCO).

Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. *SAS System for Mixed Models*. Cary, NC: SAS Institute.

Varvel, G. E., and T. A. Peterson. 1990. "Nitrogen Fertilizer Recovery by Corn in Monoculture and Rotation Systems." *Agronomy Journal* 82(5): 935-38.

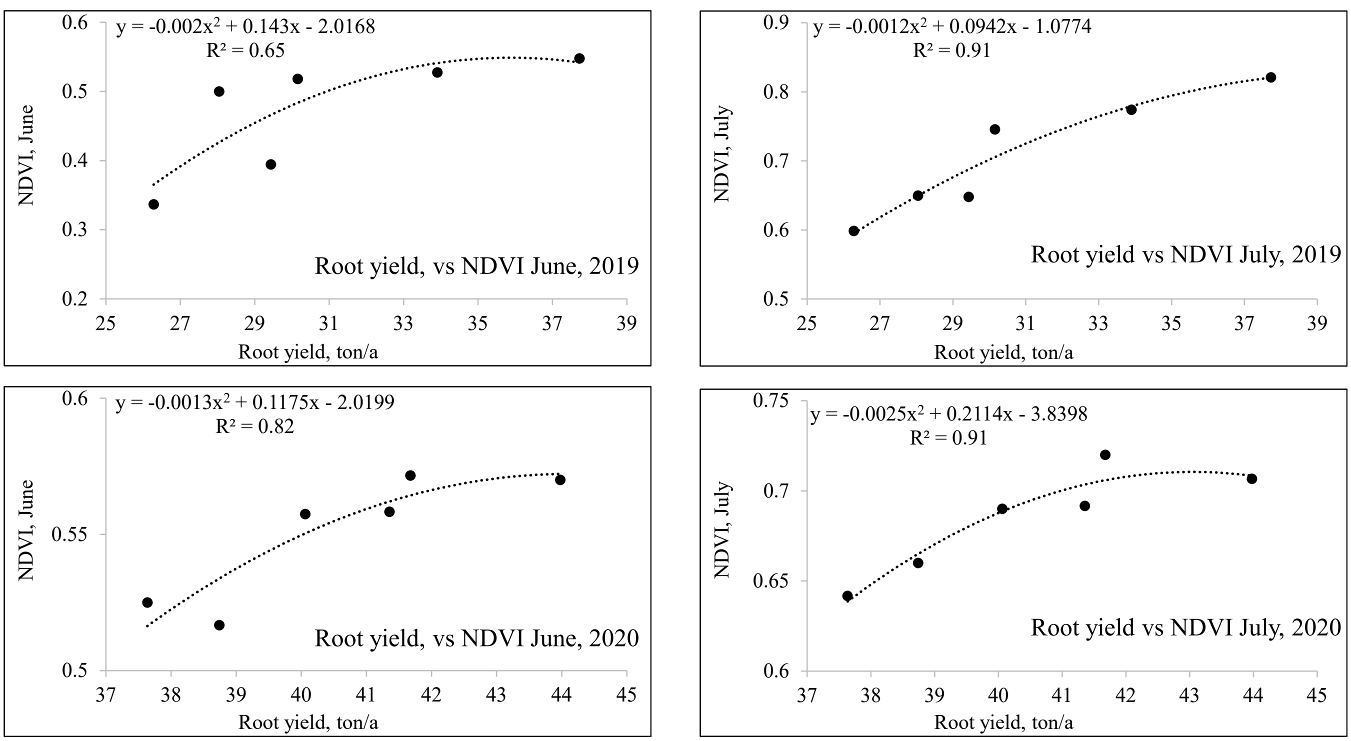

Figure 3. Relationship between mean UAV NDVI in June and July and sugar beet root yield (ton/a), 2019 and 2020, Parma, Idaho.

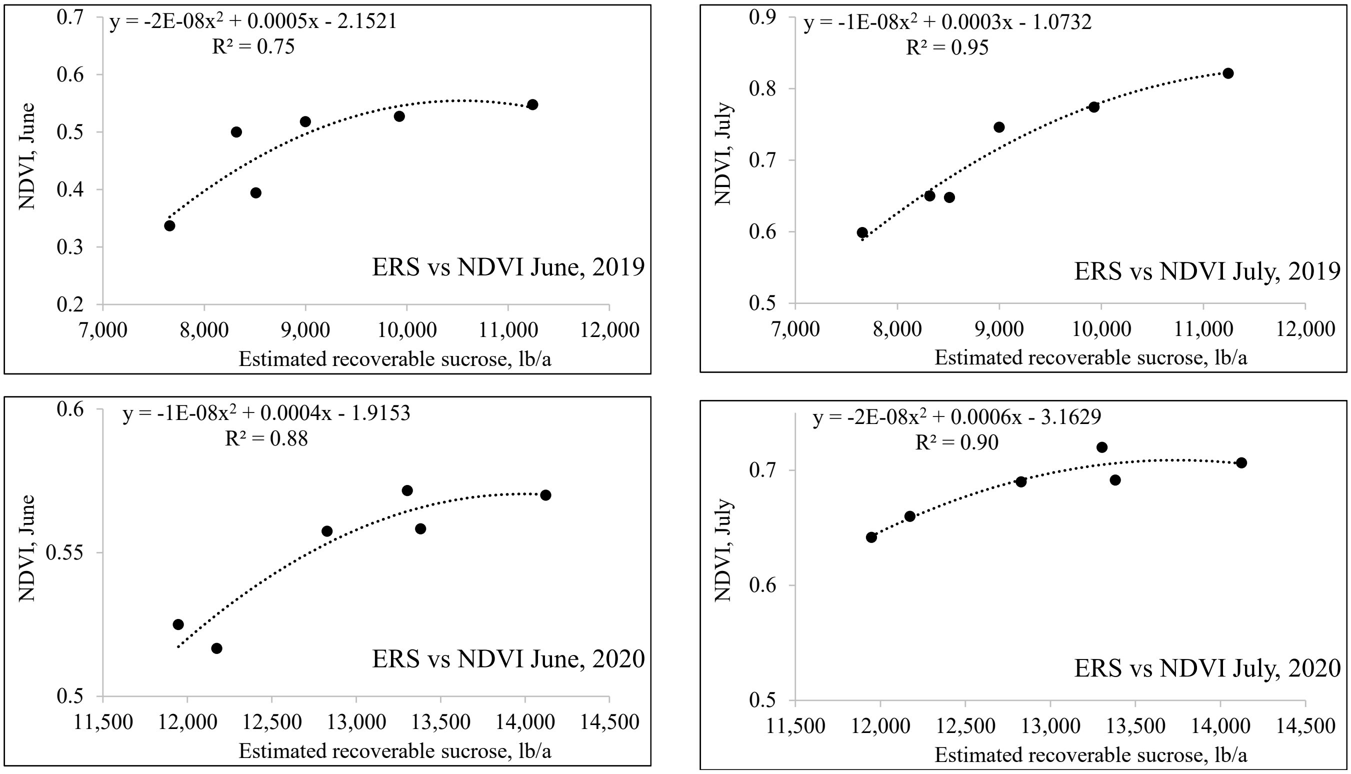

Figure 4. Relationship between mean UAV NDVI in June and July and ERS (lb/a), 2019 and 2020, Parma Idaho.

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