Application of a Ground-Based Sensor to Determine N Credits from Sugarbeet

D.W. Franzen[1], G. Wagner[2] and A. Sims[3]

Nitrogen is released from green sugarbeet tops and becomes available to the subsequent crop (Crohain and Rixhon, 1967; Abshihi et al., 1984; Moraghan and Smith, 1996). Current recommendations allow 80 lb N/acre for crops following areas with green leaves, 30 lb/acre with yellow-green leaves and 0 lb N/acre for yellow leaves (Franzen, 2003). Use of these principles reduces input costs to other rotational crops and also helps to deplete residual N levels preceding sugarbeets, which results in a higher quality sugar crop.

Satellite NDVI (red – infrared/red + infrared) images with resolution of about 100 feet are used to delineate zones of sugarbeet vigor. These images are obtained as close to harvest as possible, with some available in late July, early to late August, and some in September. In some years, clouds obscure fields and no image is obtained. In other years, perhaps an image from July or early August is available. Due to the deep-rooting habit of sugarbeet, early images may not reflect the final patterns of the harvest foliage. Soil moisture conditions near harvest also affect late season soil organic matter mineralization and top color at harvest. Ground-truth visits to some fields within a satellite image area are used to calibrate the vigor rating of the tops with the "green", "yellow-green" and "yellow" N credit categories.

A ground-based NDVI sensor could be used on a sugarbeet defoliator so that the reading was made at the time of harvest, when the reading would be most related to the N credit. A ground-based sensor would also be expected to have a much finer resolution, perhaps less than a square yard. Small scale N variability could therefore be better addressed. Use of a ground-based sensor has been tested over two years, with the objective of determining its possible usefulness as a supplement to satellite imagery for determining N credits following sugarbeet.

Methods

2002-

A forty-acre field east of Crookston, MN was subdivided into a series of smaller plots during a variable-rate N application study in sugarbeets. A "Greenseeker®" handheld sensor was obtained as a gift from Oklahoma State University (Figure 1). This sensor provides its own light source, red and infrared, with a pulsed light using a patented technology that allows similar readings in dark, light and any light in between. Such a sensor is different than satellite or aerial images, because clouds or partial clouds have no effect on the readings obtained from the sensor. The sensor obtains several readings per second and compiles them in a spreadsheet data base. Sensor readings were obtained on thirty feet of row and averaged together in each plot. A sugarbeet top height reading was also obtained using a meter stick. Sugarbeet tops were harvested, weighed, and a subsample taken for dry matter and N content.

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[1]North Dakota State University

[2]Sugarbeet grower, Climax, MN

[3]University of Minnesota, Crookston

Figure 1. NDSU staff learning how to operate the OSU sensor, May, 2002.

2003-

A Greenseeker® sensor was mounted on a sugarbeet defoliator and modified so that a GPS reading would be associated with the sensor readings. Satellite images of the fields were also obtained.

Results

2002-

Using the sensor alone, dry matter, N content and N concentration were all significantly correlated with NDVI reading (Table 1). However, when the NDVI reading was multiplied by the canopy height measurement, correlations were improved, especially in with regards to N content. It is possible that when NDVI readings become saturated (close to 1) due to vigorous, full canopies, the additional leaves beneath the canopy are not accounted for. By considering a height measurement, the volume of leaves and the N they contain may then be taken into account and an improved picture of N content can be obtained.

Table 1. Comparison of dry matter, N content (% N), and total N (lb N/acre) of sugarbeet tops with ground-based NDVI and NDVI X top height at Crookston, MN, 2002.

Property	Correlation value (r)	
	NDVI	NDVI X Canopy height
Dry matter	0.40	0.69
N Content	0.55	0.81
Total N	0.51	0.57

2003

Both satellite and ground-based images are shown in Figure 2.

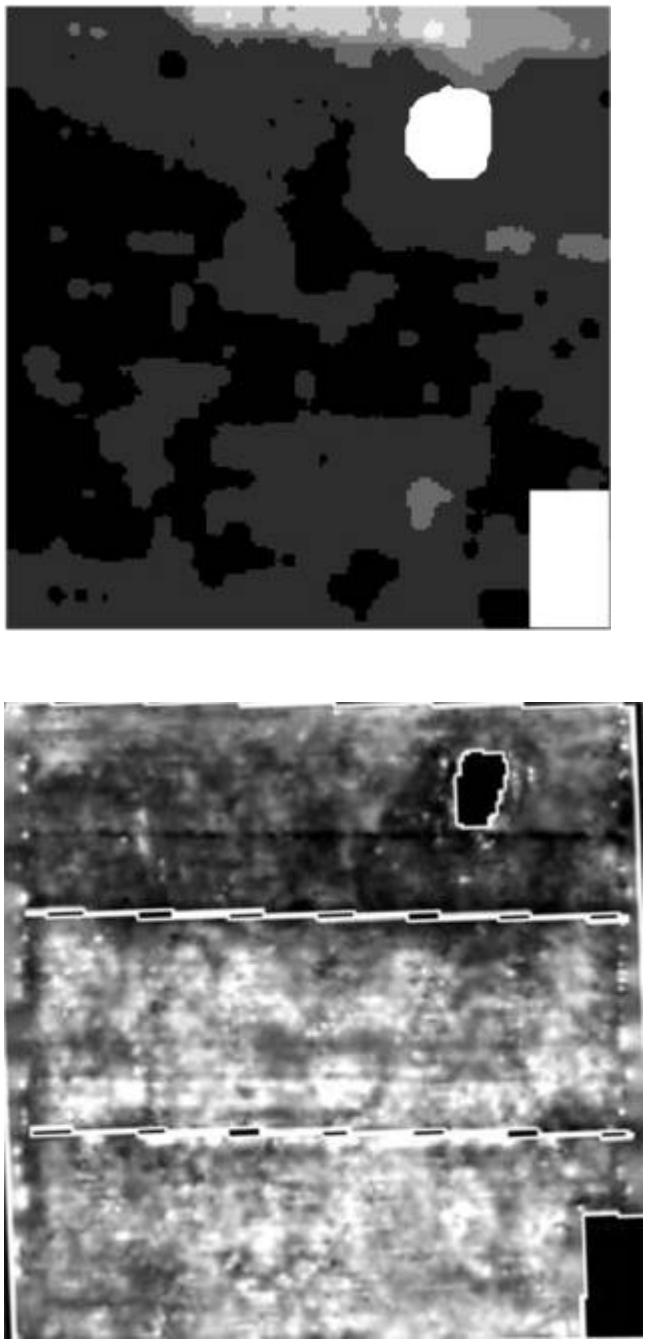

Figure 2. Field with a satellite image taken in late August (top), compared with ground-sensor obtained at harvest, early October (bottom). Darker colors within each image correspond to higher NDVI (more vigor, more dense, greener canopy), lighter colors indicate low NDVI (low vigor, less canopy). Horizontal lines in bottom image indicate preharvest areas.

Much finer detail is provided in the bottom, ground-based sensor image. Areas of about five square yards are represented by the image. An advantage of the satellite imagery is the area along the west (left) side of the bottom image, which seems to indicate less vigorous canopy compared to the satellite image (top). This area was affected by a north-south gravel road which resulted in dust that covered the leaves late in the season. In the satellite image, there was either no dust present, or the image was not affected by the dust.

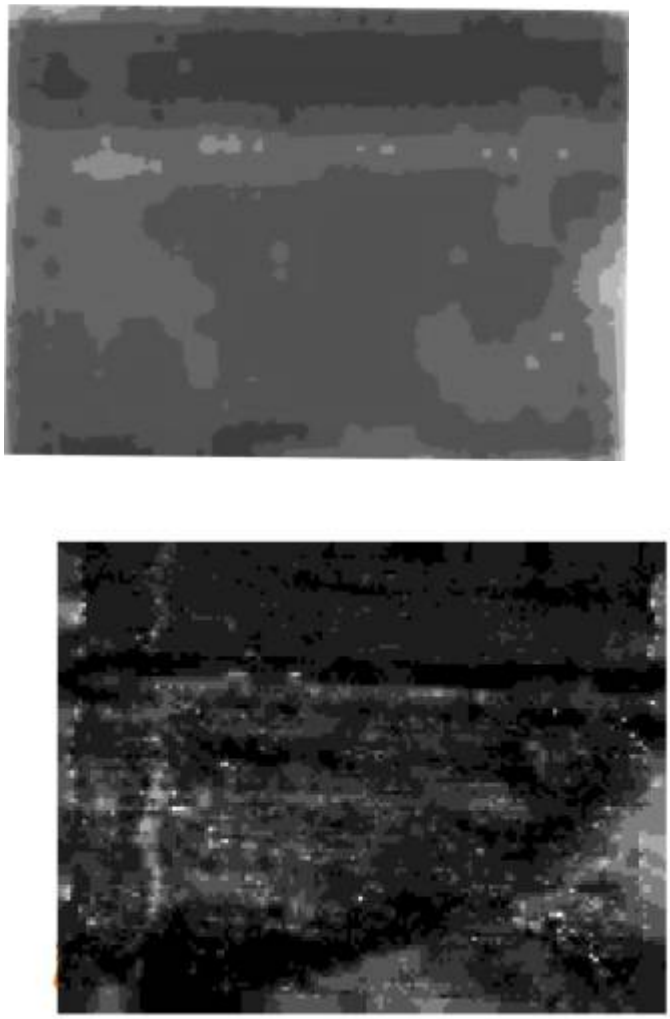

Figure 3. The satellite image (top) is compared to the Greenseeker® image (bottom).
Darker indicates higher NDVI (greater vigor and greener canopy color).

In a second field (Figure 3), there is a sharp, curved boundary in the southeast part of the difference between these two images that the satellite image only roughly defines. The satellite image defines a more vigorous area in the north, similar to the pattern of the ground-based sensor. General patterns of vigor are expressed by the satellite image, but finer detail is available from the ground-based sensor.

Summary

Use of the ground-based Greenseeker® was explored over two harvest seasons for use in helping to define N credit zones for sugarbeet. The ground-based sensor provided finer spatial details compared to the satellite image, while the satellite image provided general patterns of larger areas similar to the ground-based sensor. Gravel dust reduced the NDVI readings from the ground-based sensor, while the satellite image either was not impaired by the dust, or the image was obtained when dust was not present.

The use of a ground-based sensor appears promising. Additional work should be conducted to take advantage of the finer scale and proximity to harvest by better correlating the NDVI X height relationship with dry matter and N content for producing a possible continuous scale of N credits instead of the current three step system.

References

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