SDSU Extension

iGrow Wheat

BEST MANAGEMENT PRACTICES

Chapter 15:
Using Canopy Reflectance Sensors for Managing N in Wheat

Cheryl Reese (Cheryl.Reese@sdstate.edu)

Chapters 1 and 8 both discuss the importance of in-season N application. One approach to implement in-season N is to utilize crop reflectance for assessing yield-limiting factors. This chapter will provide users with the scientific background on how to use and evaluate the potentials of canopy reflectance sensors.

Introduction

Most commercially available remote sensing sensors collect information from the visible and near infrared portion of the electromagnetic spectrum (Fig 15.1). This information can be used to identify healthy and stressed plants. If the yield-limiting factor affects the plant's reflectance, then remote sensing data may be used to help develop prescriptions. Wheat yields in many South Dakota fields are limited by both N and water stress, which in turn impact the accuracy of crop reflectance N-based recommendations. Given the complexity of our soils, we recommend that reflectance-based N recommendations be checked for accuracy. Misdiagnosing a problem (for instance, N for water) can reduce yields and profitability. The use of well-fertilized check plots can reduce errors.

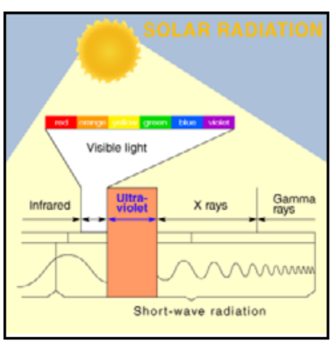

Figure 15.1. Electromagnetic spectrum.
http://serc.carleton.edu/usingdata/nasaimages/index4.html

Using crop reflectance to assess plant stress

When sunlight (energy) strikes a plant leaf, the energy can be absorbed (photosynthesis), reflected or transmitted (i.e., pass through the leaf) (Fig. 15.2). The energy source used in photosynthesis is in the visible light range. Leaves reflect more green light than the other visible bands (blue and red light), which is why plants look green. The energy in the near infrared (NIR) area is mostly reflected by healthy growing plants (Fig 15.2).

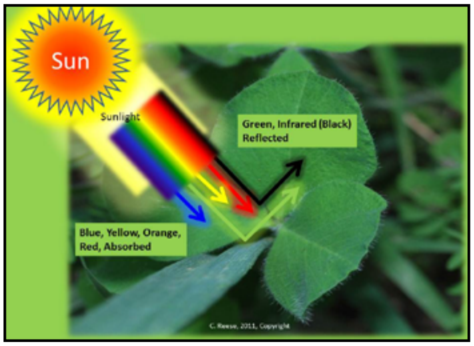

Figure 15.2. Sunlight interactions at the surface of a leaf.
(Source: C. Reese, 2011)

Enhancing information from the electromagnetic spectrum through transformations can improve its usefulness. Two useful transformation indices are the Normalized Difference Vegetation Index:

$$NDVI = (NIR-Red) / (NIR+ Red)$$

and the Green Normalized Difference Vegetative Index:

$$GNDVI = (NIR-Green) / (NIR+Green)$$

http://landsat.gsfc.nasa.gov/

Based on differences in the reflectance, prescriptions can be produced (Fig. 15.3. Clay and Shanahan 2011).

Figure 15.3. An N limited and well-fertilized reference N strip in a South Dakota hard red spring wheat field.
(Source: C. Reese, 2011)

Commercially available sensors

Commercially available sensors can be mounted on equipment or hand held. These sensors can operate in a range of light conditions by emitting energy (active systems generate their own illumination) at specified wavelengths. The energy reflected at these wavelengths is measured and recorded (Fig. 15.4). Various LED sensors are available to record data across a wide range of the electromagnetic spectrum. Based on the reflectance signature relative to check strips, a prescription is developed.

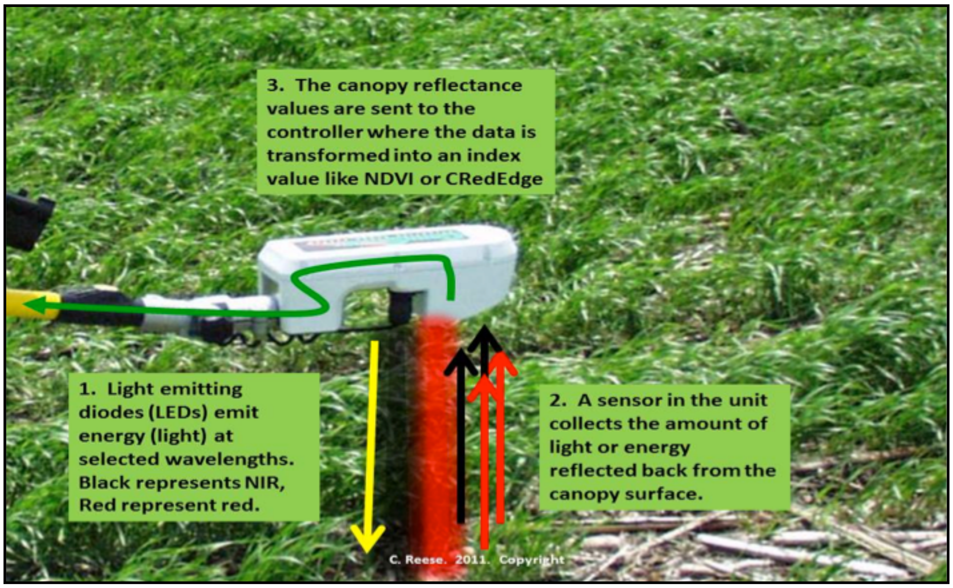

Figure 15.4. Canopy reflectance sensor operation. (Source: C. Reese, 2011)

Greenseeker®

The Greenseeker sensor system is sold through Trimble (740 South State Street; Ukiah, CA 95482; 1-888-728-2436 or gs-ws_info@trimble.com). The sensors can be mounted on a sprayer or fertilizer applicator (Fig. 15.5). The hand-held device uses either Trimble Recon® or Nomad® data loggers to record canopy reflectance. The Trimble Recon can connect to Trimble's GPS Pathfinder® receivers while the Nomad has a built-in GPS. The sprayer-mounted models RT200-N and RT200-FmX are compatible with rate controllers marketed by JD Greenstar, Raven, Rawson, Field IQ, and EZ Boom.

Manuals for the Greenseeker sensor systems are available at http://www.ntechindustries.com/manuals.php.

Greenseeker sensors are configured to calculate a variety of indices including:

1. NDVI
2. SA-NDVI $[[(R_{774}-R_{656})/(R_{774}+R_{656})](1+L)]$
3. RVI $(R_{774}/R_{656}]$
4. IRVI (R_{656}/R_{774})

R_{774} and R_{656} are the reflectance values at those wavelengths. For additional information about Greenseekers for South Dakota applications, contact GreenSeeker and WeedSeeker Sales Office (740 South State Street; Ukiah, CA 95482; 1-888-728-2436 or gs-ws_info@trimble.com).

Figure 15.5. Sprayer mounted Greenseeker sensors (RT100, RT200-N, RT200-FmX). (Source: Jim Logg, Trimble.com, 2011)

Crop Circle®

Holland Scientific Inc. (6001 S. 58th Street, Suite D; Lincoln, NE 68516; 1-402-488-1226) manufactures Crop Circle sensors and has also partnered with Ag Leader through their OptRX ACS430® sensor. Holland Scientific Inc. has sensors available that can be placed on sprayers, aircraft, or tractor cabs. Data loggers for the sensors are the GeoScout GLS-400® or GLS-420®. Collecting geo-referenced data with the GeoScout data loggers is easy because the data logger has a separate port for the sensor and a global positioning system (GPS) unit. In addition, the data is stored on a SD flash card, much like those used in digital cameras, so transferring data between the sensor and a desktop computer is seamless.

Rate controllers are compatible with a range of controllers marketed by Bogballe, Kvemeland, Agro LH 5000, Raven Industries, Rawson Accurate, and Holland Scientific. Based on measured reflectance values, a wide range of indices values can be calculated.

Calibrating sensors

The Greenseeker and Crop Circle sensors can be calibrated using a variety of approaches including placing N-rich strips in the field and two techniques that do not require reference strips. An N-rich strip is a reference strip placed in the field around planting time. The N-rate applied in the N-rich strip should be at least 100% the total N requirement throughout the growing season (Fig. 15.6). Ideally, the length of the N-rich strip should be the length of the field. If the length of the field is not possible, the minimum length should be 400 ft. The strip should be placed in an area that "best" represents field conditions (Clay and Shanahan 2011).

The last two approaches do not rely on N strips. The first non-N strip approach is the Virtual Reference Strip (VRS). With this method, the producer 'drives' several transects to calibrate the sensor. The second method is the "Drive and Apply" approach. Using this technique, the producer just starts applying N and the sensors adaptively calibrate to the crop's physiological condition. For South Dakota fields, we do not recommend the use of non-reference strip calibration techniques.

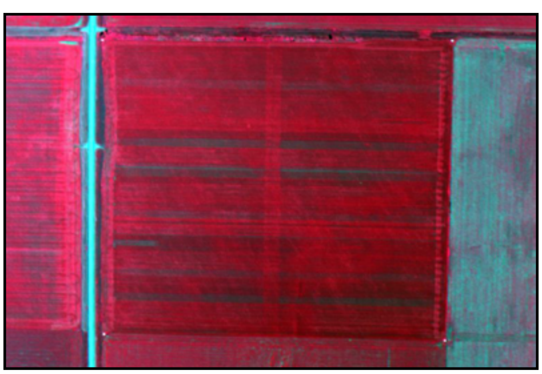

Figure 15.6. N-rich strips used to calibrate remote sensing-based N recommendations. (Source: C. Reese, 2011)

Additional information and references

Clay D.E., and J.F. Shanahan. 2011. GIS Applications in Agriculture: Nutrient Management for Improved Energy Efficiency. Volume 2. Available at http://www.crcpress.com/product/isbn/0849375266

Clay, D.E. et al. (eds.). Site Specific Management Guidelines. 19915. Potash and Phosphate Institute. Available at http://www.ppi-far.org/ssmg

http://www.npk.okstate.edu/referencestrips

http://www.ntechindustries.com/lit/technotes/How_to_use_Crop_Algorithms_080606.pdf

Acknowledgments

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