Crop Vigor Sensing for Variable-Rate Nitrogen

Introduction

Nitrogen (N) is often the most limiting nutrient for optimum corn production in New York. It is needed in large quantities, but because N is unstable, it can quickly be lost to the air through volatilization and denitrification or to groundwater through leaching. In recent years, crop-sensing technologies have been introduced to help fine-tune N management. On-the-go crop sensing combined with variable-rate N application can increase fertilizer N use efficiency (NUE) by providing the specific amount of N needed by the plants as conditions change across the field. In this fact sheet, crop sensors, field applications, and usage and interpretation guidelines will be presented.

Crop Vigor and NDVI Sensors

The NDVI sensors (Figure 1) emit certain wavelengths of light from a light emitting diode (LED), and then they measure the light reflected back to the sensor at the red (R) and near-infrared (NIR) wavelengths. Because crop sensors measure the light that is reflected by plants, they can be used to calculate various indicators of plant vigor. One of the most well known indices is the normalized difference vegetation index (NDVI), which is an indicator of greenness of the crop canopy. Readings range from zero to one; values approaching one indicate more vigorous plants. Sensors can be handheld or machine-mounted (coupled with side-dress equipment). There are several companies that sell or lease NDVI sensors, while others offer custom sensing and application services. Aerial systems (satellites, aircrafts, and unmanned aerial systems) can also measure NDVI, but this fact sheet focuses on in-field methods.

Field Applications

For accurate variable N application, timing of sensing and N side dressing is very important. Crop measurement should be done between growth stages V6 and V10 and depending on various time constraints, many users try to target V6 to V8 crop stages. The plant stage can be determined by counting the number of emerged leaves that have visible leaf collars. For example, a corn plant with eight leaf collars is in the V8 stage.

The positioning of the NDVI sensor is just as important as the crop stage at the time of sensing. The sensor can be *held or mounted 24 to 48 inches directly above the crop canopy*, but 36 inches is optimum to account for varying plant height throughout the field. It should be positioned according to each unique sensor's manual.

Figure 1: Handheld sensor displaying the NDVI value reflected by the plant canopy.

Another important factor for successful use of sensor technology is the establishment of N-rich and zero-N reference strips in each individual field. As a general rule, zero-N reference strips are strips where the starter N rate is kept at or below 30 pounds of N per acre. The N-rich strips should be *established within a week of planting*, and receive at least 20% more N than the crop's expected total N requirement. Ideally, reference strips are at least 400 feet long, positioned in areas of the field that are representative of the entire field (i.e. not in the headlands, wet spots, etc.).

Interpreting NDVI Measurements

The NDVI is calculated using the following equation:

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

where VIS is the amount of visible (typically red or green) light, and NIR is the amount of near-infrared (NIR) light that is reflected by the plant. The NDVI values range from zero to one, where zero indicates low crop vigor, and one indicates high crop vigor, suggesting that the plant had no N deficiency. Sensing of both the zero-N and the N-rich strips gives readings for plants that are N deficient (zero-N strip) and for plants that do not have a shortage of N (N-rich strip). These contrasting treatments provide the best calibration for the algorithms (a series of equations) that convert NDVI measurements into N rate recommendations for a specific field, variety of corn, and time of application.

Algorithms have been developed by various universities and commercial companies (for example, Ohio State University, Oklahoma State University, Virginia Tech, Agri-Food Canada) to provide N application recommendations using the NDVI measurements. The sensor determines the NDVI value, and its associated software converts the measurement to an on-the-go N rate using the algorithms.

Figure 2 shows how most algorithms work. In this example, low NDVI measurements receive little N because little growth response is expected (poor growth due to other reasons than a lack of N, section 1 in Figure 2). As NDVI values increase through the mid-range, N recommendations also increase because a growth response to extra N is likely (section 2). There is a point (point 3) where yield response to N no longer increases with NDVI. After that point, N recommendations decrease with increasing NDVI (section 4), reflecting sufficient N for optimal crop growth.

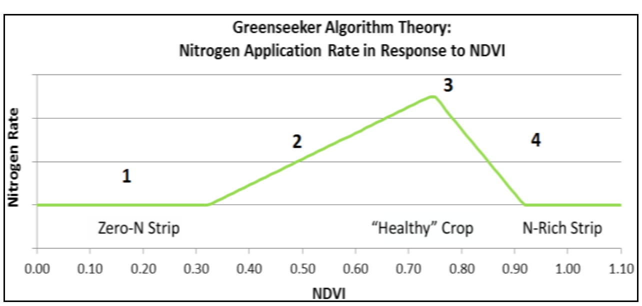

Figure 2: Depiction showing how algorithms convert NDVI values into on-the-go N recommendations (Adapted from GoCorn).

There are numerous factors that can impact the accuracy of an algorithm, including type and variety of crop, soil type, crop height, local weather conditions, and growth stage. To achieve efficient and reliable, sensor-based, on-the-go N recommendations, algorithms that were developed for local soil, field management, and climate should be used. With any algorithm, it is important to test the performance within a given area in order to provide growers with the most accurate N rate recommendations. Therefore work is ongoing to evaluate which algorithms are appropriate to use for corn in New York State.

Summary

New technologies like NDVI sensors can aid in increasing N use efficiency through variable-rate N application within an individual field and throughout the farm. Timing of measurement, positioning of sensors, and use of zero-N and N-rich strips in each field are important to achieve reliable results. Algorithms convert NDVI measurements into on-the-go N application rates while in the field. Algorithms that are based on local conditions will produce the most accurate results. Variable-rate N application allows growers to reduce N losses to the environment and possibly save on N fertilizers and/or increase yield by increasing N use efficiency.

Additional Resources

- GoCorn "10 Steps to GreenSeeker in Corn" http://www.gocorn.net/v2006/Nitrogen/articles/Seeking%20Green%2010%20Steps%20to%20Greenseeker.html

Disclaimer

For more information

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Nutrient Management Spear Program
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