CLEMSON
PRECISION AGRICULTURE

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Sensor-based Nutrient Management

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On average, growers in the US apply about 90 lb/acre nitrogen for cotton, 140 lb/acre for corn, and 90 lb/acre for wheat for a total of 9 million tons for these three crops. High production costs make it increasingly important for our growers to reduce crop input costs while maximizing yields to stay competitive in the global market. For example, a 20% reduction in nitrogen usage could save our cotton, corn and wheat growers over $1.8 billion annually.

Nitrogen is a critical nutrient because it significantly improves crop yields. When choosing nitrogen rates, producers need to carefully consider both achieving most profitable economic return and advancing environmental stewardship. Applying insufficient nitrogen for a highly responsive crop, such as corn, results in lower grain yield and quality, and profits. When nitrogen is applied in excess of crop needs, profit is reduced and negative environmental consequences are likely.

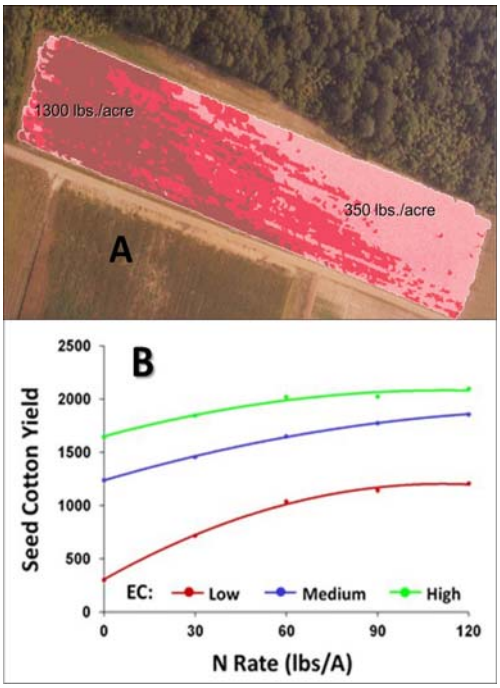
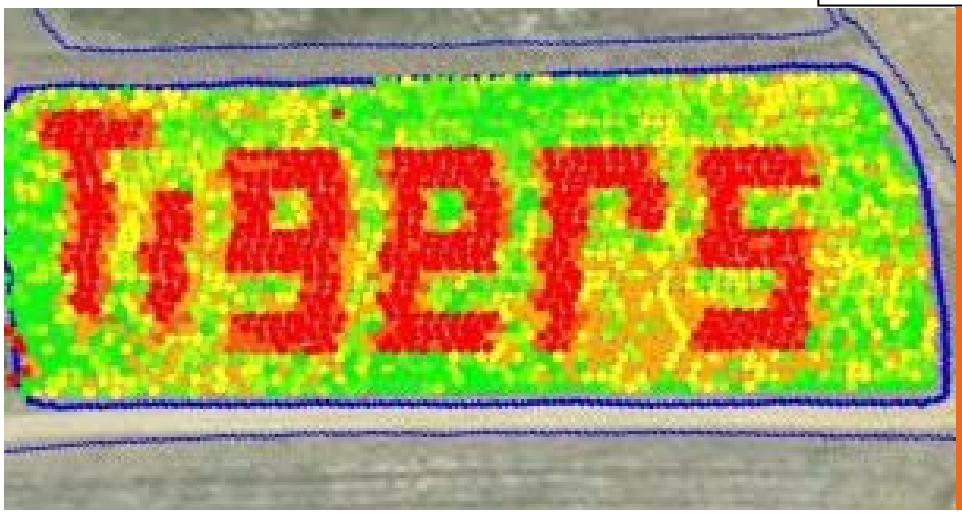


Figure 1: Effects of soil texture on cotton yield (A) and crop response to nitrogen fertilizer (B)



In This Issue

Nutrient Management cont.

The nitrate form of nitrogen is highly mobile in surface and ground water, and is a major source of water contamination, especially in the sandy soils of Southeastern Coastal Plain (SECP) region. Crops in the SECP region are generally produced in fields known to have a high degree of soil type variability which will have a major impact on fertilizer management strategies. In addition, there is a high correlation between soil texture and crop yields in the SECP region (Fig. 1-A). The yield response to nitrogen fertilizer is also affected by soil texture (Figure 1-B). Therefore, uniform application of N fertilizer over the entire field can be both costly and environmentally unsound.

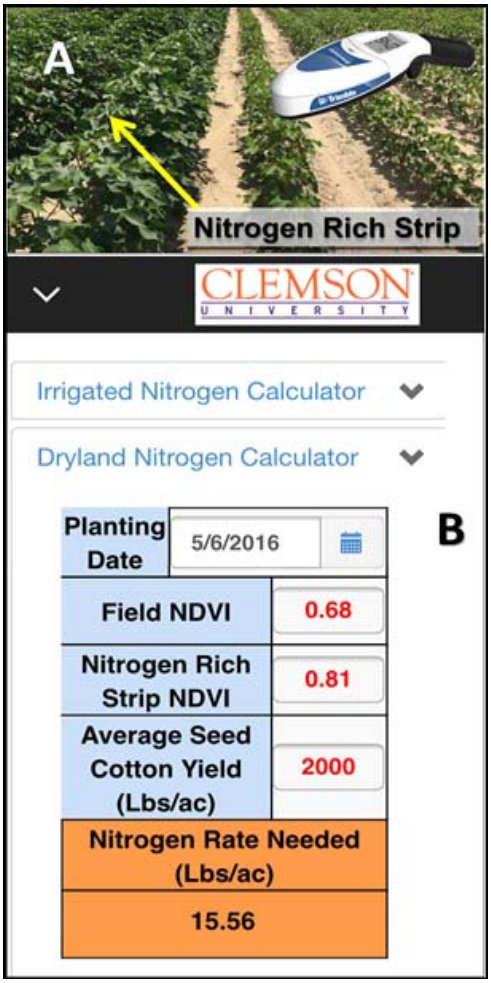


Figure 2: Nitrogen Rich Strip and GreenSeeker handheld sensor (A) and the Clemson side-dress nitrogen rate calculator (B).

Over the past 10 years, scientists at Clemson University have successfully developed cost-effective "Sensor-based Nitrogen Application" (SNA) systems designed specifically for Coastal Plain region to account for soil and climatic variables characteristic of this region, and is ready for use by growers. The Clemson system utilizes optical sensors combined with calibration equations (algorithms) and soil electrical conductivity data (zone management) to calculate side-dress nitrogen requirements for cotton, corn and wheat.

Methods for Nitrogen Management:

Handheld NDVI method.

Algorithm- and sensor-based variable-rate method

Handheld NDVI method:

The first step is to establish a “Nitrogen-Rich-Calibration-Strip” (NRCS), a rate where nitrogen will not be limiting throughout the season, and use it as a guide or ‘standard’ for mid-season side dress nitrogen application (Figure 2-A). The NRCS (4-rows by about 50 ft. long) is usually established at least one month prior to the planned in-season nitrogen application. If production field is divided into several management zones, one NRCS should be established in each zone. A commercially available handheld optical sensor (such as GreenSeeker, Figure 2-A) is used to measure average crop NDVI (normalized difference vegetative index) from the nitrogen rich strips and from a representative section of each Zone. Plant NDVI is defined as (NIR - Red)/ (NIR + Red). The Red and NIR values represent the reflectance in the Red and NIR (near infrared) bands, respectively. These optical sensors range from handheld, sprayer-mounted, or UAV-mounted. An on-line calculator (Figure 2-B), developed at Clemson, can be used to determine side dress nitrogen application rates for irrigated and dryland cotton, corn, and wheat. The N-algorithm (http://www.clemsonnitrogencalculator.com), requires information (such as planting date, NDVI from NRCS and field, max expected yield from the Zone) to calculate the appropriate amount of side dress nitrogen needed for each zone under given conditions (previous crop, soil texture, rainfall, etc.). Furthermore, by adding the price of nitrogen and cash crop, the algorithm will fine tune the nitrogen rate based on grower’s bottom line.

Nutrient Management cont.

Algorithm- and sensor-based variable-rate method:

Several sensor options are available for this purpose, such as a spray mounted multi-sensor GreenSeeker® RT-200 system (Figure 3). The applicator allows you to variably apply side-dress nitrogen in real-time, as the system passes over the crop. The NDVI-based variable-rate algorithm could be selected in the field, and all rate-changes are made "on-the-go.," The Clemson algorithm for calculating nitrogen application rates for irrigated and dryland cotton has already been incorporated into the GreenSeeker operating systems. The nitrogen fertilizer rates depends on making an in-season estimate of the potential or predicted yield (based on NDVI), determining the likely yield response to additional nitrogen fertilizer, and finally calculating nitrogen required to obtain that additional yield. The RT-200 system can also be used as a map-based, variable-rate application system.

Figure 3: The GreenSeeker RT-200 mapping system.

Several variable-rate nutrient applicators are commercially available. These systems can be retrofitted onto growers' existing fertilizer applicators for controlling the rates of nitrogen to match crop needs. Two such systems are shown in Figure 4. The Clemson variable-rate nitrogen applicator (Figure 4–left) utilizes a Rawson controller, which adjusts the outlet flow of a John Blue pump "on-the-go" by changing the drive shaft speed. The second system (Figure 4-right) is developed by the Southern Crop Solutions (see Industry Spotlight). Both systems can receive rate information (application maps) from AgLeader, John Deere, or Raven rate consoles. The performance of these applicators has been evaluated under field conditions in South Carolina and results indicated that it is possible to accurately match application rates with the crop nitrogen requirements.

Figure 4: Clemson variable-rate nitrogen applicator with a Rawson controller (left), and the Southern Crop Solutions applicator (right)

RESULTS:

The Clemson sensor-based algorithms were extensively tested in research plots and nine growers' fields. In a test field with different soil types, the Clemson algorithm recommended 54, 47, and 31 lbs. of nitrogen per acre in low, medium and high EC (electrical conductivity) zones, respectively, compared to grower's conventional uniform rate nitrogen application method (90 lbs./acre).

Nutrient Managment cont.

Averaged over three years, the Clemson algorithm applied 48% less nitrogen without affecting cotton yields (Figure 5). Similar results were obtained with other field trials in South Carolina. During 2015 and 2016 growing seasons, our work on 9 farmers' fields showed that sensor-based nitrogen management techniques, reduced nitrogen usage by 45 to 100 lbs./acre in cotton, compared to growers' methods, with no negative effects on crop yields.

Therefore, there is a potential to use mid-season plant NDVI data for variable-rate application of nitrogen fertilizer in crop production. The soil EC data is a critical tool in the nitrogen-rate prediction equation for the SECP region.

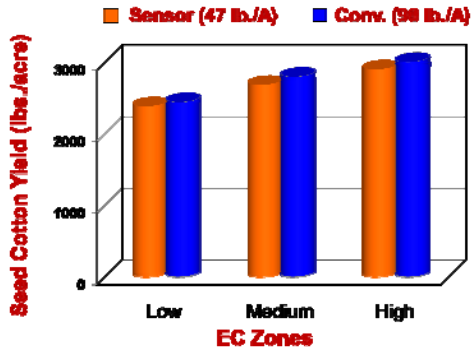


Figure 5: Effects of nitrogen management systems

Industry Spotlight

The Southern Crop Solutions (an AgLeader Technologies dealer), is located in Holly Hill, South Carolina. The company has been helping growers with precision Ag related technologies, including variable-rate nutrient management, for the past 4 years. The variable-rate nitrogen system (Figure 4-right), which can be retrofitted onto growers' existing fertilizer applicators, is based-on Raven flow meter and control valves. This setup has been running for 4 years on several farms with no issues. Currently, the system is controlled by an Ag leader monitor; however, this can be done with any rate controller. This system utilizes historical yield data from growers' fields to create yield goal regions for each field (Figure 6-left). The nitrogen rates are then calculated based on the target yield, minus the amount of N applied at planting and what is going through the pivot, to determine the amount of side-dress fertilizer (Figure 6-right). The variable-rate nutrient application system helped Mr. Emberford to reduce his nitrogen use by a tanker load compared to his uniform rate method the previous year. This technology also helped him to increase crop yields in his farm, by getting more out of the high production areas and minimizing risk on his lower production land. To make this work having good yield data is the key to getting a good idea of where the yield is coming from in the field. For more information please contact Robbie Weathers robbie@southerncropsolutions.com.

Figure 6: Yield map (left) and nitrogen rate map (right) for the Emberford Farms, 2017

Team Member Spotlight

Richard Hallman joined Clemson in 1986 as the Ag Engineering technician at the Edisto REC. Since 1996, he has provided technical help to a nationally recognized precision farming research program at Clemson for sensor-based and site-specific applications of crop inputs (fertilizer, lime, nematicides, herbicides, insecticides, irrigation, and tillage). He has helped to develop innovative technologies to provide farmers with effective and affordable tools to manage their crops, to enhance the competitive position of U.S. Agriculture and improve stewardship of the environment. These systems apply crop inputs exactly where they are needed, when they are needed, and in the amount that is needed.

Phillip Williams Joined Clemson in May, 2015 as a Program Coordinator for three USDA-NRCS projects at the Edisto Research & Education Center, and officially started his PhD program in August. Phillip is coordinating three demonstration projects “Demonstration of innovative nutrient management strategies”; “Demonstration of interseeding technology for crop rotations to enhance soil properties and reduce pest occurrence”, and “Demonstration of deep-rooted cover crop, tillage and controlled traffic on eliminating hardpan layer in coastal plain soils.” These projects involve establishing “prototype fields” in geographically diverse locations in South Carolina, directly training growers, modifying their equipment, providing training and support to ensure proper use, and conducting field days and workshops for growers, crop consultants, and county Extension agents. He is also working with agricultural scientists and engineers to develop a sensor-based, variable-rate nitrogen applicator for center-pivot irrigation systems.

Richard Hallman (left) and Phillip Williams (right).

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Upcoming Events

- Watermelon Field Day: July 13
- Peanut Field Day: September 7