SCSB Final Report

General Information
Principal Investigator(s) Name(s): C. Nathan Hancock (USCA) and Kendall Kirk (Clemson)
Organization: University of South Carolina Aiken
Date: 31 Dec 2019
Quarter: Final

Proposal Information
Title: Strategies for identification and rescue of poorly nodulated soybeans
Amount Expended to Date: about $6442.48

Project Summary
Poor or nonexistent nodulation of soybeans can occur due to inoculation problems or on land that has been flooded and submerged. This can severely limit the nitrogen available to the plants, severely limiting growth and yield. The overall goal of this project is to develop tools for soybean farmers to diagnose and treat nitrogen deficiency using digital image analysis. To accomplish this we are building a models of how visual factors (color, hue, and brightness…) relate to plant health and yield. This year, we applied different levels of nitrogen to soybeans, including mutants that are unable to perform nodulation. Comparison of leaf color to actual leaf nitrogen levels allowed us to model the relationship between leaf color and nitrogen content (Figure 1). This model allows farmers to predict leaf nitrogen levels in the field from an aerial image.

Our image analysis results were obtained from a replicated field trial performed in an irrigated research plot at the Clemson University Edisto REC. Aerial images were captured periodically (V2, V4, and R1), using a drone and leaf nutrition was taken at the R1 stage.
The images were analyzed by correlating the treatments with specific areas of the image and classifying each pixel as a plant or non-plant. The original image and classified digital output of the image can be seen in Figure 1. Colorspace histograms were then generated for plant pixels in each plot, classifying each plant pixel into one of 26 divisions for each of the red, green, and blue colorspaces. By plot, fractions of plant pixels in each of the 26 colorspace divisions for each of the three colors were then calculated.

Leaf nitrogen analysis showed that for the Nod- plants that cannot fix nitrogen, there is a direct correlation between the fertilizer applied and the nitrogen content of the leaves (Figure 2). This is a confirmation that the mutant plants didn't form nodules, mimicking the phenotype we are trying to rescue. For the control plants (Williams), the addition of nitrogen at planting didn't increase nitrogen content, likely because the excess nitrogen causes them to produce less nodules. Thus, we can conclude from this experiment that application of any supplemental nitrogen should be done after nodule initiation.

In efforts to develop a rescue plan for low nitrogen plants, fertilizer was applied to a subset of the plants with low nitrogen content at the R1 stage. We observed that high levels of nitrogen applied at R1 was detrimental in some cases, indicating that there is a limit to how much can be safely applied. Our plan was to measure yield to determine if nitrogen supplementation resulted in higher yields. Unfortunately, we were not able to measure yield due to poor field conditions. Our plan is to attempt to obtain this critical yield data in a follow up experiment in 2020.

Though we didn't collect all the data we wanted to, the results from this data set are promising. We have shown that the correlation between leaf color and leaf nitrogen levels can be used to make predictions using aerial images. For example, Figure 3 shows an example of how this technology could be used in real world conditions. Based on the 2018 results we expect that these visible differences correlate directly with yield. Thus, if we can continue to make progress on this project, we should be able to use aerial imagery data for prediction of leaf nitrogen and in-season estimation of yield. The generation of these robust models will help farmers make informed decisions regarding midseason nutrient applications.

Key Performance Indicators

What KPI(s) were used to measure project success? How were KPI(s) measured? Were KPI(s) not met? Were KPI(s) exceeded? Explain the key circumstances that impacted achieving or not achieving KPI(s).

Our goals were to generate a gradient of leaf nitrogen levels in order to draw correlations between aerial color analysis and leaf tissue analysis. This portion of the project was completed as proposed, allowing us to perform statistically sound analysis. Unfortunately, we were not able to obtain yield data this year, so we were not able to make inferences about how nitrogen deficient soybeans can be rescued. This resulted from a combination of factors including Maturity group, irrigation, and weather.

Next Steps

Explain the next steps of this project (if any) and the implementation of the findings from the project.

The researchers are preparing a follow up proposal to complete this project. We have plans to deal with the problems that occurred at the end of the season, so will be able to perform a detailed analysis of what level of nitrogen fertilization would be needed to rescue nodulation deficient plants.

Additional Information

Provide all additional supporting information, facts or figures here.

Figure 1

Left: Pixel color information extracted from aerial imagery of plots at R1, showing NDVI measurement and plot layout. Right: Actual vs. Predicted Leaf Tissue Nitrogen at R1; predictions were made from extracted aerial image data.

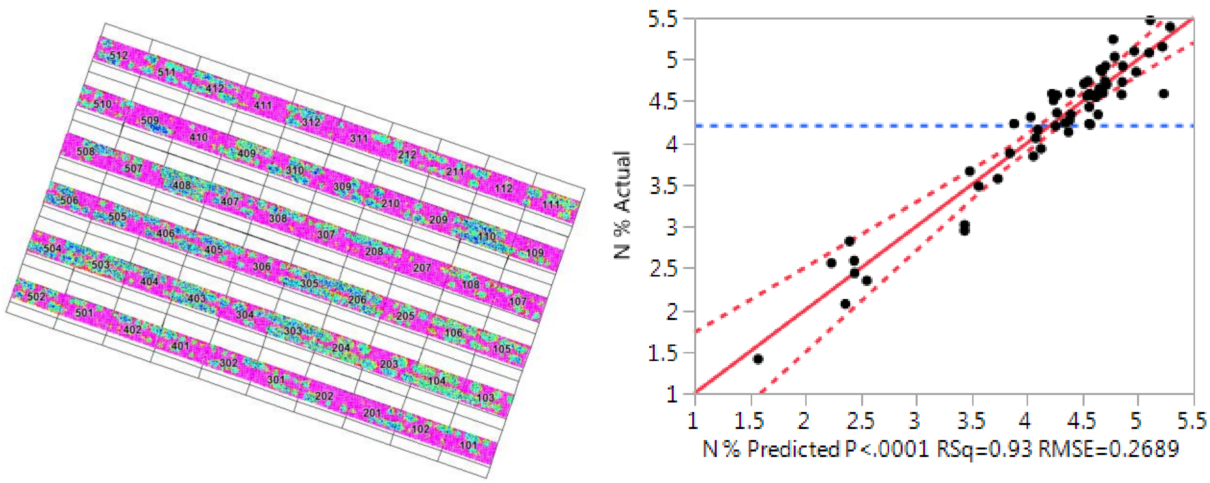

Figure 2

Leaf nitrogen content at R1 stage by treatment. Chart shows the average for 5 replicates. Error bars indicate the standard error.

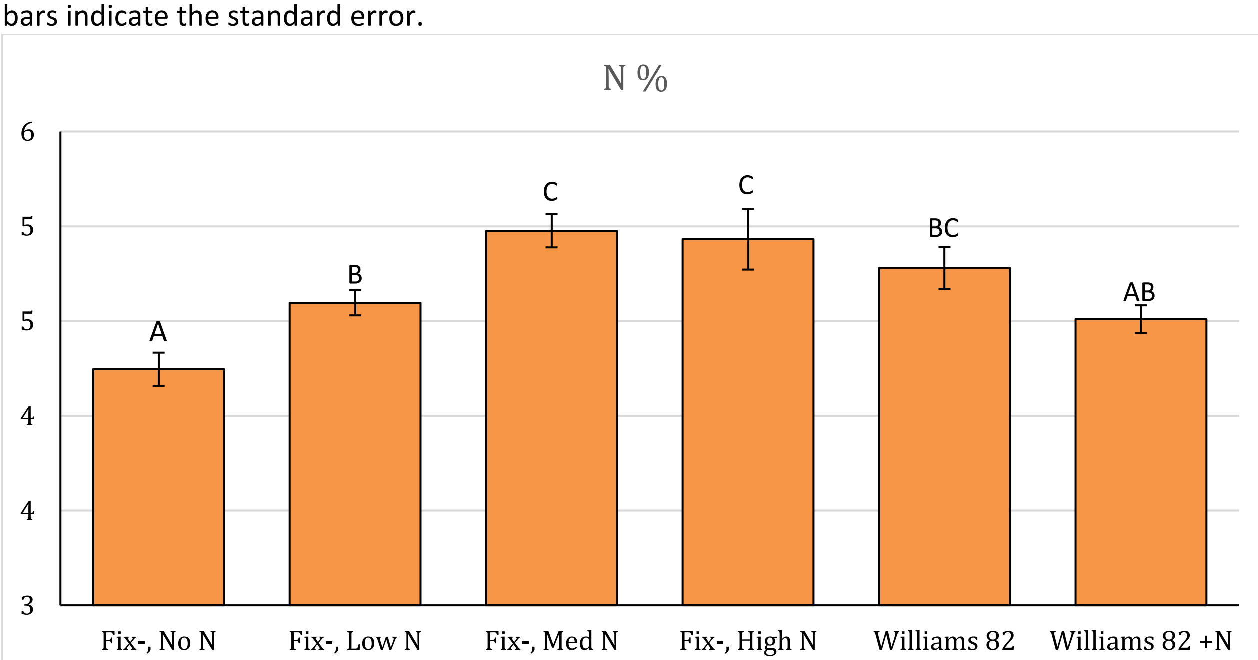

Figure 3
Example of how leaf nitrogen content could be predicted from an aerial image of a soybean field using the model. Numbers indicate the predicted leaf nitrogen content. Values were only generated for units of soybeans.