Comparison of Three Commercially Available Crop Sensors Utilizing NDVI for Monitoring Cotton Growth and Nitrogen Status

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Abstract

Crop reflectance utilizing handheld or tractor mounted sensors has the potential to direct fertilizer N applications. Three commercial sensors were examined for their effectiveness in differentiating cotton (*Gossypium hirsutum* L.) plant height and leaf N based on NDVI measurements. The YARA N Sensor (Yara International ASA, Oslo, Norway), the GreenSeeker Model 505 Optical Sensor Unit (NTech Industries, Inc., Ukiah, CA) and the Crop Circle Model ACS-210 (Holland Scientific, Inc., Lincoln, NE) were utilized in this study. Field trials were conducted in 2008 and 2009 at the Plant Science Research Farm, Mississippi State, MS. Fertilizer N rates of 0, 40, 80, and 120 lb N/acre were applied to establish wide growth differences. Values of NDVI from all three sensors correlated with plant height and leaf N for all physiological stages of growth. The magnitude of NDVI values however, varied from sensor to sensor. This trend, along with a parallel relationship through most sampling dates between the two hand-held units may be attributed to differences in viewing angles and field of view. The GreenSeeker and Crop Circle sense the canopy at a nadir viewing angle, unlike the YARA, which views the crop off-nadir between 58 and 70°. Following early square, NDVI values varied consistently between sensors for each sampling date, with the YARA consistently producing the greatest values, while the Crop Circle had the lowest. Crop reflectance based NDVI values are not standardized across sensors.

Introduction

Variable rate fertilizer N application in cotton may be most effective through crop reflectance due to spatial and temporal variability of available N. Cotton leaf reflectance has been shown to be well correlated with leaf N and chlorophyll content when N is the most limiting factor (Fridgen and Varco, 2004). Also, cotton leaf reflectance has been defined as precise enough to be the basis of a variable rate fertilizer N application (Zhao et al., 2005). Realizing this potential, various companies are marketing handheld and tractor mounted sensors. Due to potential differences in reflectance values between technologies and methodologies, it is imperative to understand inherent sensing variations to ensure proper usage by end-users.

Objective

Define relationships between plant height, leaf N, and NDVI derived from three commercially available crop sensors; 1.) YARA N Sensor; 2.) GreenSeeker; and 3.) Crop Circle.

Fig. 1. Demonstration of N induced growth differences in 2008.

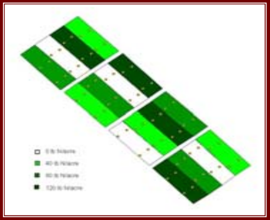

Fig. 2. Plot layout and sampling/sensing locations.

Methods

Fertilizer N applied at rates of 0, 40, 80, and 120 N/acre split 50% at planting and 50% at early square in 2008 and 2009. Plot dimensions were 12 rows wide (38 in row spacing) and 125 ft long with four replicates of treatments in a randomized complete block design. Four locations established in each plot were monitored for NDVI, plant height, and leaf N at early square, early flower, and peak flower. Reflectance measurements were taken between 11 a.m. and 12 p.m. The tractor mounted YARA was driven the entire plot length while the handheld GreenSeeker and Crop Circle instruments collected data from 30 ft of row at each location. Leaf samples were dried, ground, and analyzed using a Carlo Erba N/C 1500 dry combustion analyzer (Carlo Erba, Milan, Italy).

2008

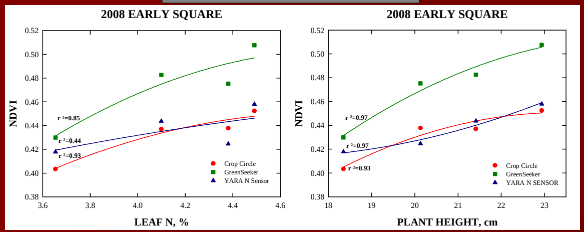

Fig 3. NDVI relationships with leaf N and plant height at early square as influenced by sensor.

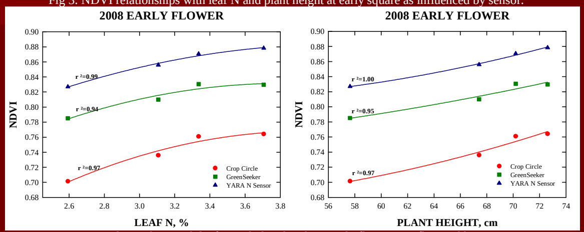

Fig 4. NDVI relationships with leaf N and plant height at early flower as influenced by sensor.

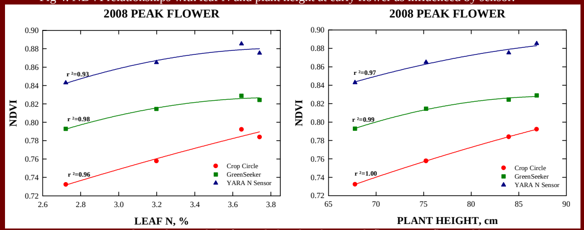

Fig 5. NDVI relationships with leaf N and plant height at peak flower as influenced by sensor.

2009

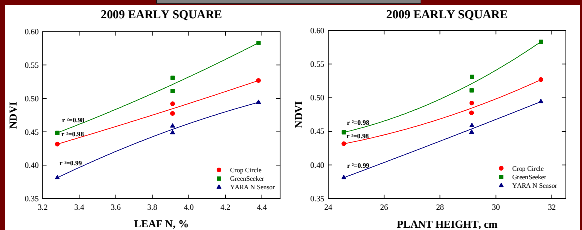

Fig 6. NDVI relationships with leaf N and plant height at early square as influenced by sensor.

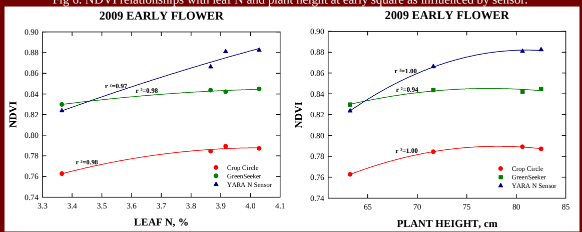

Fig 7. NDVI relationships with leaf N and plant height at early flower as influenced by sensor.

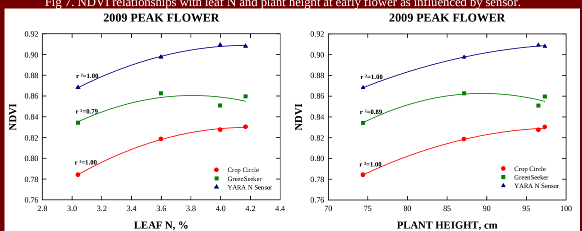

Fig 8. NDVI relationships with leaf N and plant height at peak flower as influenced by sensor.

Fig. 9. GreenSeeker unit model 505 and data collection; an active sensor emitting 770 ±15nm and 650 ± 10nm.

Fig. 10. Crop Circle unit model ACS-210 and data collection; an active sensor emitting 880 ± 10 nm and 650 nm.

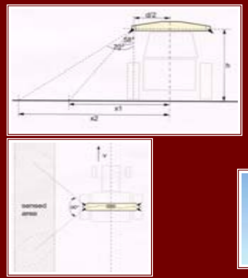

Fig. 11. YARA N Sensor viewing angles from above and behind; a passive sensor measuring 840 ± 5nm and 650 ± 5nm. Source: YARA (Hydro Agri), tec5Hellma

Fig. 12. Top: YARA N Sensor and Trimble Pro XR Receiver. Center: YARA N Sensor toolbar mounted and in use. Bottom: YARA N Sensor side view showing sensor lenses.

Results

- The correlation of all sensor NDVI values with plant height and leaf N increased across the growing season (Figs. 3-8).
- Magnitude of NDVI values varied considerably at each date while response trends were similar across years (Figs. 3-8).
- At early square, GreenSeeker NDVI values were considerably greater than YARA NDVI values, which were similar in magnitude to the Crop Circle (Figs. 3 and 6).
- By early flower, the YARA NDVI values were greater than both the GreenSeeker and Crop Circle and remained greater through peak flower both growing seasons (Figs. 4, 5, 7, and 8).
- Curvature response for the GreenSeeker and Crop Circle were similar, although the magnitude of NVDI values differed (Figs. 3-8).

Discussion

Differences in viewing angles and field of view must be considered between commercially available sensors. The handheld sensors with the most similar technology were most similar in response, yet differed in the magnitude of the measurements. A greater field of view for the YARA N Sensor likely contributed to lower NDVI values observed early in the season but resulted in greater NDVI sensitivity later in the season as “saturation” appeared to be less of a factor. The amount of soil sensed relative to the crop was greater for the YARA N Sensor as both handheld units were held nadir to the crop and centered over the crop. Inherent differences in the magnitude of NDVI values between sensors must be acknowledged in the development of fertilizer N application algorithms. Crop reflectance based NDVI values are not standardized across sensors.

Literature Cited

Fridgen, Jennifer L., Varco, Jac J. 2004. Dependency of cotton leaf nitrogen, chlorophyll, and reflectance on nitrogen and potassium availability. Agron. J. 96: 63-69.

Zhao, Duli, Reddy, K. Raja, Kakani, Vijaya Gopal, Read, John J., Koti, Sailaja. 2005. Selection of optimum reflectance ratios for estimating leaf nitrogen and chlorophyll concentrations of field- grown cotton. Agron. J. 97: 89-98.

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