UTILIZATION OF REMOTE SENSING TO DETECT FERTILIZER NITROGEN EFFECTS ON COTTON GROWTH

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Abstract

Mississippi Delta soils exhibit a high degree of spatial variability, complicating N fertilizer management. Remote sensing may be useful in identifying zones where N-use efficiency can be increased. The objectives of this research were to determine the effects of varying N status on canopy reflectance using a multispectral sensor and to evaluate the Normalized Difference Vegetation Index (NDVI) algorithm for its utility in describing cotton growth and N nutritional status. A field experiment consisting of four fertilizer N rate strips established across soil variability was initiated in 1999. Multispectral imagery was acquired throughout the season. Growth and canopy development was detected using multispectral images, but separation in treatments did not occur until mid July. NDVI was highly correlated with plant height at first bloom and peak bloom. These results suggest sufficient canopy development is necessary to detect variations in growth and use of an index such as NDVI may require near full crop canopy for evaluation of N status.

Introduction

Mississippi Delta soils are by nature highly variable in physical, chemical, and biological properties. The high degree of spatial variability makes efficient N fertilizer management difficult. Technological developments in remote sensing may prove to be a valuable tool in helping to manage N fertilization on these soils.

Remote sensing involves the acquisition, processing, and interpretation of images. Initial processing includes georeferencing and atmospheric correction of images. Images may then be processed using various indices. Broad band indices have been used to assess plant biomass, whereas narrow band indices have been more useful in determining physiological stresses (Peñuelas *et al.,* 1994). With respect to N nutrition, Blackmer *et al.* (1994) found wavelengths around 550 nm provided the best separation among varying N rates in corn.

NDVI is a ratio derived from the radiance at red and near infrared wavelengths (NIR – Red/NIR + Red). Normalization accounts for some of the irradiance differences that occur within the growing season. NDVI is a measure of greenness and plant biomass or ground cover.

This research was initiated in 1999 on alluvial soils in the Mississippi Delta. The objectives of this research were to determine the effects of varying N status on canopy reflectance using a multispectral sensor and to evaluate the NDVI algorithm for its utility in describing cotton growth and N nutritional status.

Materials and Methods

The study was conducted on the eastern half of a 400 acre irrigated field on Perthshire Farms in Bolivar County, Mississippi. Four fertilizer N rate strips consisting of eight rows each were established across known soil variability. Six locations were chosen based on differing soil characteristics. Three sites were mapped as Commerce silt loam, two sites as Robinsonville silt loam to sandy loam, and one as Souva silty clay loam. Fertilizer N rates ranged from deficient to excessive. Rates were 0, 50, 100, and 150 lb N/A. An eight-row applicator was used to apply a 50/50-split application of UAN solution. The first application was at planting, followed by a second application at early square.

Prior to planting, soil samples were taken in increments down to three feet to determine available soil N. Sample depths included 0 to 6”, 6 to 12”, 12 to 24” and 24 to 36” depths. Delta Pine 458B/RR was planted on 24 April 1999. Plant height and leaf samples were taken at early square, first bloom, and peak bloom. Leaves were dried, ground through a 1 mm sieve, and analyzed for total N content using a Carlo Erba C/N analyzer.

Multispectral images were acquired from an aerial platform at an altitude of 12,000 ft. This provided an image resolution of 2 m. Three digital cameras comprised the multispectral sensor and each was equipped with a narrow bandpass filter. These consisted of a green band at 540 nm, a red band at 695 nm, and a near infrared band at 840 nm.

A 210-foot strip of four rows was mechanically harvested with a spindle picker. The seed cotton was weighed in a boll buggy equipped with load cell sensors, and subsamples were taken to determine lint percentage.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:568-569 (2001)
National Cotton Council, Memphis TN

Results and Discussion

Plant Height

Plant height generally increased with increasing N rate, but depended on stage of growth. At early square, there was little difference between treatments when averaged across all locations with a standard deviation of less than 4 cm. At first bloom, stunting of the non-fertilized check became obvious. At peak bloom, visible separation in treatments was greatest (Fig. 1), with 0 lb N/A averaging 20 cm less than 150 lb N/A.

Plant height showed a strong correlation with NDVI at both first and peak bloom. Readings taken at early square showed little correlation with plant height. The best correlation occurred at first bloom with a coefficient of determination of 0.87. At peak bloom there was still a high correlation (r^2 = 0.79), but was lower than at first bloom (Fig. 2).

Leaf Tissue N

Leaf tissue N was greatest at early square, and declined for all treatments as the season progressed. A decline in leaf tissue N from 5.14% to 3.34% was greatest with 0 lb N/A. At first and peak bloom, leaf tissue N concentrations for the 0 lb N/A rate would be considered deficient. The 50 lb N/A rate exhibited borderline deficiency at peak bloom. The 100 and 150 lb N/A rates had the least decline in leaf tissue N and remained in the sufficiency range throughout the season. The greatest separation in treatments was observed at peak bloom (Fig. 3).

Leaf tissue N showed little correlation with NDVI on any of the three sampling dates (Data not shown). Lack of correlation is most likely due to NDVI’s strong dependence on plant biomass. Leaves may contain more N and be greener during early growth stages yet yield lower NDVI values due to a lack of ground cover.

Summary

The results of this research indicate that variations in cotton growth due to N availability can be detected using a multispectral sensor, but sufficient canopy development is necessary to detect differences. Soil radiance plays a major part in remote sensing and can drastically influence readings. Therefore, near full crop canopy development may be required to minimize soil effects and accurately detect differences in crop N status.

References

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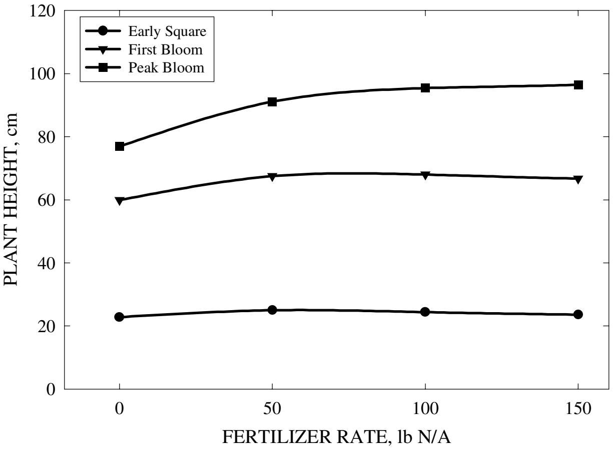

Figure 1. Response of plant height to N fertilizer rates.

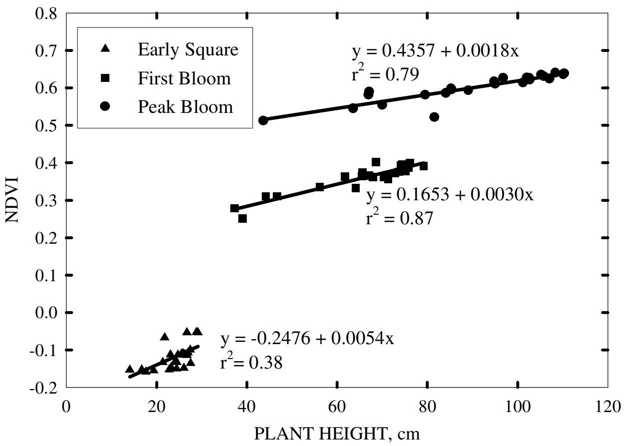

Figure 2. Linear regression of plant height to NDVI.

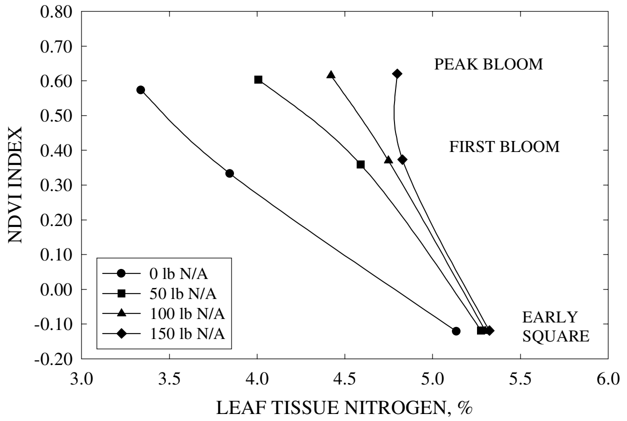

Figure 3. Relationship of NDVI index values to leaf tissue N concentrations.