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COTTON GROWTH, YIELD, AND CANOPY HYPERSPECTRAL REFLECTANCE AS AFFECTED BY NITROGEN APPLICATION

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Abstract

Cotton (*Gossypium hirsutum* L.) growth and yield formation are very sensitive to nitrogen (N) fertilization due to its indeterminate growth habit. Nitrogen deficiency affects growth and physiology and reduces lint yield and fiber quality. On the other hand, excess N supply causes rank growth, increases production practice costs, and results in some environmental problems. Therefore, it is important to detect plant N status using the realistic means in crop fertilization management.

Recent studies have shown that remote sensing technologies can be used to detect crop environmental stresses, to monitor crop growth and physiology, and to predict yield from different scales. The major principles of remote sensed data analysis in agriculture are to obtain reflectance indices or ratios from reflectance spectra of leaf, canopy or landscape level and to determine the relationships between the indices and crop growth or yield parameters. Most commonly used indices are simple ratios (SR) of reflectance at the infrared to red ranges and normalized difference vegetation index (NDVI).

Field experiment was conducted in Mississippi Agriculture and Forestry Experiment Station, Mississippi State University in 2001 and 2002 to investigate relationships between hyperspectral reflectance (350-2500 nm) and cotton growth, physiology, and yield as affected by N application. Cotton cv. NuCOTN 33B was planted on 14 May 2001 and 24 May 2002. Four treatments were: (i) No N application during growth (0 N); (ii) 50 lbs N acre^{-1} applied at the 2nd true leaf stage (50 N); (iii) 50 lbs N acre^{-1} at the 2nd true leaf stage and the other 50 lbs at the first square stage (100 N); and (vi) 50 lbs N acre^{-1} at the 2nd true leaf stage and additional 100 lbs at the first square stage (150 N). The experiment was arranged in a randomized complete block design with 5 or 6 replications. Plot size was 50 feet long and 26 feet wide with eight rows spaced 39 inches apart. Weekly or biweekly measurements of leaf photosynthetic rates, leaf and canopy spectral reflectance, plant height, and mainstem nodes were made during growth. Aboveground dry matter accumulation and leaf area index were also determined by harvesting 1-m row plants in each plot at different growth stages. Seed cotton yield was obtained by mechanical harvest. The number of bolls per unit area, boll weight and lint percentage were obtained by hand picking all bolls in 1-m row of each plot. Lint yield was calculated by multiplying seedcotton yield with lint percentage.

In 2001, there were no statistical differences among treatments in leaf photosynthesis, aboveground biomass and lint yield, although leaf N concentration was highly related to N fertilizer application rate. In 2002, leaf photosynthetic rates of 0 N and 50 N treatments were significantly lower than those of 100 N and 150 N treatments during boll development. The 0 N treatment had significantly less LAI, lower biomass and lower lint yield than other treatments. Nitrogen deficiency significantly increased canopy reflectance in the visible range. Thirteen reflectance indices of simple ratio (SR) of near infrared to red range or normalized difference vegetation index (NDVI) were calculated and used in regression with growth or yield parameters. Results indicate cotton plant height and mainstem nodes could be estimated using SR (R750/R550) by either a logarithmic or linear function (R^2 = 0.63~0.67***). Leaf area index and biomass could be estimated using the SR (R935/R650, R750/R550, or R935/R661) or a NDVI, [(R935-R661)/(R935+R661)] by an exponential function (R^2 = 0.56~0.78***). Both seed cotton and lint yields were highly correlated with the NDVI around the first flower stage (R = 0.82~0.93****). A linear model could be used to estimate cotton yield by measuring NDVI at the first flower stage. Therefore, canopy reflectance may provide a useful tool to monitor cotton N deficiency, to estimate plant growth, and to predict yield.