# DETERMINATION OF COTTON NITROGEN STATUS WITH A HAND-HELD CHLOROPHYLL METER IN ALABAMA AND MISSOURI

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## Abstract

An experiment was conducted to test the ability of a hand held chlorophyll meter (SPAD-502 Chlorophyll Meter, Minolta Camera Co., Ltd., Japan) to determine cotton (*Gossypium hirsutum* L.) N status at sites in Alabama and Missouri. Nitrogen was applied at rates of 0, 45, 90, 135, 180 and 225 kg ha$^{-1}$ to establish a range of cotton N status. Chlorophyll meter readings on the uppermost fully-expanded main stem leaf were compared to standard leaf blade total N and petiole $NO_3$-N at first square, first bloom and mid-bloom as predictors of seed cotton yield. A typical curvilinear response to N fertilizer was observed in Alabama experiments. Cotton yields did not respond to N in Missouri due to adverse weather. Chlorophyll meter readings were significantly correlated to leaf blade total N at all three growth stages in all experiments. In Alabama, chlorophyll meter readings compared favorably with leaf blade total N and petiole $NO_3$-N as a predictor of seed cotton yield at all three stages of growth. It appears that hand-held chlorophyll meters have promise as a tool to be used to determine supplemental N fertilization for cotton. However, more research will be required before chlorophyll meters can be used for routine cotton N recommendations.

## Introduction

Researchers have searched for methods to evaluate cotton N status during the season to assist in determining the need for supplemental N applications. Nitrogen deficiencies can reduce vegetative growth, boll set and yield; while excess N promotes rank vegetative growth, boll rot and delayed maturity. In addition, excess N fertilization can cause contamination of ground and surface waters.

Methods used to predict cotton N requirements include soil and tissue testing. Soil $NO_3$-N tests prior to planting have been successful in predicting cotton N requirements in the western U. S. (Gardner and Tucker, 1967) but have been less effective in the Southeast (Lutrick et al., 1986). Petiole $NO_3$-N tests have been used to predict cotton N needs in Arkansas and Georgia (Lutrick et al., 1986) but have been less successful in Alabama (Adams, 1980), Mississippi (Jenkins et al., 1982) and Tennessee ( Howard and Hoskinson, 1986). Leaf blade total N analyses tend to be less affected by climatic and seasonal changes than petiole $NO_3$-N tests (Sabbe and Zelinski, 1990). This allows the producer to sample the crop in a less rigorous manner than would be possible with petiole $NO_3$-N, because of less fluctuations in leaf blade N concentration as the growing seasons progresses.

Hand-held chlorophyll meters may offer a good corollary to leaf blade total N analysis and therefore be a useful tool for predicting N requirement for cotton. The effectiveness of chlorophyll meters for predicting N status has been demonstrated for rice (*Oryza sativa* L.) (Turner and Jund, 1991; Takebe et al., 1990) and corn (*Zea mays* L.) (Wood et al., 1991). Chlorophyll meter readings are instantaneous and involve no tissue collection. Therefore, if cotton N status can be determined with these meters, producers could respond to N deficiencies in a more timely fashion than previously possible.

The objectives of this study were to 1) determine the feasibility of using hand-held chlorophyll meters for evaluation of cotton N status, and to 2) compare leaf chlorophyll measurements with standard leaf blade total N and petiole $NO_3$-N analyses as predictors of cotton seed yield.

## Methods

The SPAD-502 Chlorophyll Meter (Minolta Camera Co., Ltd., Japan) was tested under irrigated and non-irrigated conditions in both Alabama and Missouri during 1991. Alabama experiments were conducted on Norfolk sandy loam (Fine-loamy, siliceous thermic Typic Kandiudults) at the E. V. Smith Research Center near Shorter, AL. Missouri experiments were carried out on a Tiptonville fine sandy loam (Fine-silty, mixed, thermic Typic Argiudoll) at the Delta Research Center at Portageville, MO. Recommended cultural practices, and pest control were used for each experiment. Nutrients other than N were applied according to soil test recommendations. Stoneville 506 was planted in Missouri on 31 May 1991. Deltapine 50 was planted on 22 April 1991 in Alabama (Table 1).

The irrigated experiment in Missouri received 200 mm of supplemental moisture via four 50 mm surface furrow irrigation events. No supplemental irrigation was applied to the irrigated experiment in Alabama due to the high amount of rainfall during the growing season.

Experimental designs were randomized complete blocks of four replications, and were identical in Alabama and Missouri. Nitrogen rate treatments of 0, 45, 90, 135, 180 and 225 kg N ha$^{-1}$ were applied at planting to establish a range of cotton chlorophyll levels, tissue N concentrations and seed cotton yields. Individual plot size was 8.1 X 7.6.m.

Chlorophyll measurements (10 plot$^{-1}$)were made at first square, first flower and mid-bloom (Table 1). In addition, thirty of the uppermost fully expanded leaves in each plot were collected, and separated into leaf blades and petioles. Petiole samples were analyzed for $NO_3$-N and leaf blades were analyzed for total N. Leaf blade tissue and petioles from Missouri experiments were analyzed by the University of Arkansas. Leaf blades from Alabama experiments were analyzed for total N at Auburn University with a LECO CHN-600 analyzer. Cotton was harvested with a spindle picker on 16 September and 24 October in Alabama and Missouri, respectively.

Data were Analyzed via regression procedures with the SAS package (SAS Institute, 1988). The proposed adequate linear model included linear and quadratic terms. Dummy variables (Draper and Smith, 1981) for irrigation and irrigation by other independent variable interactions were tested to determine deviations between irrigated and non-irrigated experiments. Stepwise elimination of nonsignificant independent variables was utilized, and terms were eliminated from the model if nonsignificant at the alpha = 0.10 level. Because no supplemental irrigation was applied to the irrigated experiment in Alabama, no attempt was made to separate irrigation effects in Alabama experiments.

## Results and Discussion

Abundant , well distributed rainfall during the growing season promoted high seed cotton yields and N response in Alabama. A typical curilinear seed cotton yield response to N fertilization was observed with a maximum agronomic yield of 3.54 Mg seed cotton ha$^{-1}$ at 207 kg N ha$^{-1}$ in Alabama. Based on a ginning fraction of 0.38, a lint price of \$1.43 kg$^{-1}$ and a N cost of \$0.6 kg$^{-1}$ a maximum economic yield of 3.46 Mg seed cotton ha$^{-1}$ was obtained at 191 kg N ha$^{-1}$. Although yields were high, ranging from 2.5 to 3.4 Mg seed cotton ha$^{-1}$, N fertilization had no effect on yield in Missouri. The lack of response to N fertilization in Missouri was primarily caused by late planting and an early frost which froze many unopened bolls at the higher N rates. Seed cotton yield was 0.5 Mg ha$^{-1}$ greater in the irrigated than in the non-irrigated experiment across all N rates in Missouri.

Chlorophyll meter readings were highly correlated with tissue N concentrations at all three stages of growth (Table 2). A narrower range of leaf blade total N concentrations was observed in Missouri than in Alabama experiments. The smaller leaf blade N range could have been due to higher soil N fertility regime in Missouri. Although the leaf blade tissue N range was small, significant relationships with chlorophyll meter readings were obtained at all three stages of growth in Missouri. Quadratic relationships between chlorophyll meter readings and leaf blade total N at first square and first bloom in Missouri may indicate a buildup of leaf $NO_3$-N at those stages of growth. Chlorophyll meter readings were lower in the irrigated than in the non-irrigated experiment in Missouri at mid-bloom, perhaps due to a greater leaf blade $NO_3$-N:chlorophyll ratio under irrigation.

As previously mentioned, adverse weather conditions disallowed seed cotton yield responses to N fertilizer in Missouri experiments. Therefore, no significant correlations between seed cotton yield and leaf blade N, chlorophyll meter readings or petiole $NO_3$-N concentration were observed in Missouri. Leaf blade total N was a good predictor of yield at all three stages of growth in Alabama (Table 3). As expected from high correlation between leaf blade tissue N concentrations and chlorophyll meter readings, Alabama chlorophyll meter readings were good predictors of yield. Chlorophyll meter readings were not as highly correlated to seed cotton yields as leaf blade N or petiole $NO_3$-N at first square and first bloom. However, chlorophyll meter readings predicted yield similarly to leaf blade N at mid-bloom and had a superior seed cotton yield predictive capability when compared to petiole $NO_3$-N at mid-bloom.

## Conclusions

Chlorophyll meter readings compared favorably to standard leaf blade N and petiole $NO_3$-N tests for evaluation of cotton N status. Because of the rapidness of this procedure, chlorophyll meters deserve further attention. Much additional research will be required before chlorophyll meters become a tool for prediction of in-season cotton N applications.

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Table 1. Sampling dates (SD)and days after planting (DAP) in relation to development of the cotton plant in Alabama and Missouri.

| Growth Stage | Alabama | | Missouri | |
|---|---|---|---|---|
| | SD | DAP | SD | DAP |
| Planting | 4/22 | 0 | 5/31 | 0 |
| First square | 6/3 | 42 | 7/1 | 31 |
| First Bloom | 6/21 | 60 | 7/28 | 58 |
| Mid-bloom | 7/31 | 100 | 8/29 | 90 |
| Harvest | 9/16 | 147 | 10/24 | 146 |

Table 2. Relationship between leaf blade total N (x) and chlorophyll meter readings (Y) at first square, first bloom and mid-bloom in Alabama and Missouri experiments.

| Location | Growth stage | Equation | $R^2$ |
|---|---|---|---|
| Alabama | first square | $Y=25.5+0.24x$ | 0.71 |
| | first bloom | $Y=23.3+0.45x$ | 0.53 |
| | mid-bloom | $Y=21.5+0.51x$ | 0.79 |
| Missouri | first square | $Y=0.04+1.8x-0.02x^2$ | 0.54 |
| | first bloom | $Y=50+4.6x-0.05x^2$ | 0.41 |
| | mid-bloom (irr.) | $Y=21.9+0.61x$ | 0.55 |
| | mid-bloom (non-irr.) | $Y=25.6+0.61x$ | 0.55 |

Table 3. Relationships between seed cotton yield (Y) and leaf blade total N (leaf), leaf chlorophyll meter readings (SPAD) and petiole $NO_3$-N (petiole) at first square, first bloom and mid-bloom in Alabama experiments.

| Variable | Growth stage | Equation | $R^2$ |
|---|---|---|---|
| Leaf | first square | $Y=0.2+0.001x^2$ | 0.79 |
| | first bloom | $Y=-1.9+0.10x$ | 0.78 |
| | mid-bloom | $Y=-3.6+0.32x-0.004x^2$ | 0.77 |
| SPAD | first square | $Y=-9.9+0.34x$ | 0.68 |
| | first bloom | $Y=-3.35+0.14x$ | 0.55 |
| | mid-bloom | $Y=14.8+0.78x-0.008x^2$ | 0.76 |
| Petiole | first square | $Y=0.8+0.16x-0.002x^2$ | 0.73 |
| | first bloom | $Y=1.4+0.27x-0.008x^2$ | 0.80 |
| | mid-bloom | $Y=2.4+1.02x-0.188x^2$ | 0.27 |