USE OF A CHLOROPHYLL METER TO DETERMINE COVER CROP, ROTATION AND N RATE EFFECT ON CROP N STATUS

D. J. Boquet, E. M. Holman, R. E. A. Brown, W. J. Thomas and A. B. Coco
Louisiana State University Agricultural Center Northeast Research Station Winnsboro and St. Joseph, LA

Abstract

It is essential that producers know the nitrogen status of their cotton crop throughout the growing season. Laboratory tests often do not provide accurate and rapid assessment of crop N status. A chlorophyll meter may be able to provide rapid and accurate determination of N status of cotton plants. Field studies that provided a wide range of N sufficiency were used to: (1) evaluate a chlorophyll meter (SPAD 502, Minolta Camera, Ltd. Japan) for consistency and accuracy of determining N levels in cotton plant leaf blades, (2) determine if the chlorophyll meter could be used to monitor treatment effects on N availability and uptake by cotton plants, and (3) determine the effect of variety and leaf age on chlorophyll readings. SPAD chlorophyll readings were strongly associated with N availability (R^2 = 0.8 – 0.99), whether from fertilizer or legume N. The meter was able to identity small differences in N availability as affected by tillage practices or termination date of cover crops. Leaf age and variety had large effects on SPAD readings. The SPAD chlorophyll meter was an accurate instrument for determining N status of cotton in uniform experiments and may have applications in commercial production fields. Because of inherent difference among varieties in leaf color, the meter will require calibration for each variety and, perhaps, other factors.

Introduction

In cotton production, nitrogen (N) is often the most critical nutrient with under-fertilization of N resulting in reduced yield while over-fertilization can promote excessive vegetative growth, boll rot, delayed maturity, and may lead to environmental contamination. Efforts to estimate N fertility requirements for cotton are complicated by the complexity of N cycling in the soil and the indeterminate growth habit of cotton.

Soil and tissue tests for assessing cotton N needs have been investigated (Gardner and Tucker, 1967; Lutrick et al., 1986; Keisling et al., 1995; Sunderman et al., 1979; Sabbe and Zelinski, 1990; Phillips et al., 1987; Bell et al., 1998), however soil and plant N analysis of require considerable time and expense. A non-destructive, instantaneous method for assessing cotton N status would be more efficient and, possibly, avoid some of the inherent problems associated with soil and tissue testing.

Chlorophyll, an N-rich pigment molecule in leaves, has been correlated with leaf N content in corn (Schepers et al., 1990), rice (Turner and Jund, 1991), and cotton (Edminsten and Wood, 1992). The development of the SPAD-502 chlorophyll meter (Minolta Camera Co., Ltd., Japan) has increased interest in the use of chlorophyll content as an indicator of plant-N status. This hand-held device nondestructively estimates the chlorophyll content of leaves by measuring the difference in light attenuation at 430 and 750 nm. The spectral transmittance peak for both chlorophyll *a* and *b* occurs at 430 nm, whereas the 750 nm wavelength is in the near-infrared spectral region where no transmittance occurs.

The SPAD-502 chlorophyll meter has been successfully used to monitor N status of several crops (Murdock et al., 1997; Piekielic et al., 1997; Peterson, et al., 1993). Recent reports by Wood *et al.* (1992) confirm that leaf chlorophyll content measured with the SPAD meter and leaf-N contents were correlated for field-grown cotton. In the same study, chlorophyll meter readings of the upper-most fully expanded leaf compared favorably to leaf-blade N and petiole NO_3-N with respect to seed cotton yield predictability at three stages of growth. However, differences in chlorophyll content among varieties and the interaction effects among production practices, such as N rate, crop rotation and cover crops, have not been investigated.

Materials and Methods

The SPAD-502 chlorophyll meter was evaluated in four field experiments at the Macon Ridge Research Station near Winnsboro and Northeast Research Station near St. Joseph, LA. Experiment 1 at Winnsboro had four treatment variables that affected the availability and uptake of N -- Tillage practice of surface tillage and no till; N rates of 0, 35, 70, 105, and 140 lb per acre; cover crops of wheat, hairy vetch and native vegetation; and cover crop termination date. Experiments 2 and 3 were rotational sequences of corn and cotton with different N rates for each crop -- 0, 150, 200 and 250 lb per acre for corn; and 0, 25, 50, 75, 100 and 125 lb per acre for cotton. Experiment 2 was located at Winnsboro and Experiment 3 was located at St. Joseph, but both had identical treatments. The varieties planted in each experiment were 'Stoneville 474' in Experiments 1 and 2, and 'Sure-Grow 125' in Experiment 3. Experiment 4 was a cotton variety test at Winnsboro with 30 varieties of cotton fertilized with a constant N rate of 80 lb per acre. All of the tests were irrigated except for Experiment 3 and were grown using standard production practices. The soil for Experiments 1, 2 and 3 was a Gigger silt loam and for Experiment 3 was Commerce silt loam. The experiment

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1269-1271 (1999)
National Cotton Council, Memphis TN

design for all experiments was a randomized complete block with four replications.

Chlorophyll readings were taken in Experiments 1, 2, and 4 at two dates, 91 and 103 days after planting (DAP). Readings in Experiment 3 were taken on one date, 62 DAP. Readings in Experiment 4 were taken 84 and 98 DAP. The general sampling procedure was to take readings from 10 random plants per plot using the first fully expanded uppermost leaf blade – the same leaf usually sampled for petiole nitrate- NO_3 or total leaf blade N (Leaf 2). To determine the effects of leaf age on chlorophyll readings, the leaf blade immediately above and below Leaf 2 also were sampled in Experiment 2. At the time of sampling, the petioles and leaf blades were collected, oven dried and ground for N analysis. These analyses are not yet completed.

For each experiment, the SPAD readings were analyzed by analysis of variance. The Fisher protected LSD test at the 0.05 level was calculated for mean separation. Where fertilizer N rate was a variable, regression analyses were calculated to determine the relationship between N rate and SPAD readings.

Discussion

Experiment 1

There was a strong association between N rate and SPAD reading, which differed among the cover crops (Figure 1). The regression lines for SPAD readings closely paralleled the yield responses to N rates and cover crops that have occurred for several years in this study, which have shown that the largest responses to N rate occur following wheat and the smallest occur following vetch. SPAD readings that indicated N sufficiency were between 38 and 40. The N rate x sample date interaction was significant because at low N rates the SPAD readings decreased over time and at high N rates the SPAD readings increased over time. This is an expected occurrence because the cotton with low N rates would run out of N later in the growing season, which would be reflected in lower leaf chlorophyll. The cover crop x sample date interaction was also significant because SPAD readings for cotton following wheat and native covers were the same at both sample dates while readings for cotton following the vetch cover were higher at the second date (Figure 2). This was related to the large quantity of available N from legume and fertilizer N in the vetch treatments. Early termination of cover crop growth for wheat and native vegetation did not affect SPAD readings, whereas early termination of vetch growth reduced SPAD readings.

Experiments 2 and 3

The SPAD readings for Leaf 2 at both sample dates in Experiment 2 were similar and there was no interaction between the N rate applied to cotton and sample date. As in Experiment 1, there was a strong association between SPAD reading and cotton N rate (Figure 3). A SPAD reading of 39 indicated N sufficiency, which was in agreement with the results from Experiment 1.

There was a significant effect of leaf age on SPAD readings with Leaf 1 having the lowest and Leaf 3 having the highest readings. Using any one of the leaves that were sampled would give results strongly correlated with N rates but sampling across leaf ages would give inconsistent results.

As in Experiment 2, the SPAD readings in Experiment 3 were strongly associated with cotton N rates. The sufficiency level, however, was indicated by a SPAD reading of 28, which was quite different from the results in Experiments 1 and 2. The large differences between locations may be related to the different soil types, varieties or to drier (non-irrigated) conditions at St. Joseph.

Corn residual N rate had no effect on SPAD readings of cotton leaves in either experiment. This indicates that, even with high N rates applied to corn, cotton did not benefit from residual N. This agrees with the yield results from this study in that, for two rotational cycles, there has been little or no effect of residual corn N on cotton growth or yield.

Experiment 4

There were large differences among varieties in SPAD readings that ranged from an average of 31.1 to 40.4 (Figure 4). SPAD readings were lower at the second sample date 98 DAP than at the first sample date 84 DAP. There was, however, no significant variety x sample date interaction for SPAD. Thus, although the SPAD readings showed great consistency within varieties and across dates, there were large differences among varieties when fertilized with an optimal N rate, which will complicate the use of the chlorophyll meter in commercial cotton fields.

Summary

The SPAD-502 chlorophyll meter readings were strongly correlated with fertilizer N rates and with available N as affected by cover crops. The meter was able to identify small differences in N uptake as affected by tillage practices, cover crops and cover crop termination date. Because of inherent differences among varieties in leaf color, the meter will require calibration for each variety. Leaf age was a major factor in SPAD readings. Plant to plant leaf selection will therefore be an important factor in obtaining accurate and consistent results.

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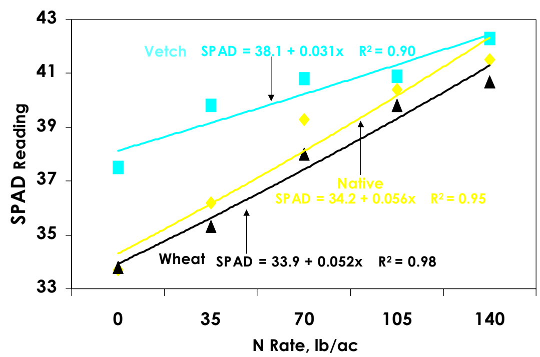

Figure 1. Nitrogen rate and cover crop effect on SPAD chlorophyll readings of cotton leaves - 1998.

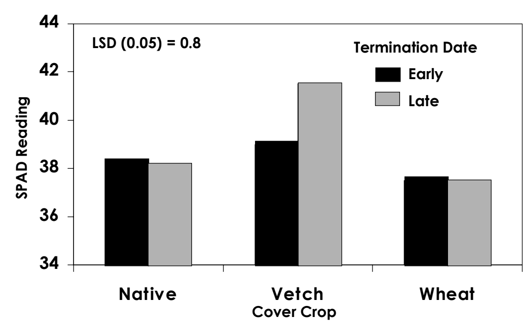

Figure 2. Cover crop and cover crop termination date effect on SPAD chlorophyll readings of cotton leaves - 1998.

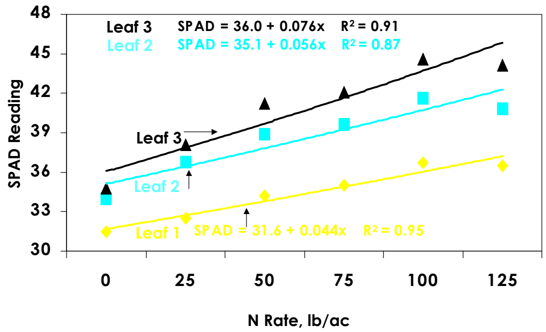

Figure 3. N rate and leaf age effect on SPAD chlorophyll readings of cotton leaves.

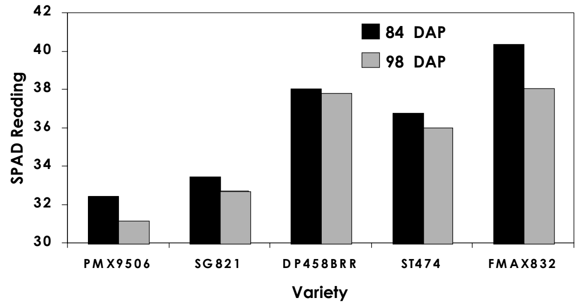

Figure 4. Variety effect on SPAD chlorophyll readings of cotton leaves at two dates - 1998.