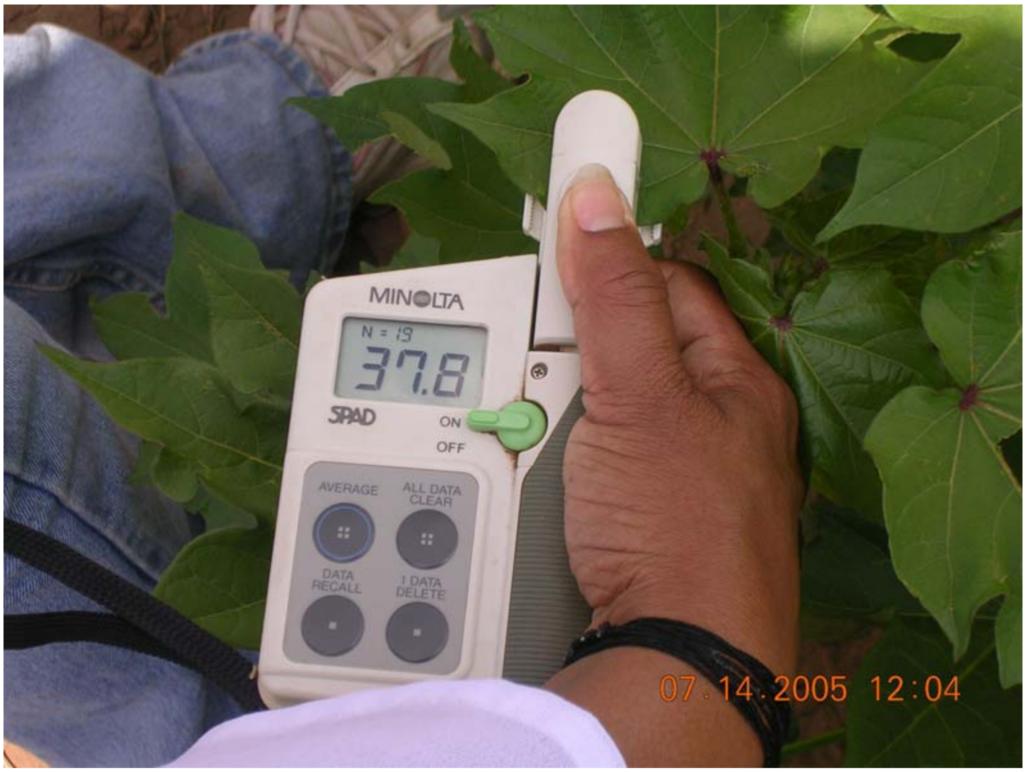
Use of the Chlorophyll Meter to Guide In-season Nitrogen Fertilizer Applications in Irrigated Cotton



Following water, nitrogen (N) is the most important constraint to upland cotton production. Most of the cotton in the semiarid western U.S.A. is irrigated, and in areas like the Southern High Plains, center pivots are the preferred irrigation method. Nitrogen fertilizer management is convenient with center pivots since liquid N can be injected into the irrigation system, and this mode of application is efficient as well. The timing of N fertilizer injections then becomes a management question producers need guidance on. Traditionally, spring, pre-plant soil nitrate tests have been the basis for N fertilizer recommendations for cotton in the semiarid western USA (Zhang et al., 1998). Soil nitrate-N measured in early spring, however, may be leached or lost as gases before crop N uptake is appreciable. Decomposition of organic matter, on the other hand, can increase the supply of N to the crop. In-season monitoring of plant N status may be an approach that can complement soil testing and ensure that N is applied on an as-needed basis for the growing conditions of each particular season, field, and cotton variety.

The chlorophyll meter provides a rapid and nondestructive diagnosis of plant N status and has been widely tested for crops like rice (*Oryza sativa* L.), corn (*Zea mays* L.), wheat (*Triticum aestivum* L.), and cotton (Turner and Jund, 1991; Peterson et al., 1993; Varvel et al., 1997, Follett et al., 1992). Bronson et al. (2001) found that in-season chlorophyll meter measurements of cotton correlated with petiole nitrate-N, leaf N, and lint yield, and that the measurements were less variable than petiole nitrate. Using the chlorophyll meter as a guide to in-season N fertilization is usually based on a sufficiency index calculated as follows (Varvel, 1997):

$$\textbf{Sufficiency index} = \frac{\textbf{average chlorophyll meter readings of unknown area}}{\textbf{average chlorophyll meter readings of well-fertilized area}} \ \textbf{X 100 \%}$$

In-season N is applied when the sufficiency index < 95%. The sufficiency index approach allows the chlorophyll meter to be used in different environments and with different varieties, as these factors affect raw chlorophyll meter readings (Peterson et al., 1993).

For producers who want to use the chlorophyll meter to guide the timing of liquid N fertilizer injections to center-pivot irrigated cotton, a well-fertilized area needs to be established prior to planting or near planting. The simplest approach is to use an 8-row ground rig to apply 90 to 120 lb N/ac in a strip. The length of the well-fertilized area/strip can vary but could be from 100 to 1000 yards long. If solid urea is used (46-0-0), then it should be applied shortly before an irrigation. We recommend monitoring each circle every 2 weeks starting at early squaring and ending at peak bloom. Since injecting into the irrigation system gives a single, blanket rate of N across the circle, subsamples of chlorophyll meter readings should be averaged. A minimum of about 30 readings per circle should be taken. Readings should be on the uppermost fully expanded leaves. The chlorophyll meter easily stores data, and when 30 readings have been taken, the "AVERAGE" button can be pushed to display the average reading for a circle or other area. For typical quarter-section centerpivots (120 acres of irrigated cropland), a 1000-gallon tank of 32-0-0 (32 % N as urea ammonium nitrate) provides about 30 lb N/ac. Thirty lb N/ac should therefore be injected whenever the sufficiency index falls below 95 %.

Table 1 shows results from three site-years of testing of chlorophyll meter-based N management at Ropesville and Lubbock Texas (Chua et al., 2003). The soil test –based treatment consisted of a target N supply of 150 lb N/ac for a 2 ½ bale/ac yield goal. The nitrate-N in a 0-24 inch pre-plant, spring soil test was subtracted from 150 lb N/ac to give the seasonal N fertilizer amount to be applied/injected. These amounts were then split into 30 lb N/ac doses and applied on a fixed schedule at time of planting, first square, first flower, and peak bloom. In the chlorophyll meter treatment, 30 lb N/ac was applied near planting. Additional 30 lb N/ac doses were applied at first square, first bloom and peak bloom if the sufficiency index (calculated from chlorophyll meter readings as shown above) was less than 95 %. At the Ropesville site, early season hail storms and mid season insect pressure limited N response and yields. The chlorophyll meter correctly indicated no need for in-season N (30 lb N/ac application was at planting). At the Lubbock site, 60 lb N/ac was saved with the chlorophyll meter compared to the soil test treatment and without hurting yields. In 2001 at Lubbock favorable growing conditions resulted in high yields of 2 ½ bales/ac. In that case, the amount of N saved with in-season chlorophyll sensing was 30 lb N/ac.

Irrigated lint yields as affected by chlorophyll meter-based nitrogen management (Chua et al., 2003).

Treatment	Ropesville 2000	Lubbock 2000	Lubbock 2001
	-------------------------Lint Yield (lb/ac)	----------------------------	
Well-fertilized	609 (180)	946 (180)	1326 (120)
Soil Test	629 (120)	954 (120)	1276 (90)
Chlorophyll meter	556 (30)	922 (60)	1246 (60)
Zero nitrogen	631 (0)	792 (0)	1038 (0)
LSD (*P*=0.05)	NS	80	123

Note: Total, seasonal Nitrogen fertilizer rates are in parenthesis. LSD is least significance difference.

Many have asked the question: Do chlorophyll meter readings vary much with different cotton varieties? In the following table we present recent chlorophyll meter data where different varieties and the effect of N fertilizer applied at first square at 100 lb N/ac were examined. As expected different varieties showed different chlorophyll meter readings. However there were no actual N deficiencies (as determined by laboratory analysis of leaf N) in any of the N-fertilized plots. The variation in readings among varieties underscores the point that well-fertilized reference plots or strips are absolutely necessary to interpret chlorophyll meter reading data properly.

Mid-bloom chlorophyll meter readings as affected by nitrogen fertilizer and variety, Lamesa, TX, 2005

Variety	Zero-N	Plus N Fertilizer
Stoneville 5599 BR	36.5	42.9
FiberMax 989 BR	38.4	46.0
Paymaster 2280 BR	37.0	44.3

LSD for any comparison = 2.0.

Plant growth regulators like PIX (Mepaquat chloride) can dramatically affect plant height and also leaf size and thickness. The following table shows the effect of PIX (1 pint/ac at early bloom) on mid-bloom chlorophyll meter readings. Readings were lower in zero-PIX plots compared to plus PIX plots, and this affect was strongest in the N-fertilized plots (100 lb N/ac applied at first square). The reason for this was that the extra top-growth associated with the zero-PIX plots diluted plant N such that leaf N and chlorophyll meter readings were less. However the marked response in chlorophyll meter readings to added N fertilizer was evident in the PIX and zero-PIX plots. We conclude that well-fertilized reference plots or strips are required in PIXed areas to reference chlorophyll meter readings when PIX is used.

Mid-bloom chlorophyll meter readings as affected by nitrogen fertilizer and PIX (averaged across variety), Lamesa, TX 2005

	Zero-N	Plus N Fertilizer
Zero-Pix	36.4	42.1
Plus Pix	38.2	46.7

LSD for any comparison = 1.5.

Research results suggest that the chlorophyll meter has strong potential to help guide in-season N fertigations for irrigated cotton in semiarid regions. In seasons with low to moderate yield potential, the chlorophyll meter/sufficiency index approach can help producers avoid un-necessary in-season N applications. In high-yielding seasons this approach is effective at indicating greater N needs, and the savings may be less. We emphasize that a well-fertilized reference strip or area is required in this approach, in order to calculate the sufficiency index. Use of well-fertilized areas may not work as well in more humid cotton growing regions, as the high N supply may lead to rank growth. Chlorophyll meter-based N management can probably be applied to subsurface drip irrigated cotton as well.

References

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For further information contact one of the following at 806-746-6101:

Kevin F. Bronson (k-bronson@tamu.edu), Associate Professor of Soil Fertility, Texas Agric. Exp. Stn.

Randy K. Boman, Associate Professor and Cotton Extension Specialist, Texas Coop. Extn.

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