Agronomy Guide

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Determining Nitrogen Fertilizer Sidedress Application Needs in Corn Using a Chlorophyll Meter

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Balancing the amount of nitrogen (N) fertilizer needed for optimum corn yields with the potential threats of surface and ground water contamination by leaching of excessive soil nitrate levels has become a constant challenge for corn production throughout the Midwest. One strategy for reducing the threat of nitrate leaching from agricultural lands is to apply no more N than the crop can use during the growing season. As a result, only minimal amounts of N will remain in the soil after harvest to be lost by leaching over the winter.

However, reducing fertilizer N rates also increases the risk that N loss during the early part of the growing season will lead to crop N deficiency and yield loss. If lower N fertilizer application rates are to be encouraged, farmers and/or their consultants need tools or procedures that rapidly and inexpensively determine the N status of a growing crop, giving them the opportunity to apply additional N fertilizer if initial applications are insufficient.

Research in a number of states, including Indiana, has shown that chlorophyll meter readings can be used to determine the N status of corn late in the vegetative growth period. (For this publication, a Minolta[1] SPAD 502 was used.) The meter allows for fast, non-destructive measurements of the relative greenness of the plant. Greenness is affected by a number of factors, one of which is the N content of the leaf. During the latter part of the vegetative growth period, roughly the 10-leaf stage (V10) through pollination, relative greenness can be used to assess N sufficiency.

Figure 1. A chlorophyll meter in use

The greenness of a corn plant can be influenced by a number of factors other than the N content of the leaf. These include hybrid differences, leaf age, stresses related to other nutrient deficiencies or excesses, leaf diseases, insect damage, weather and so forth. Studies in Indiana have shown 50% to 70% differences in greenness between commonly grown commercial corn hybrids. Table 1 shows an example from a Purdue University experiment. Hybrid C had 11% lower SPAD readings when fully fertilized than Hybrid A at the V8 growth stage but yielded 11 bushels more per acre.

Table 1. The degree of leaf greenness varies substantially among optimally fertilized commercial hybrids.

Commercial Hybrid	N Rate lb./A	Chlorophyll-meter Reading		Yield bu/A
		V8	V10	
"A"	90	51	51	137
	180	55	54	156
"B"	90	50	49	124
	180	51	51	165
"C"	90	47	47	131
	180	49	50	167

Before You Start

Monitoring the N status of corn is beneficial only if the farmer has the capability of applying more fertilizer N when a deficiency is identified. For Indiana growers, this usually means having access to high clearance application equipment which can be used to apply N without damaging the crop. Irrigation systems equipped for fertigation, highboys that can dribble N solutions on the soil surface or airplanes to apply granular urea or ammonium nitrate can all be used for late season N applications.

Using the Chlorophyll Meter

There are two primary ways to utilize the chlorophyll meter in N management for corn. One is to make initial fertilizer applications of 50% to 70% of the recommended N rate, then use the chlorophyll meter readings to schedule additional applications as needed. This works particularly well for irrigated systems where additional N is easily applied through the irrigation system.

A second approach is to fertilize the corn with the recommended N rate and then use the meter as a quality assurance tool to identify instances when additional N is needed due to unusually high yields or N loss from leaching or denitrification. Most Indiana farmers would typically use this approach. Both methods require prior planning to make the best use of this tool. This includes ensuring that the fertilizer application equipment will be available if needed and establishing well fertilized reference strips in the field for calibrating the chlorophyll meter.

Establishing Reference Strips

Because so many factors can influence greenness, the chlorophyll meter must be calibrated in each field using reference strips. Reference strips are 6 to 12 row strips of well-fertilized corn where N deficiency is not expected to occur. To ensure N is non-limiting, we suggest that the reference strip receive 10% to 25% more N than the usual recommended rate. Three to five such strips should be established per field. If hybrids change within a field, separate reference strips need to be established for each hybrid.

Taking the Chlorophyll Meter Readings

When farmers plan to make late season N applications based on chlorophyll meter readings, weekly meter readings starting at the 8-leaf stage and continuing through pollination are recommended. In fields where the meter is being used to monitor that N supply is sufficient, less frequent readings are needed. For such quality assurance purposes, readings at the 10- to 12-leaf stage through pollination are probably adequate. Remember that chlorophyll meter readings need to be taken in reference areas as well as in the bulk corn. At each sampling location within a field, individual leaf measurements should be made on 30 different plants and the average greenness score (as calculated by the chlorophyll meter) should be used as the SPAD value for that location. As with other plant analysis techniques, care must be taken that the plants that are sampled represent the area. Plants near skips or doubles, unusually large or small plants, and excessively damaged plants should be avoided.

The same relative leaf should be sampled on each plant. Prior to tasseling, the uppermost leaf with a visible leaf collar should be sampled. After tasseling, the ear leaf should be sampled. The readings should always be taken at the same relative position on each leaf, halfway between the leaf tip and the collar and midway between leaf midrib and margin. Readings should not be taken when the leaves are wet.

Interpretation of Chlorophyll Meter Readings

In order to convert chlorophyll meter readings into a crop N status or fertilizer need assessment, an N sufficiency index (SI) is calculated. The SI is calculated as follows:

$$SI = [(\text{Average reading from bulk area}) \div (\text{Average reading from reference strips})] \times 100$$

Studies both in Indiana and Nebraska have shown that when the SI drops below 95%, the probability of a response to additional N is great. These studies also show that monitoring the SI through the season is valuable since natural changes in rooting depth, mineralization of N from residue or manure, and interactions of soil N processes with weather will create changes over time. By starting the readings at the 10- to 12-leaf stage, the farmer can have greater confidence in the SI interpretation because the trends in meter readings have been followed over time.

For example, Figure 2 shows chlorophyll meter readings (8-leaf stage) and relative yields (yields expressed as a percent of the highest yielding plot) from a Purdue University experiment on fertilizer N rates. Both the meter readings and yields increase up to a rate of 135 lbs. N per acre. The highest N rate, 225 lbs. N per acre, is well over the recommended N rate of 180 lbs. N per acre for this soil and thus can be used as the reference strip. Readings from the reference strip averaged 53, while readings from the areas receiving no N fertilizer averaged 45. Using the formula above,

$$SI = (45 \div 53) \times 100 = 86\%$$

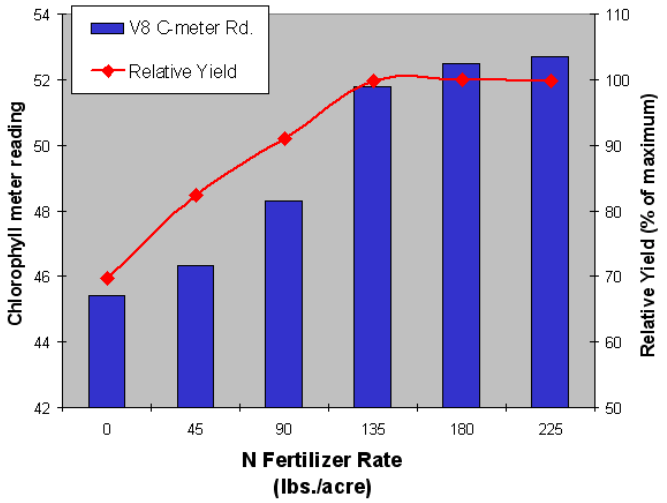

Figure 2. Chlorophyll meter readings at the 8-leaf stage identify N rates that are too low to achieve maximum yields.

Making N Recommendations from the SI

The chlorophyll meter readings do a good job of identifying N deficiencies, but do not tell us how much additional N should be applied if the crop is nitrogen deficient. In situations where fertigation is available, an additional 20 to 40 lbs. N per acre should be applied when the N sufficiency index is at or below 95% (calculated from chlorophyll meter readings taken at 8- to 12-leaf stage). The meter should then be used weekly following the nitrogen application to determine if the field is responding and if yet another N application is needed.

Under non-irrigated conditions, sidedress nitrogen applications can be both costly and destructive to tall corn, and multiple applications are not a good option. Indiana research suggests the following recommendations based on chlorophyll meter readings taken at the 8- to 12-leaf stage:

- If SI values are 90% to 95%, then 30 to 40 lbs. N per acre should be applied.
- If SI values are below 90%, then 40 to 60 lbs. N per acre should be applied.

Table 2 shows the SI values for the experimental results shown in the figure above. An additional 40 lbs. N per acre based on an SI of 92% would have been sufficient to optimize yields for the plots that had already received 90 lbs. N per acre. More N would have been needed for the plots that had received no or only a very low rate of N.

Remember that if a corn plant experiences severe N stress in its early growth stages, the size of the ear and the number of potential kernels may be reduced and a full recovery of yield cannot be achieved with a late season nitrogen application. Therefore, the amount of N recommended for rescue applications late in the season is capped at 60 lbs. per acre. After tasseling, the chances of crop response to fertilizer are reduced and N applications should probably be limited to 30 lbs. or 40 lbs. per acre regardless of the SI value. Finally, even where fertigation is available, corn is unlikely to respond at all to an N application made more than 20 days after silking.

Summary

The chlorophyll meter should be considered a "fine-tuning" tool, used to reduce the risk of yield loss from N deficiency. It is important to remember that this particular tool is best used to manage the last 40 pounds of N, not the first. In Indiana, it may prove to be a very useful tool to help determine if N loss due to excessive early season rainfall will lead to an economic yield reduction from N deficiency. However, to use this tool effectively requires some prior planning, including the establishment of reference strips.

Table 2. The calculated Sufficiency Index and the recommended amount of additional N fertilizer to apply for the experiment shown in Figure 2.

N already applied lbs./A	Chlorophyll-meter Reading	Sufficiency Index (%)	Additional N lbs./A to apply
0	45	86	60
45	46	88	60
90	48	92	40
135	52	98	0
180	52	99	0
225*	53	100	

* Reference strip receiving 25% more N than recommended for a preplant N application.

References and Acknowledgements

[1] The Minolta SPAD 502 meter may be purchased at Spectrum Technologies (on the Web at http://www.specmeters.com or telephone (800) 248-8873. The unit currently (March 2003) lists for $1395. *Mention of a brand name does not imply endorsement by Purdue University.*

This document is based in part on "Using a Chlorophyll Meter to Improve N Management" NebGuide G93-1171-A, available on the Web at http://www.ianr.unl.edu/pubs/soil/g1171.htm (URL verified March 2003), University of Nebraska, Lincoln, NE.

For more information on developing N recommendations for corn, see the "Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat and Alfalfa" Extension Bulletin E-2567, Rep. August 1996, on the Web at http://www.agcom.purdue.edu/AgCom/Pubs/AY/AY-9-32.pdf (URL verified March 2003).

For related information on sidedress N, see publication AY-314-W, "The Presidedress Soil Nitrate Test for Improving N Management in Corn," at http://www.agry.purdue.edu/ext/pubs/AY-314-W.pdf (URL verified April 2003).

For additional agronomic information, please visit the Purdue University Agronomy Extension Web site at http://www.agry.purdue.edu/ext/index.html (URL verified April 2003).

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