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Todd A. Peterson
*University of Nebraska - Lincoln*

Tracy M. Blackmer
*University of Nebraska - Lincoln*

Dennis D. Francis
*USDA-ARS*

James S. Schepers
*University of Nebraska - Lincoln*, james.schepers@gmail.com

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NebGuide

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# Using a Chlorophyll Meter to Improve N Management

**This NebGuide describes how to use a chlorophyll meter as a tool to improve nitrogen management by detecting nitrogen deficiency and determining the need for additional N fertilizer.**

*Todd A. Peterson, Extension Cropping Systems Specialist*
*Tracy M. Blackmer, Graduate Research Assistant*
*Dennis D. Francis, Soil Scientist, USDA-ARS*
*James S. Schepers, Soil Scientist, USDA-ARS*

- Field Use of the Chlorophyll Meter

Fertilizer nitrogen (N) is increasingly recognized as the source of nitrate contamination in much of Nebraska's groundwater. Improving the efficiency of fertilizer N use reduces the amount of N that can potentially contaminate water resources. Effective management of fertilizer N is a major challenge for grain crop producers. Many factors that affect its efficiency are beyond a producer's control. Weather, equipment limitations and breakdowns, and availability of labor and fertilizer during critical periods can lead to inadequate N supply to the crop. Fertilizer N is relatively inexpensive, and deficiencies can result in substantial yield reductions. Producers are inclined to manage fertilizer N to minimize the risk of deficiency, which can lead to excessive fertilizer applications. Although they understand fertilizer applied at excessive rates costs money and may lead to contamination of the environment, producers also want assurance that applying less fertilizer N will not reduce crop yields.

Researchers have been looking for ways to increase fertilizer N use efficiency. The use of a soil test to adjust fertilizer N rates for residual nitrate works well under Nebraska conditions and producer acceptance of the practice is increasing. However, the potential exists to "fine-tune" N management decisions during the growing season to react to changing weather and crop conditions.

**Figure 1. A chlorophyll meter in use.**

The concept of using tissue testing to provide an assessment of crop N status is not new. Recent research indicates a close link between leaf chlorophyll content and leaf N content, which makes sense because the majority of leaf N is contained in chlorophyll molecules. The Minolta[1]

chlorophyll meter (model SPAD 502) enables users to quickly and easily measure leaf greenness which is affected by leaf chlorophyll content. Chlorophyll content or leaf greenness is affected by a number of factors, one being N status of the plant. Since the chlorophyll meter has the potential to detect N deficiencies, it also shows promise as a tool for improving N management.

The chlorophyll meter (see *Figures 1* and *2*) has several advantages over other tissue testing methods. A reading that indicates adequate nitrogen (or critical value) is not affected by luxury consumption; a plant will only produce as much chlorophyll as it needs regardless of how much N is in the plant. It is not necessary to send samples to a laboratory for analysis, saving time and money. Producers can sample as often as they choose, and can easily repeat the procedure if they question the results. Using a chlorophyll meter to monitor leaf greenness throughout the growing season can signal the approach of a potential N deficiency early enough to correct it without reducing yields.

**Figure 2. Close-up of chlorophyll meter.**

Monitoring crop N status during the growing season accomplishes little unless it is possible to correct an N deficiency before it reduces yields. Using a chlorophyll meter as an N management tool is especially appropriate where additional N can be applied through the irrigation system (fertigation). Fertigation is generally limited to moving sprinkler systems due to the uniformity of application possible with center pivots or lateral move systems, although much progress is reported in the development of surge-flow fertigation systems. Fertigation applications in Nebraska must conform to state chemigation regulations which require certification of the operator and inspection of the required safety equipment (see your local Natural Resources District).

In non-irrigationd cropping systems additional N fertilizer can be injected with a sidedress application if crops are not too tall, or broadcast or banded between rows using high-clearance equipment. One benefit of fertigation is that the applied N is rapidly taken up by the crop to correct the N deficiency. In a non-irrigationd system, N application to dry topsoil may not be utilized until the next rain occurs, which may be too late for the plants to fully recover and produce optimal grain yields. Although the technique is quite new, we feel chlorophyll meters can be utilized on a large number of acres in Nebraska, and promises to improve fertilizer N efficiency and decrease risks associated with reduced fertilizer applications.

Many factors affect chlorophyll meter readings. Variety or hybrid differences can greatly affect the meter reading as some corn and sorghum hybrids are darker green than others. Stage of growth can affect leaf greenness as can recent environmental conditions such as temperature, moisture stress and sunlight. Plant diseases, nutrient deficiencies and nearly any other kind of plant stress can affect the ability of the plant to produce chlorophyll, thus affecting leaf greenness. Because the chlorophyll meter is affected by so many things, we are not able to say that a given meter reading indicates sufficient N. Meter readings mean very little by themselves and must be calibrated for each field, soil, hybrid and environment in order to make use of the readings. The best way to calibrate the meter is to maintain several adequately fertilized reference strips in each field.

## Field Use of the Chlorophyll Meter

1. **Establishing Reference Strips**. For reasons outlined above, it is crucial that the chlorophyll meter be calibrated for each field, previous crop, hybrid, fertilizer and/or manure application and differing soil types. Several adequately fertilized reference strips, identical to the rest of the field

except that they receive sufficient levels of nitrogen fertilizer, should be established in each field. The amount of N applied to these strips should be adequate to insure that plants in the reference strip do not exhibit an N deficiency.

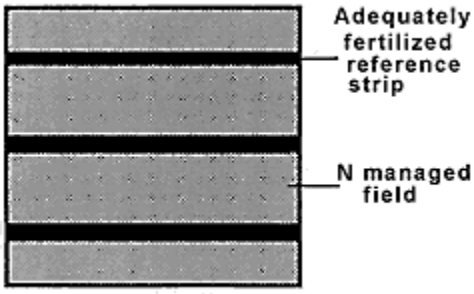


**Figure 3. Field planted with reference strips.**

We suggest that **the entire field be fertilized with one-half to two-thirds of the total amount of fertilizer N recommended** by standard soil test procedures. The reference strips should then be established by applying additional N fertilizer so the total amount applied to the strips is equal to or slightly higher than the N rate suggested by the University of Nebraska (see NebGuide G74-714, *Fertilizer Recommendations for Corn*). A large excess of N applied to the reference strips is not recommended and may reduce yields. Three to five reference strips should be established in each field to accurately represent conditions in that field (see *Figure 3*). By comparing the average chlorophyll meter readings from the reference strips to those from the rest of the field, N sufficiency and the need for additional N supplied through fertigation can be determined.

2. **How to sample**. Weekly chlorophyll meter readings from the reference strip and the bulk field should be compared at a minimum of three locations in each field. At each location, the average reading of 30 plants from the reference area and the adjacent bulk field should be compared. The Minolta SPAD 502 collects and stores up to 30 individual readings and calculates the average automatically. Care must be taken during collection of these readings to insure their accuracy. Individual readings will vary up to 15 percent from plant to plant, but the goal is to collect 30 readings so that the average accurately represents leaf greenness for that crop. Avoid taking readings from plants that do not represent typical plant spacings (e.g., wide guess rows, doubles or planter skips). It may be helpful to systematically sample each row across the planter width to avoid problems caused by differences among rows such as plant population, compaction or variations in starter or other fertilizer application.

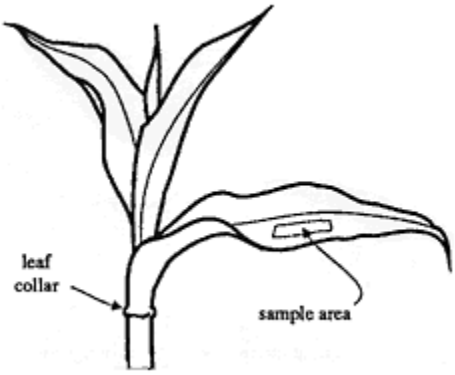


**Figure 4. Sample area for taking chlorophyll readings.**

The same leaf should be sampled from each plant. Avoid sampling very old or very young leaves. For plants between the six leaf stage (about 1 foot tall) and tassel, we recommend sampling the newest fully expanded leaf that has a leaf collar exposed (see *Figure 4*). After the tassel stage, sampling the ear leaf (the leaf attached to the primary ear shank) should give an accurate comparison. Readings taken from plants less than 1 foot tall are usually quite variable and probably not worth collecting. After selecting the leaf to be sampled, it is important to take the reading on about the same location on each leaf. We have found it works well to collect the reading from a point one-half the distance from the leaf tip to the collar, and halfway between the leaf margin or edge and the leaf midrib (*Figure 4*). Chlorophyll meter readings may vary with time of day, but as long as readings are collected from the reference strip and the bulk field at about the same time, the comparison is valid. It is best to avoid collecting readings whenever there is moisture on the leaves (i.e., after a rain or sprinkler irrigation or in the early morning) as this can distort the

readings. Extreme temperature changes can cause meter readings to fluctuate, so the meter should not be left in the sun on a vehicle dashboard or taken from an air conditioned vehicle directly to the field on a hot day.

3. **Interpretation of chlorophyll meter readings**. After recording average meter readings from the bulk field and reference area at several locations in each field, an N sufficiency index can be calculated as follows:

$$\text{Sufficiency Index} = \frac{\text{Average Bulk Reading}}{\text{Average Reference Strip Reading}} \times 100\%$$

For example 1, we sampled four places in the field and obtained the following N sufficiency index values: 101, 98, 97, and 96 percent (see worksheet). Our experience shows that a sufficiency index lower than 95 percent indicates an N deficiency that should be corrected or it may lead to a yield reduction. In example 2 (see worksheet) the readings average less than 95 percent, indicating the need for additional N. At least 20 lbs N/acre should be applied through the irrigation system to correct the N deficiency, particularly since we know the crop is rapidly taking up N during this period. This field should be checked again with the meter 4-6 days after the N application to make sure the deficiency has been corrected or that recovery is under way.

Since the readings vary depending on weather and growing conditions, readings collected from a single sampling date are not as useful as comparing trends in the sufficiency index through the growing season. Readings should be collected weekly from the six leaf stage until about 20 days after silking. Fertigations applied later than this do not increase yield.

4. **The chlorophyll meter as an N management tool**. It is important to realize that the chlorophyll meter enhances a producer's ability to make N management decisions but does not replace other aspects of good N management. Environmentally and economically sound N management must begin with a representative soil sample and a realistic value for expected yield. We suggest that at least one-half to two-thirds of the total fertilizer N be applied to the entire field prior to the six leaf stage in order to insure the chlorophyll meter technique is effective. If a corn plant experiences severe N stress in the early growth stages, the size of the ear and number of kernels can be limited so additional N fertilizer applied later will not allow full recovery of grain yield.

Using the chlorophyll meter to schedule fertigations allows adjustments throughout the season based on the amount of N supplied by mineralization of organic matter and manure, by contaminated irrigation water, or when plant roots come in contact with additional N.

When the need for additional N is indicated by the chlorophyll meter (e.g., N sufficiency index is at or below 95 percent, or a trend indicates it soon will be), an additional 20 to 40 pounds N per acre should be applied through fertigation. The decision on how and when to fertigate is affected by many factors including stage of growth, developing trends in chlorophyll meter readings, equipment limitations and anticipated crop N needs for the rest of the growing season. Most N fertilizer should be applied before the tassel stage. N applied more than 20 days after silking probably will not affect grain yields. Generally chlorophyll meter readings will respond to show crop recovery within two to three days after fertigation depending on environmental conditions.

The chlorophyll meter technique allows "fine-tuning" N management to field conditions and reduces the risk of yield-limiting N deficiencies. Producers should recognize this as another tool that may complement, but does not replace, other aspects of sound N management. One soil scientist said it succinctly, "Use the chlorophyll meter to schedule your last 50 lbs N/acre, not

your first." Potential uses of these techniques in the future may include remote sensing by satellite or airplane to schedule the need for additional fertilizer N.

[1]Mention of a brand name does not imply endorsement by the University of Nebraska or the USDA Agricultural Research Service.

**Worksheet Example 1.**

| Field: North 80 | | Date: June 28 | |
|---|---|---|---|
| | Average Bulk Field Reading | Average Reference Strip Reading | N Sufficiency Index |
| Location 1 | 54.5 | 54.1 | 100.7% |
| Location 2 | 56.8 | 58.0 | 97.9% |
| Location 3 | 49.6 | 51.3 | 96.7% |
| Location 4 | 57.2 | 59.5 | 96.1% |
| | | Average | 97.9% |
| Action: none required | | | |

**Worksheet Example 2.**

| Field: South 40 | | Date: July 10 | |
|---|---|---|---|
| | Average Bulk Field Reading | Average Reference Strip Reading | N Sufficiency Index |
| Location 1 | 50.2 | 52.4 | 95.8% |
| Location 2 | 48.2 | 51.6 | 93.4% |
| Location 3 | 51.3 | 54.4 | 94.3% |
| Location 4 | 54.0 | 58.1 | 92.9% |
| | | Average | 94.1% |
| Action: Fertigate | | | |

**Your Data**

| Field: _____ | | Date: _____ | |
|---|---|---|---|
| | Average Bulk Field Reading | Average Reference Strip Reading | N Sufficiency Index |
| Location 1 | _____ | _____ | _____ |
| Location 2 | _____ | _____ | _____ |
| Location 3 | _____ | _____ | _____ |
| Location 4 | _____ | _____ | _____ |
| Location 5 | _____ | _____ | _____ |
| | | Average | _____ |
| Action: _____ | | | Average: _____ |

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