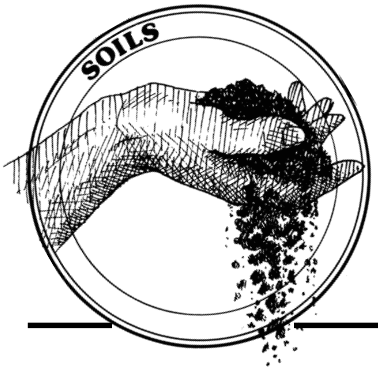


Agronomy Facts 53

The Early-Season Chlorophyll Meter Test for Corn

SUMMARY

The chlorophyll meter is a portable, hand-held device that instantaneously measures the greenness (or chlorophyll content) of a plant in the field.

Nitrogen (N) is closely associated with leaf chlorophyll; thus chlorophyll meter readings of corn leaves reveal the N status of the corn plants.

The early-season chlorophyll meter test consists of taking meter readings of corn leaves when plants are between the six- and the eight-leaf stages (when plants are about 10 to 20 inches tall), which allows time to sidedress if necessary.

Meter readings taken from plants in a field are compared to readings taken from high N reference plots that have been adequately fertilized with N fertilizer.

Additional N is required for optimum corn yield if the average meter reading of the field is less than 95% of the high N reference value. An N fertilizer estimate can be calculated using meter readings and field factors.

Advantages of the early-season chlorophyll meter test:
- Chlorophyll meter readings are quick, easy, and provide instantaneous values.
- No samples need to be collected, processed, and sent to a laboratory for analysis.
- Cost of sampling involves only labor costs.
- N recommendations are accurate (comparable to the Pre-sidedress Soil Nitrate Test).

Disadvantages of the early-season chlorophyll meter test:
- Initial expense is high (the meter costs about $1400).
- Early-season corn leaf chlorophyll levels are affected by hybrid selection and environmental stresses; therefore, high N reference plots must be established.
- This test is not applicable to fields that have received a preplant or an at-plant N fertilizer application beyond starter N.

NITROGEN AND CORN PRODUCTION

The nitrogen (N) requirement for optimum corn production can be met in a number of ways. Soils supply N by organic matter decay. In Pennsylvania, manure and N added to the soil by legumes like alfalfa are important sources of N. Also, N can be supplied in fertilizers. In most situations, the total N requirement of the corn crop is supplied by a combination of these sources. When the only sources of N are the soil and fertilizer, N fertilizer recommendations have been successfully estimated based on realistic expected crop yield. However, estimating the contributions of manure and legume N is complicated because of the variability of factors such as forage stand composition and the timing, method, and rate of manure applications. Therefore, it is difficult to make economically and environmentally sound N recommendations on many farms in Pennsylvania.

NITROGEN CONTAMINATION AND THE ENVIRONMENT

Nitrogen from agricultural operations has been identified as a significant source of nitrate contamination not only in much of Pennsylvania's surface water and groundwater in agricultural areas, but also in other areas of the Northeast, such as the Chesapeake Bay. Good N management, including efficient fertilizer N use, can minimize the amount of nitrate N that is excessive for crop growth and available for possible contamination of water resources. Since N deficiencies can lead to significant yield reductions and the cost of fertilizer N has been relatively low, growers may be reluctant to risk applying fertilizer N rates that may be too low. Pennsylvania farmers need a reliable method of determining N fertilizer rates that are economically sound and environmentally safe.

CORN N NEEDS AND SOIL TESTING

The complex behavior of N in the soil has several important implications for managing N for optimum corn production and for determining availability of soil N. Corn has the greatest need for N starting about 30 to 45 days after emergence, which is after the period of greatest change in soil N availability in the spring. The efficiency of N utilization can be improved if the N is applied after the spring wet season and near to the time of greatest need by the crop. Sidedressing N in June when the corn is 10 to 20 inches tall has become a common practice for Pennsylvania corn growers. Since corn has the greatest need for N several weeks after emergence, an N test at that point in time can more accurately reflect the actual availability of soil N for the corn crop.

Soil testing has been used effectively for years to determine the availability of phosphorus (P) and potassium (K) in agricultural soils and for determining fertilizer recommendations for these nutrients. Unfortunately, due to the complex behavior of N in the soil, development of a reliable soil test for N availability has been more difficult. A major difficulty in managing N is that while manure and fertilizer are applied far in advance of harvest, N availability can be affected by numerous factors throughout the growing season. A soil test conducted during the growing season, such as the Pre-Sidedress Soil Nitrate Test (PSNT), can help growers adjust fertilizer N rates to meet the demands of the crop. (For additional information on PSNT, refer to *Agronomy Facts 17: Pre-Sidedress Soil Nitrate Test for Corn*.)

A NEW NITROGEN INDICATOR: CHLOROPHYLL METER READINGS

Recently, a small, portable chlorophyll meter (Minolta SPAD-502; retail cost = ~$1400) was introduced. This meter measures instantaneously in the field the greenness of a plant leaf, which is directly related to the chlorophyll content of the leaf. Since most leaf N is contained in chlorophyll molecules, there is a close relationship between leaf N and leaf chlorophyll content. Therefore, chlorophyll meter readings of corn leaves can be an indicator of the N status of corn plants and the need for additional N fertilizer for optimum yields. A chlorophyll meter test has many advantages. Taking chlorophyll meter readings of corn plants is easy and rapid. There are no samples that need to be collected, processed, and sent to a laboratory for analysis. Results are available immediately in the field.

However, other factors besides N status can affect the chlorophyll meter readings of corn leaves. Leaf color may vary by hybrid. Soil and air temperatures, planting date, leaf stage, and leaf position may affect leaf greenness. Plant diseases, other nutrient deficiencies, or any other factor that causes plant stress also may affect plant color. One way to minimize the effect of these complicating factors is to establish in each field to be tested a small reference area that has been adequately fertilized with N fertilizer. (See the High N Reference Value section below.) Chlorophyll meter readings in the field can then be compared to readings from this reference area.

Research in Pennsylvania has led to the development of a testing procedure that enables chlorophyll meter readings to be used as an accurate indicator for fertilizer N sidedress requirements for corn. The procedure is applicable for corn crops that have received *no* fertilizer N before or at planting except for a normal amount of starter N (i.e., about 100 pounds per acre of total starter fertilizer). Chlorophyll meter readings are taken from corn plant leaves shortly before the time suitable for N sidedressing. These readings are compared to readings from a high N reference area (a small section of the field that has had additional fertilizer N applied). The result indicates whether the field requires N sidedressing and also provides an estimate of the amount of N needed. Research is continuing in an attempt to simplify the test and make it applicable to other conditions. Additional research is being conducted to develop a late-season chlorophyll meter test that will conveniently provide information on the N status of a corn crop at the end of the growing season. This information will help to assess current N programs for corn and determine whether adjustments to the program need to be made for successive corn crops.

THE EARLY-SEASON CHLOROPHYLL METER TEST FOR CORN

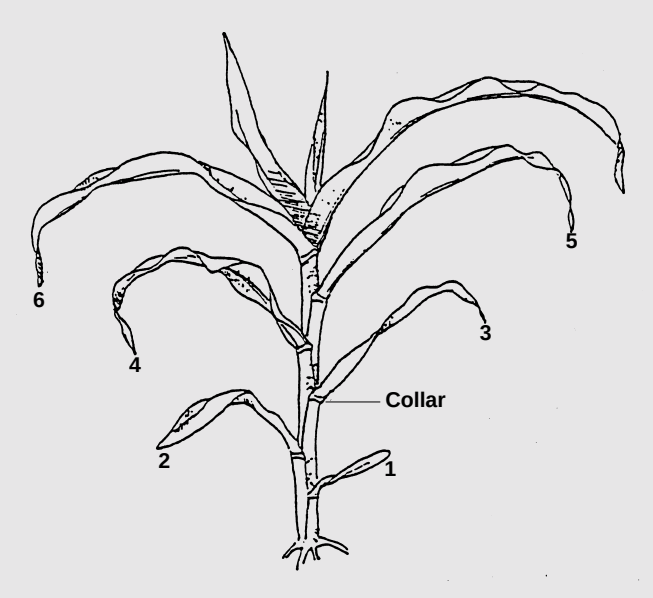
High N Reference Value

Because early-season corn leaf chlorophyll levels are dependent on factors besides N fertility (e.g., hybrid selection, soil temperatures, cold stress), it is necessary to have a high N reference value for each field tested. The high N reference value is the average chlorophyll meter reading of plants in a fertilized area of the field (at least 150 to 180 pounds N per acre—the actual rate is not critical). This area could consist of at least two small hand-fertilized sections about four rows wide by about 20 feet long or it could be a longer strip that was machine fertilized. The fertilizer should have been applied to the reference area no later than the spike stage so that plant leaves are not burned. The reference area should be in a representative part of the field where the corn will not be unusually stressed by factors like weed competition, soil compaction, or other negative impacts.

Time of Sampling

Chlorophyll meter readings should be taken when corn plants are between the six- and eight-leaf stages (when corn is usually 10 to 20 inches tall). Figure 1 shows a corn plant at the six-leaf stage. The first leaf on the corn plant is often rounded and small. Usually, each succeeding leaf will be wider and longer than the leaf below it. As each leaf becomes mature, a collar will form around the stalk of the plant at the base of the leaf. The collar will appear as a thin, lighter-colored line. Leaf six of the plant in Figure 1 is fully mature and collared. Leaf seven has not fully emerged and has no leaf collar. As plants mature (sometimes by the eight-leaf stage), the lower leaves may senesce (mature and die) and fall off, which makes it difficult to determine the leaf stage. Sometimes the high N reference area of the field may be the best place to first check for the leaf stage since high N plants retain their lower leaves longer than N-stressed plants.

Figure 1. Illustration of corn plant showing leaf number and collar region.



Often, all of the plants in the field will not be at the same leaf stage. To estimate the leaf stage of the field, you should use the following guide:

6.00	almost all plants at the six-leaf stage
6.25	mostly six-leaf-stage plants with a significant number of seven-leaf-stage plants
6.50	about half six-leaf-stage plants and half seven-leaf-stage plants
6.75	mostly seven-leaf-stage plants but a significant number of six-leaf-stage plants
7.00	almost all plants at the seven-leaf stage
7.25	mostly seven-leaf-stage plants with a significant number of eight-leaf-stage plants
7.50	about half seven-leaf-stage plants and half eight-leaf-stage plants
7.75	mostly eight-leaf-stage plants but a significant number of seven-leaf-stage plants
8.00	almost all plants at the eight-leaf stage

Chlorophyll meter readings should not be done if the corn in the field being tested is not yet at the six-leaf stage or older. Plants younger than leaf stage six may still be overly affected by starter N and environmental stresses. Readings at the seven- and eight-leaf stages usually result in more accurate fertilizer recommendations than those done at the six-leaf stage. Depending on weather conditions, corn plants may mature one leaf stage in about three to six days. Readings can be done later than the eight-leaf stage, but plants may be getting too large to sidedress or leaf five may be beginning to senesce.

Taking Chlorophyll Meter Readings of Corn Leaves

Chlorophyll meter readings of the field are taken and compared to the average readings from the high N reference area. The field being tested should have received no fertilizer N beyond a normal amount of starter N and the N applied to the high N reference area.

The manual provided with the chlorophyll meter gives detailed instructions for operating the meter. Below is a brief explanation of how to use the meter to take leaf readings for the early-season chlorophyll meter test:

1. Internal calibration of the meter is necessary when the meter is switched on. To calibrate the meter, turn on the meter. CAL will appear in the window. With no sample in the sample slot, press the measuring head down. The meter will beep when the calibration is complete. The display will now show N = 0. (N is the sample number.) If the display flashes CAL and beeps, the calibration was not performed correctly (probably because the sample head was not closed completely). Repeat the procedure. If the meter beeps and EU appears at the top of the display, the top and bottom windows of the measuring head may be dirty. Wipe them clean and repeat the procedure.
2. To take a leaf reading, place the leaf in the slot of the meter head. Use the center line on the measuring head to align the measuring head window and the spot on the leaf to be read. When the head is closed on the leaf, the meter will beep, a digital reading will appear on the display, and the reading will be stored in the meter. Sometimes the meter will beep and not give a reading. When this happens, try changing the alignment slightly before closing the head again.

Chlorophyll meter readings of corn leaves are affected by the part of the leaf and the position of the leaf on the plant that is sampled. Therefore, it is necessary to standardize which part of the corn plant is read with the chlorophyll meter. For this test, chlorophyll meter readings should always be done on leaf five (Figure 1) of the plants being tested. The reading is done at a point on the leaf approximately 1/2 inch from the edge of the leaf and at a point 3/4 of the leaf length from the leaf base (Figure 2). Do not take readings on the leaf midrib or too close to the edge. Pick representative plants in the field for meter readings. Care should be taken to avoid any unusual or damaged parts of the leaf when doing meter readings. Plants chosen should be relatively evenly spaced rather than separate from others or in a cluster. Use your body to shield the meter from direct sunlight. Wet leaves may be read if beaded water is shaken or rubbed off before inserting the leaf in the meter.

Figure 2. A chlorophyll meter in use.

3. Occasionally you may get readings that are very different from others in the field or that do not seem correct to you. These can be deleted by pressing the 1 DATA DELETE button (Figure 3), which will remove the last reading. Be careful not to press the ALL DATA CLEAR button because this will remove all readings taken to that point. If you want to look over all of your readings at any time, use the DATA RECALL button to scan the readings that you have taken. During the scan you may use the DELETE button to remove a reading and then replace it by taking another reading.
4. The chlorophyll meter will store up to 30 readings. At any point, pressing the AVERAGE button will display the average of the readings taken. When you are ready to begin a new set of readings, press the ALL DATA CLEAR button to delete all the readings currently saved.

Once the operator has become familiar with the meter operation and leaf stage identification, readings can be done very quickly. Since the meter will store up to 30 readings in memory and then calculate an average reading, at least 30 readings should be done. If a field is very variable, more readings may be necessary for an accurate field average, or to determine if several different N rates would be appropriate for the field. At least 25 to 30 readings should be taken of plants in the high N reference sections.

Figure 3. Picture of chlorophyll meter showing function buttons, display screen, and meter head.

Calculation of N Fertilizer Recommendation

The following worksheet can be used to calculate N fertilizer needs using the values from the meter and other factors related to the field

The N recommendation from this calculation can range from about 0 to 200 lb N/A. Research has shown that when this calculated N rate is less than 30 lb N/A, the probability is extremely low that the field will respond to N fertilizer. In other words, this formula can identify additional nonresponsive sites that had relative meter readings below the critical level of 0.95. However, in these cases other background factors may influence the N fertilizer recommendation. For example, if the calculated N fertilizer rate is 25 lb N/A and the plant population is high, growing conditions look good, and the corn is to be harvested for silage, the final recommendation might be to sidedress with approximately 30 to 50 lb N/A. In contrast, if the plant population is low, conditions are droughty, and the corn is to be harvested for grain, the recommendation might be no additional N.

When the calculated N fertilizer recommendation is greater than 30 lb N/A, the number is only a rough guide and should be rounded to a number that is practical or convenient for the farmer.

RECOMMENDATION CALCULATIONS

Relative SPAD reading[a]			÷		=		1
		Average field meter reading		High N reference value		Relative SPAD reading	

If the relative SPAD reading is ≥ 0.95, the N recommendation is zero.
Otherwise continue the calculations below.

Yield factor[b]			x	0.9	=		2
		Expected yield (bu/A)				Yield factor	
Manure factor[c] (Enter factor from list below box.)	17 x		x		=		3
		Manure since last harvest None = 0.75 Any = 3.5		1 Relative SPAD reading		Manure factor	
Leaf stage factor[d]	19 x		x		=		4
		Leaf stage of corn crop		1 Relative SPAD reading		Leaf stage factor	
Reference plot factor	4 x				=		5
		High N reference value				Reference plot factor	

Recommendation

280+		–		–		–		=	
	2 Yield factor		3 Manure factor		4 Leaf stage factor		5 Reference plot factor		lb N/A[e]

[a] SPAD refers to the portable chlorophyll meter (Minolta SPAD-502).

[b] Express in bushels per acre (bu/A). The yield should be a realistic goal. Increasing the yield goal will increase the N recommendation.

[c] 0.75 for field where *no* manure was applied since the previous crop's harvest; 3.50 for field where *any* manure was applied since the previous crop's harvest.

[d] Leaf stage of the field (not the high N reference plot).

[e] If the calculated recommendation is less than 30 lb/A, a zero recommendation is suggested.

METER CARE

- Do not leave the meter on the dashboard of your vehicle or lying in the sun.
- The meter is water-resistant and can be used on wet plants, but it should not get excessively wet or be immersed in water. If the meter is dirty or wet, wipe it gently with a clean, soft cloth.
- Turn off the meter when it is not in use. Remove the batteries if the meter will not be used within two weeks.

REFERENCE

Peterson, T. A., et al. 1993. *NebGuide: Using a Chlorophyll Meter to Improve N Management.* Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln. No. G93-1171-A.

Prepared by William Piekielek, research support associate; Dwight Lingenfelter, assistant extension agronomist; Douglas Beegle, professor of agronomy; and Richard Fox, professor of soil science. Illustrated by Kirsten Macneal.

Penn State College of Agricultural Sciences research, extension, and resident education programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

This publication is available from the Publications Distribution Center, The Pennsylvania State University, 112 Agricultural Administration Building, University Park, PA 16802. For information telephone (814) 865-6713.

Issued in furtherance of Cooperative Extension Work, Acts of Congress May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture and the Pennsylvania Legislature. T. R. Alter, Interim Director of Cooperative Extension, The Pennsylvania State University.

This publication is available in alternative media on request.

5M597ps6409