Sensing Nitrogen Stress in Corn

Determining the proper nitrogen (N) fertilization rate is important for the economic viability of corn production. A desire for high yields, fueled by low fertilizer N costs, led producers to apply rates that ensured adequate N rather than risk costly yield losses due to a shortage of N. Due to water quality concerns and recently high N fertilizer prices, management strategies are needed that can improve the efficiency and profitability of N use. With N application rates based on economic return instead of maximizing productivity, producers want to confirm that rate decisions are working adequately. Also, if unexpected N losses occur, help is needed with decisions for rescue N applications.

IOWA STATE UNIVERSITY
University Extension

PM 2026 July 2006

Corn plant N sufficiency/stress sensing offers an approach to determine crop N status and manage in-season fertilizer N application. Adequate time remains after significant corn N uptake to make N rate decisions, apply N, and have the crop respond to that N. Various sensing tools are available, including the Minolta SPAD 502® chlorophyll meter (CM). This handheld device measures the greenness of corn leaves as reflected by the chlorophyll content and N status. The relationship between leaf greenness and N sufficiency is well documented. Corn plants will reach a maximum greenness with adequate N. When N stressed, the plant will be less green. The CM can detect N stress in corn, but cannot differentiate between adequate and excess N. The Minolta SPAD CM is highly portable and provides an instantaneous reading of the corn N status. Through N sufficiency/stress sensing, in-season N fertilization can connect N application to plant indication of N need each season.

Procedure for Minolta SPAD Chlorophyll Meter Use

Each CM is provided with a calibration disc to ensure the meter is functioning properly. Always follow the CM use instructions. To collect a CM measurement, place a corn leaf between the sensors and hold the sensors together. Always place the top of the meter on the top side of the leaf. It is important to sample the same leaf on each plant at approximately the same spot on each leaf (halfway down the leaf from the tip to the base and halfway from the leaf edge to the midrib). Before tassel emergence, readings should be taken from the uppermost leaf that is fully collared (leaf collar fully visible around the stalk). If readings are collected at or after tassel emergence they should be taken from the leaf at the uppermost ear shoot.

Readings should be collected from many plants to account for sampling errors and natural color variation across leaves and between plants. The CM memory holds up to 30 sensor measurements. Pressing the CM "Average" button calculates an average of all sensor measurements. After collecting readings from 20 to 30 different plants, scroll back through the data display to review measurements. Numbers significantly higher or lower than the expected range might distort the average CM reading, and can be deleted individually and replaced by re-sensing additional plants.

Sensing and Nitrogen Application Timing

Corn takes up N rapidly beginning with the V8 growth stage. Since we want to detect and correct any N deficiency in time for adequate yield recovery, N stress sensing can begin at the V10 vegetative growth stage, and should be completed before tassel emergence, with preference closer to V10. To approach in-season N management in this way, high clearance equipment is needed to apply additional N. Applications should be completed before the silk emergence growth stage.

Determining Needed Nitrogen

A CM reading is a unit-less value, and by itself does not adequately determine N sufficiency/stress. When CM readings are compared with readings from an adequately N fertilized reference area, however, we can evaluate corn N status relative to the "greenest" corn in the field. It is critical that each field have reference strips or areas. By adjusting (normalizing) CM sensor measurements to reflect the adequately fertilized

Table 1. Relative SPAD chlorophyll meter (RCM) value and in-season N application rate.

Relative CM Value†	N Rate to Apply‡
RCM	lb N/acre
< 0.88	100
0.88 - 0.92	80
0.92 - 0.95	60
0.95 - 0.97	30
> 0.97	0

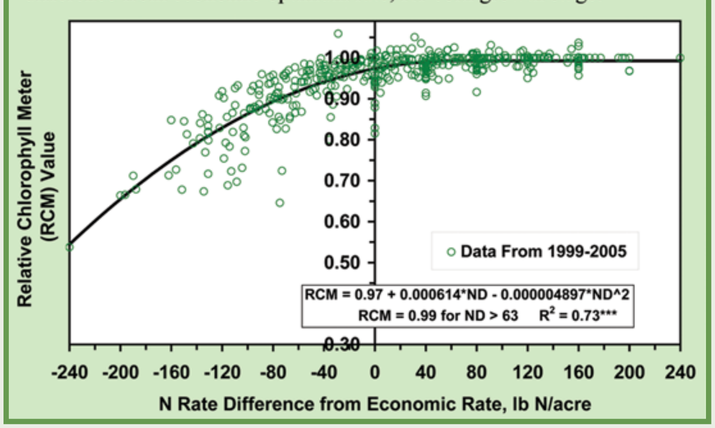
† Readings taken from V10 to VT corn growth stages.

‡ Suggested N rate limited to a maximum of 100 lb N/acre.

N reference area, the user reduces the effects of other variables such as hybrid differences or moisture stress. Reference strips or areas can be created by applying extra N (approximately 50 to 100 percent more than typically required for the rotation) at preplant or early sidedress. Enough reference strips are needed to characterize differing field areas. To normalize the CM readings, take the average CM reading of the corn in the area of interest and divide this number by the average CM reading of the reference strip closest to that area (see example field diagram). This normalized value gives you the relative CM (RCM) value. Then use Table 1 to determine how much, if any, additional N is needed.

The N rate suggestions in Table 1 were determined from six years of trials in Iowa where the optimal N rate was determined for each trial. The RCM value is plotted versus the difference of each N rate from the optimal rate. This relationship is graphed in Figure 1, and is similar for continuous and rotated corn. Note that RCM values decline below optimal N. However, RCM values are similar with slightly deficient N, adequate N, and excess N. This makes it difficult to determine in-season N need when N deficiency is slight. Research has shown that in-season N applications may be suggested by RCM when the N deficiency appears slight, but yield response indicates the in-season N is not always needed.

Figure 1. Relative SPAD chlorophyll meter (RCM) value versus N rate difference from economic optimum rate, R1 corn growth stage.



Therefore, the decision process (RCM) outlined here is somewhat conservative with slight deficiency; that is, some N may be applied when none is needed. If you are uncertain how to proceed, an advantage of the handheld meter is that you can take more readings, see the distribution of N stress across the field (distribution of RCM values), refer to the N response in Figure 1, and make your own decision whether to add more N.

Example Field

Below is a layout for a field with two adequately N fertilized reference strips. The numbers in the diagram are average CM readings from 20 to 30 plants in that area of the field. Each field-length strip is split into five zones to illustrate variability within a field. Areas A and B are fairly uniform in soil and management practice, however, area C has a manure application history. Calculating the RCM values and determining additional N need by using Table 1, we see the importance of multiple reference strips to account for dissimilar soils and management history (for example, field areas with a history of manure application).

According to Table 1, field areas A and B would get an additional 60 lb N/acre applied in-season, while field area C requires no additional N.

Example Field Diagram

↑ Corn Row Direction in Field

	A		Reference	B		Reference	C	
	Reading	(RCM)	Reading	Reading	(RCM)	Reading	Reading	(RCM)
	55.6	(0.92)	60.4	55.2	(0.89)	61.8	60.2	(0.97)
	56.9	(0.95)	59.8	55.0	(0.93)	59.3	58.8	(0.99)
	53.3	(0.86)	61.8	57.0	(0.91)	62.3	59.8	(0.96)
	60.1	(1.01)	59.5	59.1	(0.99)	59.9	60.6	(1.01)
	56.0	(0.93)	60.3	55.5	(0.90)	61.7	59.1	(0.96)
Average for Each Area	56.4	(0.93)	60.4	56.4	(0.92)	61.0	59.7	(0.98)

RCM (relative) values:

Average for Area A: 56.4 ÷ 60.4 = 0.93

Average for Area B: 56.4 ÷ 61.0 = 0.92

Average for Area C: 59.7 ÷ 61.0 = 0.98

Summary of important *Points*

1. Check the CM calibration to ensure it is functioning properly and follow instructions that come with the meter.

2. Collect sensor readings from the appropriate leaf and location on each leaf.

3. Take CM readings between V10 and tassel emergence growth stages, preferably closer to V10.

4. ALWAYS include several reference areas of known, adequately N-fertilized rates.

5. Calculate if additional N is needed using the RCM values and Table 1.

6. Use high clearance equipment to apply any additional N as quickly as possible, and before the silk emergence growth stage. This application usually will be urea-ammonium nitrate (UAN) solution (32 or 28 percent UAN), either coulter injected or dribbled on the soil surface. Do not spray UAN solution across the corn canopy.

IFL Integrated Farm / Livestock Management DEMONSTRATION PROGRAM

Developed for the In-Season Nitrogen Management Project

John Sawyer
Associate Professor, Soil Fertility Extension Specialist

John Lundvall
Extension Program Specialist

Jennifer Hawkins
Graduate Research Assistant

Dan Barker
Assistant Scientist

Jean McGuire
Editor

Micki Nelson
Graphic Designer

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Jack M. Payne, director, Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa.
Filecode: Agronomy 2-2