In-Season Sensing for Nitrogen Stress in Corn

Determining appropriate nitrogen (N) fertilization rate is important for the economic viability of corn production. A desire for high yields, fueled by previously low fertilizer N costs, led producers to apply rates that ensured adequate N rather than taking the risk of falling short of N and costly yield losses. Due to water quality concerns and recent historically high N fertilizer prices, N management strategies are needed that can improve N use efficiency and economic return. With N application rates based on economic consideration instead of maximum 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.

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. One such tool is the Minolta SPAD 502® chlorophyll meter (CM). This is a handheld device that 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 a virtually instantaneous indication of the corn N status. Through N sufficiency/stress sensing, in-season N fertilization can tie 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 that is used to ensure the meter is functioning properly. Always follow the CM use instructions. To collect a CM measurement, simply 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 (VT growth stage) readings should be taken from the uppermost leaf that's fully collared (leaf collar fully visible around the stalk). If readings are collected at or after the VT growth stage they should be taken from the leaf at the uppermost ear shoot.

Many plants should be sensed because of sampling errors and natural variation in greenness across leaves and plants. The CM has memory space for 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. Outlier numbers that might influence the average CM reading can be deleted individually and replaced by re-sensing additional plants.

SENSING AND NITROGEN APPLICATION TIMING

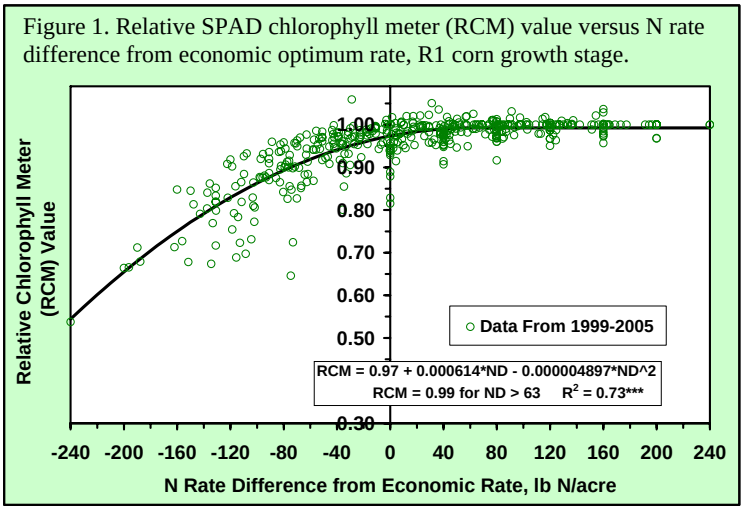
Corn takes up N rapidly beginning about the V8 growth stage. Since we want to detect any N deficiency and correct it in time for adequate yield recovery, N stress sensing can begin at approximately the V10 vegetative growth stage, and should be completed before VT (tassel emergence), with preference closer to V10. In order to approach in-season N management in this way, high clearance equipment is needed to apply any additional N. Applications should go on before R1 (silk emergence) growth stage.

DETERMINING NEEDED NITROGEN

The number that appears on the CM screen 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 (non-N limiting) 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. Adjusting (normalizing) CM sensor measurements to the adequately N-fertilized reference area reduces effects on plant greenness other than from N deficiency stress, for example hybrid differences or moisture stress. Reference strips or areas can be created by applying extra N (approximately 50 to 100% more than typically required for corn in the rotation being used) at preplant or early sidedress. Enough references are needed to characterize differing field areas.

To normalize the CM readings, simply 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.

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



The N rate suggestions in Table 1 were determined from six years of N response trials in Iowa where the optimal N rate was determined for each trial, and then the RCM value plotted versus the deviation 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 from slightly deficient N, to adequate N, to excess. This makes it difficult to determine in-season N need when N deficiency is slight. Research has shown that an in-season N application may be suggested by RCM when the N deficiency appears slight, but yield response indicates the in-season N is not always needed. Therefore, the decision process (RCM) outlined here tends to be

somewhat conservative with slight deficiency; that is, some N may be applied when none is needed. If you are uncertain as to what action to take, an advantage of the handheld meter is that you can take more readings, look at the distribution of N stress across the field (distribution of RCM values), look at the N response in Figure 1, and then make your own decision whether to add more N.

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.

EXAMPLE FIELD

Below is a layout for a field with two non-N limiting 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 references to account for dissimilar field areas.

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

According to Table 1, both field areas A and B would get an additional 60 lb N/acre applied in-season, while field area C would not need any additional N.

SUMMARY OF IMPORTANT POINTS

1. Check the CM calibration to make sure 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 VT (tassel) growth stages, preferably closer to V10.
4. ALWAYS include several reference areas of known, non-limiting N 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 R1 (silk emergence) growth stage. This application usually will be urea-ammonium nitrate solution (32 or 28% UAN), either coulter injected or dribbled on the soil surface. Do not spray UAN solution across the corn canopy.

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