Illinois NRCS
Adaptive Nitrogen Management Guidelines

Nutrient management plans are based on the four central concepts known as the “4R’s”. The central concepts are using the “right” rate, “right” form, “right” time, and “right” placement of crop nutrients. The concept applies to all crop nutrients. Crop nutrients need to be applied in a way that balances profits for producers while minimizing environmental risk. Universities provide sound guidelines based on years of data collection, research and field experience. The guidelines are straightforward, generally easy for farmers to implement, and provide an excellent starting point for farmers seeking to optimize nutrient use efficiency for their operations. In the Corn Belt, nitrogen has been the most difficult nutrient to manage. Nitrogen from natural and applied sources in an agricultural environment undergoes complex transformations that are affected by variables such as moisture, temperature, and other factors.

Synchronizing adequate plant available nitrogen with the period of rapid and maximum crop uptake while minimizing leaching and denitrification losses can be difficult. The difficulty comes primarily from our inability to predict all the variables that govern nitrogen availability to a crop, along with other factors contributing to final crop yield besides nitrogen supply. Farmers strive to apply nitrogen only at a rate that will maximize the return for the money spent for the fertilizer. Determining the “right” nitrogen rate for a given field in a given year is difficult as crop response to applied nitrogen also varies from year to year. As an example, one University of Illinois (UI) study at Urbana, Illinois found that optimum nitrogen rates in the same field over a 10-year period (1999-08) were 192, 107, 176, 147, 112, 174, 169, 95, 137, and 167 lbs. N per acre. Furthermore, yields were not closely tied to the optimum N rate each year. Scientists at Land Grant Universities in the Corn Belt developed the Nitrogen Rate Calculator based on data from a large number of nitrogen rate trials conducted in recent years to enable farmers to find nitrogen rates that will be provide the highest return for the invest in nitrogen fertilizer. The approach is superior to former yield goal methods, which often did not work well in some regions. It remains true, however, that the unpredictability of N responses in a given field in a given year means that the rate chosen by any method is likely not to be very precise; we simply cannot know before the season how the weather will affect the crop, soil N supply, and N loss.

Adaptive management is a concept by which farmers can be involved in helping to optimize management in their own field environments. Adaptive management is a process used to iteratively test, evaluate and adjust specific farming practices based on the information learned from the testing. In all cases, the process involves obtaining data according to established protocols and evaluating the data to determine what information can be derived. On-farm trials need to be carefully planned for results to be meaningful. Additionally, a single year’s worth of data will seldom be sufficient; especially in years of drought or excess moisture. Adaptive management is not just about trying new techniques. It is about proper testing to answer a basic question about a particular technique or method. The process can be used by farmers or groups of farmers to answer a wide variety of questions. As mentioned above, determining the best *consistent* nitrogen rate for a give field has always been problematic. The purpose of the document is to describe common adaptive nutrient techniques that can be used in Illinois specifically for nitrogen. In most cases, farmers engaging in on-farm testing will need to cooperate with researchers or technical service providers in

order to properly structure, collect, and analyze data from field trials, and in order to change current practices as a result of the findings.

On-Farm Strip Trial Testing to Determine Optimal Nitrogen Rates

On-farm strip trial testing is the most reliable way for farmers to determine the optimal nitrogen rates for their own fields.

Some suggested guidelines are listed below.

- In order to use nitrogen rates higher than UI calculated MRTN (maximum return to nitrogen) recommendations, on-farm test results should show a higher N rate than the Illinois MRTN calculator at least 3 out of 4 site-years. On-farm trials conducted on two different fields for 2 years constitute 4 site-years. But it is risky to do trials in 4 fields for a single year, since results will not apply to many years after that if the one year turns out to be unusual.

- Strips need to be in a relatively uniform field or part of a field, in a soil type typical for the area. Strips need to be wide enough to allow harvest inside the N application strip, preferably with two to four border rows on each side to prevent "spillover" N effects from one strip to the next. Most strips will be 12 or 16 rows wide, with 8 to 12 of the center rows harvested for yield. Strips should be at least 300 ft. long if they'll be harvested using a weigh wagon, and 400 ft. or longer (up to ¼ mile) if a yield monitor is used.

- For the on-farm test, any nitrogen form (anhydrous ammonia, 28% UAN, etc.) and application season (fall, spring, sidedress) is acceptable. If applying preplant anhydrous ammonia, try to place it so that the planted rows are not directly on top of the knife tracks. Fertilizer applied preplant will need to be straight with the rows.

- The minimum number of N application strips in the on-farm test for N rate will be 15. Use five nitrogen rates: 0, 50, 100, 150, and 200 lb. actual N per acre, with three strips of each rate. If other forms of N have been or will be applied (DAP/MAP, starter N, herbicide carrier), the nitrogen can be in addition to the above rates as long as the same treatment is applied equally to all test strips. If the "other" N will total to more than 40 lbs. or so per acre, the usefulness of the trial will be decreased because the "other" N application may mask the effects of the varying rates. Consult with a technical advisor before proceeding if the rate of N over the entire trial area (other than the N rates applied) will be more than 45 lb.

- The diagram below provides the suggested order of the 15 strips or plots, starting after a border strip or area at the side of the field or plot area.

Border strip	150 lb N	50 lb N	200 lb N	0 lb N	100 lb N	200 lb N	50 lb N	100 lb N	0 lb N	150 lb N	50 lb N	150 lb N	0 lb N	200 lb N	100 lb N	Border strip

- Yields can be taken with a yield monitor or weigh wagon (or both); whichever is considered most accurate and convenient. Sampling guidelines and calculations are detailed in the publication. If using a weigh wagon, record weight and grain moisture.

- Data can be submitted to Dr. Emerson Nafziger, ednaf@illinois.edu, University of Illinois Crop Sciences, for statistical analysis and a computer fit response curve.

End of Season Corn Stalk Nitrate Test

End of season corn stalk nitrate testing is another evaluation technique that farmers can use as a "report card" of the performance of their nitrogen management practices. The test is based on the knowledge that under normal growing conditions, corn plants can mobilize nitrogen from the lower portion of the stalks during the grain-filling stage when inadequate nitrogen is available. By contrast, corn plants that have a surplus of available nitrogen, or that have limited ability to use this nitrogen due to poor growing conditions will accumulate nitrate-nitrogen in the lower portion of the stalks. Similar to corn yield, the end of season stalk nitrate test will vary from year to year even if the same nitrogen rate has been applied each year. A corn field receiving the optimum nitrogen rates can exhibit low stalk nitrate levels in some years and high stalk nitrate levels in other years. The value of the test lies primarily where end of season corn stalk nitrate test values are consistently high from year to year. This is most common when manure is applied, along with fertilizer N. But even if a change in nitrogen management is suggested based on several years of high nitrate values, the end of season stalk nitrate test **cannot** be used to determine with confidence how much less nitrogen should be applied in future years.

The publications listed below describe how the corn stalk samples should be obtained along with guidelines for interpreting the results.

http://www.extension.iastate.edu/Publications/PM1584.pdf [URL accessed Aug 2012]

http://www.extension.iastate.edu/CropNews/2010/0914sawyer.htm [URL accessed Aug 2012]

http://www.agry.purdue.edu/ext/corn/news/articles.03/StalkNitrateTest-0915.html [URL accessed Aug 2012]

http://fyi.uwex.edu/grain/files/2010/10/stalk-nitrate-test.pdf [URL accessed Aug 2012]

Using Active Canopy Sensors to Determine Nitrogen Rates

Precision technologies that integrate information, global positioning systems, and variable rate controllers allow farmers to prescriptively apply inputs such as seed, fertilizer, and chemicals to crop fields. In other words, inputs needed for crop production are applied at rates that can be varied by position in the field. Interest has emerged in using in-season methods to determine and apply nitrogen using variable rate technology. Active canopy sensors have been developed that can indirectly measure the "nitrogen status" of plants by using machine vision to compare the hue ("greenness") of the leaves to that of plants known to be amply supplied with nitrogen. The fundamental premise is based upon the understanding that plants suffering from nitrogen deficiency are paler green than plants with adequate nitrogen content. Data from adequately calibrated sensors are used to produce an index that can translate to a nitrogen rate. Using active canopy sensing technology for variable nitrogen rate application has the major issue of trying to predict N need early in the season, often before plants are capable of accurately reflecting N status as a shade of green. It is also difficult to know that a plant that is dark green on a particular day will have access to enough N so it won't become deficient later. Of course, paying for variable-rate N technology has to come from saving N or from increasing yields on average, or both. Variable-rate N based on current crop sensing, while innovative, is not always straightforward and may not always be the most profitable method for farmers to implement.

Key Points to Successful Implementation of Active Canopy Sensing to Determine Optimal Nitrogen Rates:

- A nitrogen rich area will need to be created in each field or field area, for use in machine vision calibration. The sensors are most effective when corn is in the later vegetation stages, which in most cases will mean making the last N application in taller corn, usually with high clearance equipment.
- Ample rainfall and/or irrigation are required for late-season nitrogen to be absorbed by corn plants.
- Calibration must be performed for each sensor.
- For each sensor make and model, an index must be selected that correlate well with nitrogen fertilization.
- Farmers must recognize when plant health (greenness) is affected by factors other than nitrogen nutrition.
- Sensing must be done at a time in the crop season where corn will adequately exhibit nitrogen stress but soon enough for remedial nitrogen applications to be effective.
- Nitrogen rate algorithms developed in different regions of the country will not likely be portable to other regions.

The publications listed below provide further information about active canopy sensing:

http://cornandsoybeandigest.com/equipment/are-crop-canopy-sensors-ready-prime-time-pay-attention-how-you-apply-information-they-prov [URL accessed Aug 2012]

http://cornandsoybeandigest.com/equipment/crop-sensor-limits-sound-nutrient-management-needed-make-it-work [URL accessed Aug 2012]

Emmert, D. R.L. Nielsen, and J. Camberato. Using Active Sensors to Refine Nitrogen Rates in Corn. Site specific Management Center Newsletter, Purdue University, January 2008.

Roberts, D.F., N.R. Kitchen, P.C. Scharf, and K.A. Sudduth. 2010. Will Variable-Rate Nitrogen Fertilization Using Corn Canopy Reflectance Deliver Environmental Benefits? Agron. J. 102:85-95.

Sawyer, J.E., D.W. Baker. Quantifying Corn Nitrogen Deficiency and Application Rate With Active Canopy Sensors. North Central Extension-Industry soil Fertility Conference. 2010. Vol 26. Des Moines, IA.

Solari, S., J.F. Shanahan, R.B. Ferguson, and V.I. Adamchuk. 2010. An Active Sensor Algorithm for Corn Nitrogen Recommendations Based on a Chlorophyll Meter Algorithm. Agron. J. 102:1090-1098.

Other References

http://www.extension.org/pages/63452/adaptive-nutrient-management [URL accessed Aug 2012]