CROP INSIGHTS

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Protecting Your Nitrogen Fertilizer Investment

by Greg Luce and Jeff Mathesius

Summary

- Increases in nitrogen prices and corn grain prices have changed the equation for N rate determination. Growers are encouraged to use the newest university/extension calculators to help with this year's N rate decision.
- Sidedress applications provide nitrogen closer to the time the corn plant needs it, which helps to reduce potential nitrogen losses.
- Nitrogen stabilizers and additives such as N-Serve® and Agrotain® are effective tools for reducing the risk of nitrogen loss.
- In specific areas of the country soil nitrate tests (both preseason and pre-sidedress) can help farmers predict optimum fertilizer N rates.
- Chlorophyll meters and remote sensing have shown favorable results in measuring the N status of plants, helping to further refine N management.
- The basal stalk nitrate test can provide a post-mortem examination that indicates whether the level of N was sufficient to the crop during the growing season.

Aerial photo showing nitrogen-deficient field areas. Source: University of Missouri.

Introduction

Nitrogen (N) is a nutrient easily lost from the soil with heavy rainfall and prolonged ponding or saturated soils. Such conditions in the spring of 2008 led to severe nitrogen losses in many areas of North America. Because of the high cost of nitrogen fertilizer, growers are re-thinking ways to reduce nitrogen losses and optimize the economic returns to this major production expense. This *Crop Insights* will discuss several ways growers can effectively manage their nitrogen fertilizer investment.

Nitrogen Rate Recommendations

Every season, corn producers must decide on the correct amount of nitrogen fertilizer to apply, and generally look to the extension university in their state to provide guidance. Recently, the increase in nitrogen prices as well as corn yields has prompted extension soil fertility specialists to re-examine their recommendations for this nutrient. New recommendations and nitrogen rate calculators have been developed based on the most current nitrogen response studies, nitrogen costs, commodity prices, and in some cases, grain yields. (Research has shown that yield level alone is not an accurate way to estimate nitrogen needs. Consequently, specifying a yield goal is no longer part of the N-rate determination method in many states.)

University/Extension Resources for N-rate Determination (for Multiple States in Midwest)

Iowa State University
http://extension.agron.iastate.edu/soilfertility/nrate.aspx

Ohio State University:
http://agcrops.osu.edu/fertility/documents/New_Nitrogen_Recommendations_2008_000.xls

University of Missouri
http://extension.missouri.edu/explore/agguides/pests/ipm1027.htm

University of Nebraska:
http://soilfertility.unl.edu/corn_fert_recom/unl_n_calculator_2008.xls

As the list above indicates, universities still vary in the methods they use to recommend nitrogen rates. Producers are encouraged to follow their state's newest recommendations, or at least re-examine their own nitrogen rate decisions based on up-to-date N costs, grain price, yield expectations, etc. Soil type, organic matter, previous crop, manure applications and other credits should be considered in any N-rate calculation. Local research and on-farm experience should also be factored into this important decision.

Nitrogen Timing

Plants use nitrogen most efficiently if applied as close as possible to the time of crop uptake. Ideally, this might include multiple applications of N during a growing season.

However, in portions of the country, fall application is a viable option for corn as a time management tool. Fall applications may be suitable if soils are fine-textured and the soil temperature is below 50° F, on average, for a week or longer and expected to stay cool. Anhydrous ammonia is the only nitrogen source that should be applied in the fall (because it initially is not leachable). With either fall or spring preplant application, nitrification inhibitors such as N-Serve® and dicyandiamide (DCD) can help reduce the potential for leaching or denitrification losses of nitrogen.

Sidedress N application allows for more efficient fertilizer use since the producer applies nitrogen close to the period of maximum nitrogen uptake for corn. All common N fertilizers can be used for sidedress applications. Dr. Fabian Fernandez at the University of Illinois ranks N fertilizers from most to least desirable for sidedress application (Fernandez, 2008):

1) injected anhydrous ammonia or UAN solution between rows

2) broadcast of solid ammonium-containing fertilizers such as ammonium nitrate or ammonium sulfate

3) broadcast urea

4) dribble UAN solution between row

5) broadcast UAN solution

In the case of surface applications, the fertilizer must be incorporated by rain or irrigation to move N to the root zone. With injection applications it is recommended to apply N between rows to reduce the potential for plant injury. There is no advantage to applying N close to the row since roots will grow into the middle of the row by the 4th leaf stage. It is also possible to apply N in every other row without negatively impacting yield, because every row will have N applied on one side or the other.

It is also possible, though less desirable, to apply N by aerial application or high-clearance equipment. With aerial application, it is important to keep rates below 125 lb N per acre and avoid applying when the canopy is wet to reduce plant injury. If liquid applications are used, the rate should not exceed 10 lb N per acre.

Nitrogen Stabilizers and Additives

When nitrogen is applied well in advance of crop uptake, it is more susceptible to loss through natural soil processes. Two products commonly used to help reduce these losses are N-Serve® and Agrotain®. Each is effective at reducing the risk of N loss with a specific formulation of N fertilizer. ESN® is yet another type of nitrogen stabilizer.

Classic symptoms of nitrogen deficiency on corn leaf.

N-Serve is a nitrification inhibitor that is used mainly with anhydrous ammonia. Although it can be used with other N sources, its benefits are most proven with ammonia. Ammonium ions are positively charged and adhere to soil particles, which are negatively charged. In this form, nitrogen is protected from loss. But soil bacteria convert ammonium to nitrate ions (a process called nitrification), which are negatively charged, repelled by soil particles, and subject to loss.

N-Serve works by inhibiting the bacteria responsible for nitrification, therefore, slowing the fertilizer conversion to nitrate and reducing the risk of loss. Using N-Serve as an additive with fall-applied anhydrous ammonia is a well accepted practice.

Risk of N loss is higher with fall applications than with spring applications because of the additional time the nitrogen is in the soil. However, N-Serve may also provide benefits with spring anhydrous ammonia applications. This is especially true in years with wet June weather and on poorly drained soils, which can result in large N losses.

Agrotain, the compound NBPT [N-(n-butyl) thiophosphoric triamide] is used primarily with urea and secondarily with urea-ammonium nitrate solutions. Agrotain inhibits urease, a naturally occurring soil enzyme involved in the conversion of urea to ammonia. This allows more time for rainfall to occur and incorporate the urea into the soil.

The use of Agrotain is a sound practice when urea is broadcast and not incorporated with tillage or irrigation. Research shows that N loss from surface-applied urea can range from 0 to 50 percent. The amount of loss depends on weather conditions; loss is greatest with warm, windy weather and a moist soil surface but is ended by rain that moves the urea into the soil.

Agrotain® Plus contains both N-(n-butyl) thiophosphoric triamide, a urease inhibitor which prevents nitrogen loss by ammonia volatilization from synthetic or organic urea, and dicyandiamide (DCD), an organic nitrogen material which retards nitrification.

Surface applied urea fertilizer is subject to volatility losses. Source: University of Nebraska – Lincoln.

ESN®, Environmentally Smart Nitrogen is another type of nitrogen stabilizer which encloses N in a patented polymer membrane that releases the N as soil warms. This time release method is an alternative way to reduce nitrogen losses due to volatility.

Preplant Soil Nitrate Test

The preplant soil nitrate test has historically been used west of the Missouri river where rainfall amounts are low enough to prevent substantial leaching of nitrate from the crop rooting zone during the late-fall to early-spring period. Recent research has also shown a benefit of using the test in Wisconsin and Minnesota. This test quantifies the amount of residual nitrate present in the crop rooting zone so farmers can adjust their fertilizer rates accordingly. Samples should be collected to a depth of at least 24 inches.

The preplant soil nitrate test is generally most useful in fields where substantial carryover of nitrogen is expected (e.g., corn fields with manure histories, abnormally low yields due to drought or hail, and/or high fertilizer N rates in preceding years). The total amount of nitrogen in the sampled layer should be subtracted from the overall recommended rate of fertilizer nitrogen applied. Another option is to use an algorithm or model that considers soil nitrate levels along with other factors to calculate an N fertilizer recommendation. For example, the N recommendation algorithm developed at the University of Nebraska is shown below:

N Rate = 35 + (1.2 * EY)-(8.0 * NO3) -(.14 * EY * OM)- N credits

where EY is Expected Yield (bu/acre), NO3 is the weighted-average Soil Nitrate Content in ppm, OM is the soil organic matter content of the surface layer in percent, and N credits are estimated for preceding legume crops, manure or bio-solid waste applications, and/or nitrate content of the irrigation water.

Late-Spring Soil Nitrate Test

The late-spring soil nitrate test, also called the pre-sidedress nitrate test, PSNT, is being applied in more humid areas where soil testing for residual nitrogen has not proven effective. This test is essentially an in-situ mineralization test to determine if additions of fertilizer nitrogen are needed. The PSNT has the greatest potential for soils with high mineralization potentials (e.g., manured soils or soils with high organic matter levels). With this test, samples from the surface 12-inch layer of soil are collected when corn is 6 to 12 inches tall and analyzed for nitrate concentration. The critical concentration of nitrate-nitrogen is generally between 21 to 25 ppm. If the soil concentration exceeds the critical level, it is unlikely the crop will benefit from additional N fertilizer. If soil contains less than the critical nitrate level, the crop will likely respond to additional fertilizer N. Recommendations vary across regions so you should contact your local extension office for those specific to your area.

Soil samples are collected when corn is 6 to 12 inches tall, often in early June. Soil conditions should allow the collection of good samples from the entire one-foot depth. Test interpretations are adjusted when spring rainfall is well above normal. In fields where less than full rates of N were applied preplant, lower the critical concentration from 25 ppm to 20-22 ppm when rainfall from April 1 to time of sampling is more than 20 percent above normal. With full rates of N applied preplant (fall or early spring) or with manured soils, the suggested critical concentration is 15 ppm if May rainfall exceeds 5 inches. In these fields, if tests are between 16 and 20 ppm, consider a small N application. In situations where manure or full rates of N were applied, a suggestion is to limit additional N application to 60-90 lb N per acre, even if the test result is 10 ppm or less.

Chlorophyll Meters

The chlorophyll meter can allow farmers to fine tune N management by detecting developing deficiencies early enough that they can be corrected before they reduce grain yields. In general, farmers or crop scouts would use the meter to check the greenness of up to 30 plants or leaves in an area suspected of being deficient, and compare the average reading to a reference area supplied with adequate N. Research indicates a close relationship between leaf chlorophyll content and leaf N content, since the majority of leaf N is contained in chlorophyll molecules.

The Minolta chlorophyll meter (model SPAD 502) enables users to quickly and easily measure leaf greenness which is affected by leaf chlorophyll content. The meter itself looks like a hand-held calculator with a clamp on the top. To use the meter, simply close the clamp over a leaf, and the meter indicates and stores a value related to the leaf greenness.


Using the SPAD 502 chlorophyll meter on corn.

Chlorophyll content or leaf greenness is affected by a number of factors, one being the N status of the plant. The advantage of using a meter to evaluate N status is that the meter is fast, non-destructive, repeatable, and can detect a deficiency before it is visual to human eyes. To get an accurate estimate of nitrogen needs using a chlorophyll meter, it is important to take readings both from your area of concern and from an area that you believe to be healthy and have adequate N.

Remote Sensing

The chlorophyll meter is capable of detecting N status of plants only in those specific areas sampled. Efforts have been underway to utilize certain sensors mounted on satellites, airplanes, or high-clearance ground equipment. These sensors could determine the same information from canopy reflection that we can learn from the chlorophyll meter only over a larger area. If an aerial image could indicate areas of the field that are developing an N deficiency, farmers or their advisors could evaluate whether or not correcting the deficiency is justified.

Sensors are being used that are mounted on high-clearance sprayers, and connected to spray mechanisms that would supply supplemental N fertilizer only to those areas where they are needed. Field applicators have been equipped with remote sensing devices similar to those contained in satellites or aircraft. Then, the applicator moves through the field, sensing the N status of the crop and directing the application of any needed N on-the-go. Future applications may include sensors mounted on moving sprinkler irrigation systems that could trigger site-specific fertilizer applications only where and when required.

End-of-Season Stalk Nitrate Test

This test is based on the concentration of nitrate in the lower portion of the cornstalk after grain is mature. Research has shown that the quantity of nitrate present in the lower stalk at the end of the season is directly related to the supply of nitrogen present during the season. To use this test, samples are taken by cutting the corn stalk at 6 and 14 inches above the ground. The resulting 8-inch section is then analyzed for nitrate concentrations. Samples should be taken from about 15 corn plants per area sampled. These samples should be taken at about 1 to 3 weeks following physiological maturity.

If the concentration of nitrate-nitrogen is between 700 and 2000 ppm, then adequate N was supplied to that corn crop. Concentrations of nitrate-nitrogen greater than 2000 ppm indicate excess N was present for that corn crop. The greater the observed concentration above 2000 ppm, the greater the amount of excessive N that was supplied to the crop.

It is difficult to quantify N deficiencies with this test when the nitrate-nitrogen concentration is less than 700 ppm; therefore, the greatest value from using this test is for determining those situations where N is being supplied at amounts greater than those needed for optimal yields. This test is basically an end-of-season evaluation of nitrogen management practices used during the season. Significant changes in nitrogen management practices should not be made based on one year of sampling. If fields show excessive lower stalk nitrate values over multiple years then it is likely that nitrogen management practices could and should be altered.

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