Nutrient Management to Improve Nitrogen Use Efficiency and Reduce Environmental Losses

THE NITROGEN CYCLE: WHAT YOU SHOULD KNOW

Nitrogen (N) makes up 78 percent of the air we breathe in the form of nitrogen gas (N₂), but this form is unable to be used by plants. In fact, there are 34,000 tons of N in the air above an acre of land, but none of it can be used by crops. Nitrogen must be fixed in order to become available, which is done through the process of making industrial fertilizers or through nitrogen-fixing bacteria associated with the roots of legumes. A significant amount of nitrogen occurs in the soil naturally (2,000–4,000 pounds per acre, lb/A), but 98 percent of that nitrogen is in the organic form and also cannot be used by plants. This organic nitrogen is found in all living and previously living material in the soil. Nitrogen naturally becomes available in soil as organic matter is mineralized, which results in around 60–80 pounds of nitrogen per acre per year for crop uptake. Two forms of inorganic nitrogen are plant available: ammonium N (NH₄⁺) and nitrate N (NO₃⁻). Ammonium N is held on the soil particles and can be exchanged with other cations in order for plants to take it up, but it does not leach easily from the soil. Nitrate N, on the other hand, is found in the soil solution and can be leached from the profile. Nitrogen leaching needs to be managed properly to ensure that plants have access to the nitrate and also to minimize the nitrate pollution in waterways. Understanding the nitrogen cycle thoroughly allows us to do that. The processes involved in the cycle are summarized below.

The forms of nitrogen, the transformations that it undergoes in the soil, and the nitrogen loss pathways are summarized in the N cycle (Figure 1). Most of the transformations in the N cycle are the result of microbial activity. Because these are biological processes, they are very sensitive to the environment where they occur. Major factors influencing these processes are temperature and moisture and thus the weather. The challenge with managing N is to achieve maximum N availability when crops need N and to reduce loss of N to the environment. The goal is to minimize soluble forms of N when at times of little or no crop uptake. This can be achieved by understanding the N cycle and managing inputs. The three main pathways of N loss are nitrate leaching, denitrification, and volatilization, discussed below.

Nitrate Leaching

The nitrate ion has a negative charge and does not attach to the negatively charged soil particles. Because nitrate is not held to the soil, rainfall or irrigation will leach the nitrate in the soil solution down through the soil profile. Nitrate leaching occurs most often in the spring with higher rainfall and slow crop growth. Although small amounts of nitrates are found naturally in drinking water, in agricultural areas nitrate can leach into water systems in high amounts due to fertilizer and manure applications. Nitrate is potentially
dangerous in drinking water for farm animals and humans. For example, babies may become sick from “blue baby syndrome” when nitrate in the blood reduces the oxygen-carrying capacity. Because of this, a limit on the amount of nitrate in drinking water is set at 10 ppm nitrate-N. Exposure to nitrates over time could also potentially impact the health of adults as well, especially the elderly. High nitrates also impair livestock production.

Nitrate impacts the environment negatively in local waters and the Chesapeake Bay. In water environments, nitrogen is the limiting factor for biological production. Excess levels of nitrate allow algae to flourish in harmful algal blooms. When these blooms die and decay, this can result in dead zones where little can live due to the low oxygen levels. These dead zones result in widespread death of oysters, blue crabs, and other important species for the fishing industry in the Chesapeake Bay, causing a huge economic impact. With a large portion of Pennsylvania draining directly into the bay, managing nitrate leaching on farms is critical to improve water quality.

**Denitrification**

Denitrification occurs only under anaerobic (without air) conditions when soil is saturated with water. Microbes generally use oxygen in the soil when they decompose organic matter, but if oxygen (O₂) is not available due to saturation with water, they will use nitrate instead. Microbes convert nitrate to gas forms of nitrogen, which are released back into the atmosphere. Typical soils may lose up to 15 percent of nitrate in this manner. Denitrification thus results in a significant loss of available N for crop production. Also, nitrous oxide (N₂O), a gas produced during denitrification, is a major greenhouse gas and 300 times more damaging than carbon dioxide (CO₂).

**Volatilization**

Volatilization of ammonia from surface-applied manure and some fertilizers is a significant concern in Pennsylvania. The urea form of N, found in urea-containing fertilizers and in animal manure, converts to ammonia gas (NH₃) and is lost to the atmosphere if exposed to air on the soil surface. If urea or manure is incorporated, the ammonia converts to ammonium N, which is held to the soil particles, thus preventing volatilization. As with leaching and denitrification, volatilization represents a significant loss of N for crop production and a potential negative environmental effect. Ammonia in the atmosphere is a precursor for the development of potentially harmful microscopic particulate matter, usually called PM₁₅. These small-diameter particles are easily drawn deep into the lungs, causing respiratory problems such as coughing, bronchitis, asthma, and so forth. Also, a significant amount of the N volatilized as ammonia in the atmosphere is deposited in rainfall back onto land or directly into water bodies, resulting in N enrichment.

All of these losses potentially represent a significant agronomic and economic loss of N for crop production and a significant environmental problem. The goal of reducing N loss can be met most practically through appropriate management of the source, rate, timing, and method of N application. Considerable efforts have been made through education and regulation to address the need for appropriate N management to reduce these losses.

**REGULATORY REQUIREMENTS**

In Pennsylvania, per the *Department of Environmental Protection Manure Management Manual*, all farms that produce or utilize manure—whether they are large confined animal feeding operations (CAFOs) or high-density concentrated animal operations (CAOs, Act 38)—must have written nutrient management plans that follow certain regulations for managing their manure nutrients to protect water quality. One of the purposes of this fact sheet is to summarize those requirements and provide N management guidance to help farmers to comply with these requirements. The specific requirements for N management in Pennsylvania are summarized in the Appendix at the end of this fact sheet.

### NITROGEN MANAGEMENT MATRIX

The following nitrogen management matrix can be used to assess current farm nitrogen nutrient management and provide guidance on acceptable and improved nitrogen management practices. This matrix is based on the 4Rs concept of nutrient management, which provides a framework for achieving cropping system goals, such as increased production, increased farmer profitability, enhanced environmental protection, and improved sustainability by using the **right source, right rate, applied at the at the right time, and in the right place**. The management categories in the left column of the matrix are based on the 4Rs. The practices listed in the right column are not acceptable under current Act 38 regulations in Pennsylvania. The practices listed as “fair” would represent the minimum management required to meet Act 38 regulations. The “good” and “better” management categories provide guidance based on the 4Rs for improving N management beyond the legal minimum. This matrix should be used in making N management decisions for fertilizer and manure in all nutrient management plans. The objective of management over time is to eliminate management in the “not acceptable” category and move N management from the “fair” to the “good” and “better” categories. Following this matrix are more details on management practices that will improve N management for crop production on your farm and ensure that you are meeting regulatory requirements to protect the environment.
<table>
<thead>
<tr>
<th><strong>FERTILIZER MANAGEMENT</strong></th>
<th><strong>BETTER</strong></th>
<th><strong>GOOD</strong></th>
<th><strong>FAIR</strong></th>
<th><strong>NOT ACCEPTABLE BY ACT 38 REGULATIONS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N Fertilizer Rate</strong></td>
<td>Rate does not exceed crop N recommendation or N removal by legumes and considers previous legume crop, previous manure history, and planned manure application method and PSNT, chlorophyll meter, or other tests used to adjust sidedress N rate</td>
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<tr>
<td><strong>N Fertilizer Timing</strong></td>
<td>Fertilizer applied in split applications in sync with crop uptake (e.g., apply by cutting to grass forages, sidedress N on corn, apply the bulk of N in the spring to winter grains)</td>
<td>Fertilizer applied immediately (days) prior to planting annual crops or applied earlier (weeks) to a growing cover crop or applied earlier (weeks) with a nitrification inhibitor</td>
<td>Fertilizer applied well ahead (weeks) of planting annual crops with no cover crop or expected uptake by a perennial crop</td>
<td>Fertilizer applied a month or more before planting an annual crop or expected uptake by a perennial crop</td>
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<tr>
<td><strong>N Fertilizer Incorporation Timing (UAN, Urea, and Urea Blends)</strong></td>
<td>Fertilizer placed or injected directly into the soil</td>
<td>Fertilizer incorporated within 1 day</td>
<td>Fertilizer incorporated within 1 week</td>
<td>Fertilizer not incorporated (see “N Fertilizer Incorporation Methods” below for alternatives to incorporation)</td>
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<tr>
<td><strong>Manure Location</strong></td>
<td>Manure applied on level, well-drained soils far from water with growing crop or 25 percent of crop residue and conservation practices implemented</td>
<td>Manure applied on sloping, well-drained soils with growing crop or 25 percent of crop residue and conservation practices implemented</td>
<td>Manure applied on steep slopes or in areas prone to flooding and excessively well-drained or poorly drained soils</td>
<td>Manure applied within required application setbacks or where restricted by the P Index or on greater than 15 percent slope in the winter</td>
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<tr>
<td><strong>Manure N Rate</strong></td>
<td>Rate does not exceed net crop N requirement and considers previous legume crop, previous manure history, and fertilizer N to be applied regardless of manure (e.g., starter N); total manure N applied to meet the net crop requirement for available N is ≤ 2X the net N requirement</td>
<td>Rate does not exceed net crop N requirement and considers previous legume crop, previous manure history, and fertilizer N to be applied regardless of manure (e.g., starter N); total manure N applied to meet the net crop requirement for available N is ≤ 3X the net N requirement</td>
<td>Rate does not exceed net crop N requirement and considers previous legume crop, previous manure history, and fertilizer N to be applied regardless of manure (e.g., starter N); total manure N applied to meet the net crop requirement for available N is &gt; 3X the net N requirement</td>
<td>Rate exceeds net crop N requirement</td>
</tr>
<tr>
<td><strong>Manure Application Timing</strong></td>
<td>Manure applied to growing crops (primarily grass forage crops) or applied immediately (days) prior to planting annual crops</td>
<td>Manure applied to a growing cover crop within 4 weeks of planting annual crops or injected manure applied with a nitrification inhibitor within 4 weeks of planting annual crops</td>
<td>Manure applied well ahead (a month or more) of planting annual crops with a cover crop or at least 25 percent residue cover</td>
<td>Manure applied in the winter to frozen/snow-covered ground or applied well ahead (a month or more) of planting annual crops with no cover crop or less than 25 percent residue cover</td>
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<tr>
<td><strong>Manure Incorporation Timing</strong></td>
<td>Manure placed or injected directly into the soil</td>
<td>Manure incorporated within 1 day</td>
<td>Manure incorporated within 1 week</td>
<td>Manure not incorporated (see “Manure Incorporation Methods” below for alternatives to incorporation)</td>
</tr>
<tr>
<td><strong>Manure Incorporation Method</strong></td>
<td>Manure placed or injected directly into the soil with minimal soil disturbance</td>
<td>Manure incorporated by conservation tillage methods or not incorporated but applied immediately before a non-runoff-producing rainfall event</td>
<td>Manure incorporated by conventional tillage methods or not incorporated</td>
<td>Not applicable</td>
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NITROGEN MANAGEMENT PRACTICES TO IMPROVE CROP NITROGEN USE EFFICIENCY AND MINIMIZE NITROGEN LOSSES TO THE ENVIRONMENT

Nitrogen Application Rates
Basic recommended rates are determined based on your soil test report by looking at the planned crop and the expected yield for that crop. The amount of residual nitrogen in the soil must then be taken into account and subtracted from the recommendation. This includes previous manure applications and carryover N from previous legumes. Also, if fertilizer, such as a starter containing N, is applied regardless of manure applications, this N should also be taken into account. You need to account for these credits by subtracting them from the basic soil test recommendation (Figure 2). The resulting number will give you the rate you need to apply this year as fertilizer, manure, or other source of N.

- Do not apply nitrogen in excess of crop recommendations. Having an approved nutrient management plan can help you with this. See your soil test for the recommended rate and be sure to take into account the planned incorporation time, previous manure, and legumes.

- Manure application rates should be based on meeting the net crop need after all other sources of N either in the soil (legume N, manure residual N) or added N (starter fertilizer, N applied with herbicides) have been accounted for.

- Manure N availability to the crop is lower than the total amount of N in the manure. Thus, more total manure N must be applied to achieve the same results as would be needed using fertilizer to meet the same net crop requirement. However, manure N availability increases with optimum manure application management. The goal for optimum manure N management is to reduce the total N applied in manure to as close as possible to the amount that would be required as fertilizer.

- Best management such as applying manure in the spring, incorporating it immediately following application, and cover cropping will generally result in the highest manure N availability, less than two times the amount of fertilizer N that would be required to meet the net crop requirement. With good manure management, the total amount of manure N applied should be less than three times the fertilizer N requirement to meet the net crop requirement. Acceptable but less efficient manure N management may require more than three times the total manure N applied in manure to as close as possible to the amount that would be required as fertilizer.

- Best management such as applying manure in the spring, incorporating it immediately following application, and cover cropping will generally result in the highest manure N availability, less than two times the amount of fertilizer N that would be required to meet the net crop requirement. With good manure management, the total amount of manure N applied should be less than three times the fertilizer N requirement to meet the net crop requirement. Acceptable but less efficient manure N management may require more than three times the total manure N compared to fertilizer to meet the net crop requirement. See the Manure Nutrient Management section of the Penn State Agronomy Guide (extension.psu.edu/agronomy-guide/cm/sec2/sec29) for information and instructions for making these critical calculations.

- Use the PSNT (pre-sidedress soil nitrate test) or chlorophyll meter to guide sidedress fertilizer nitrogen applications. The PSNT measures nitrate in the soil right before the highest amount of crop uptake. The chlorophyll meter test estimates the nitrogen status of growing corn by measuring the greenness of the leaves. Both of these in-season tests improve N recommendations significantly in most situations, particularly when manure is being used. For more information on these tests, see Agronomy Facts 17: Pre-sidedress Soil Nitrate Test for Corn (pubs.cas.psu.edu/FreePubs/pdfs/uc067.pdf) or Agronomy Facts 53: The Early Season Chlorophyll Meter Test for Corn (pubs.cas.psu.edu/FreePubs/pdfs/uc147.pdf)

- Where appropriate, use new technologies such as on-the-go sensors and aerial photography that can provide useful information about the N status of crops, improve N recommendations, and enable variable-rate N application. Variable-rate N application has potential to improve crop yields and limit N environmental losses based on crop growth status and its interpretation for changing N rate application versus the traditional whole-field uniform-application-rate approach. Keep up on the latest technologies as they are developed and evaluated, and determine how they might fit into a program to improve N management on your farm.

Timing of Nitrogen Applications
Apply nitrogen as close to crop uptake as possible. Timing is critical! Some enhanced efficiency fertilizers can improve N use efficiency and reduce losses when ideal timing is not possible. Note: Be aware that the term “enhanced efficiency fertilizers” is generic. Products that enhance the efficiency of N fertilizer materials do so in very specific ways. Choose products based on the specific action the product provides, not on general claims for enhanced efficiency.

- At planting: From the time nitrogen is applied to the soil to the point it is taken up by plants, a great deal of it can be lost to the environment. Applying as close as possible to crop uptake minimizes these losses and saves you money.

- Sidedressing: Because corn plants take up the majority of nutrients during the period of fastest growth, it makes sense to apply some of the fertilizer/manure before planting and the rest right when the crop needs it, just before this rapid growth period (Figure 3).
• Topdressing: Topdressing is applying fertilizer/manure to a crop that is already growing, and with proper management this will not damage the crop. Similar to sidedressing, this is a way to get nutrients to the plants when they will actually use them instead of losing them to nitrate leaching between application and crop uptake. Split topdress applications of N on nonlegume forage stands between cuttings so that only the N necessary for the immediate crop regrowth is applied at one time. This can greatly improve N use efficiency.

• No fall or winter N fertilizer spreading. It is not economical to apply fertilizer nitrogen in the fall or winter when a large percentage of the nitrogen could be lost before spring planting. Off-season application of manure is never preferred, but under certain circumstances, applying manure in the fall or winter is allowed (see Act 38 regulations in the Appendix).

• A small amount of starter N may be applied on winter annuals, but the bulk of the N for these crops should be applied in the spring near to the time of crop greenup.

• Time manure applications as close to crop uptake as practical. Nitrate leaching is difficult to control, but the potential for it to occur can be reduced by minimizing the amount of time nitrate is dissolved in the soil solution. Nitrate leaching occurs most often in the spring with higher rainfall, but summer crops like corn take up a minimal amount of nitrate until early summer when growth and N uptake increase rapidly. Manure should be applied as close to planting or crop uptake as practical (Figure 3).

• For fall and winter manure applications, plant a cover crop (see the Act 38 regulations in the Appendix for the specific requirements). Basically, cover crops take up nitrate from the soil after manure applications and prevent it from leaching into the groundwater. The cover crop is then terminated before planting the next crop in the spring. As the cover crop residues decay, they slowly release nitrogen back into the soil for the crop to use. This significantly increases the recovery of fall- and winter-applied manure N by the crop planted during the growing season compared to no cover crop (Figure 3).

• Do not till legume sods in the fall. Legume sods decompose and release N very rapidly after they are tilled into the soil. This N released from the legume sod following fall tillage could easily be lost before uptake by the following summer crop.

• Use nitrification inhibitors (enhanced efficiency fertilizers) where appropriate. Nitrification inhibitors are essentially products that inhibit the bacteria responsible for converting nitrogen into the mobile nitrate form. Generally, this method may not be worth the additional cost unless loss is very high and ideal timing is not possible. The conditions where nitrification inhibitors would most likely be beneficial are poorly drained soils and coarse-textured soils, especially when N is being applied months before crop uptake.

• Controlled-release and coated fertilizers (enhanced efficiency fertilizers) release N over a period of time, providing N more in sync with crop uptake, similar to split applications of N fertilizer.

**Nitrogen Application Methods**

Placing manure or fertilizer directly into the soil is most efficient, but other methods such as banding, conservation tillage, and enhanced efficiency fertilizers can also help to increase nitrogen use efficiency.

• Immediately incorporate urea-containing nitrogen fertilizers (dry urea, urea blends, liquid UAN). As much as a third of the N in urea can be lost to the atmosphere within a few days to a week if the fertilizer is left on the soil surface (Figure 4). Immediate incorporation by tillage, injection, proper irrigation, or a gentle soaking rain will minimize volatilization of ammonia N.

• Banding or dribbling liquid UAN nitrogen fertilizer on the surface rather than broadcasting or spraying it over the surface can significantly reduce ammonia volatilization from the N fertilizer.

• Use of a urease inhibitor (enhanced efficiency fertilizer) minimizes the volatilization loss of N from urea or UAN fertilizer applied on the surface with no or delayed incorporation.

• Incorporate manure where practical. Ideally, manure should be incorporated as soon as possible into soil if it hasn’t been injected directly. Incorporation within two days of application is necessary to significantly reduce N volatilization (Figure 4). In cases where incorporation is not possible or practical, manure should be applied immediately before a non-runoff-producing rain event or incorporated by conservation tillage methods or proper irrigation. Other practices such as residue management and cover crops can also be beneficial.
Environmentally Sensitive Areas

Be aware of environmentally sensitive areas and plan accordingly. In some areas, the risk of nitrate having a negative impact on the environment or drinking water is much higher and should be avoided with setbacks and buffers.

- Use setbacks and buffers: Do not apply manure within 100 feet of open sinkholes, streams, or ponds unless there is a 35-foot permanent vegetative buffer. Do not apply manure within 100 feet of wells or drinking water supplies (Figure 5). Apply manure only when there is 25 percent plant cover or crop residue on the field.

- For winter spreading: The previous setbacks and buffers also apply. Additionally, manure cannot be applied within 100 feet of an aboveground inlet to an agricultural drainage system or within 100 feet of a wetland if surface flow is toward the wetland or if the wetland is within the 100-year floodplain of an “exceptional value” stream.

Evaluate Nitrogen Management

Use the late season cornstalk nitrate test to evaluate your overall N management on corn. Results of this test, run on a sample of corn stalks taken near to crop maturity, can be very helpful in determining if the crop had adequate N for optimum production or if it ran out of N or had excess N. Results from this test can be used as the basis for making management adjustments in the future to improve overall N management for optimum crop production with minimal environmental impact. Details on using this test can be found in Agronomy Facts 70: Late Season Cornstalk Nitrate Test (pubs.cas.psu.edu/FreePubs/pdfs/uc208.pdf).

Other Management Practices

Nitrogen, like other nutrients, needs to be managed as part of a total crop production system and cannot be managed effectively in isolation. All aspects of crop production such as soil quality, seeds and varieties, planting, pest control, pH, all essential nutrients, and water, must be managed together to achieve optimum crop production. Not only are these factors critical to the crop, but many will have important impact on N use efficiency. For example, low pH can seriously limit root growth. With a limited root system, you could use all of the N management practices discussed here but still have very poor N use efficiency and increased N losses.

APPENDIX: REGULATORY REQUIREMENTS FOR NITROGEN MANAGEMENT IN PENNSYLVANIA

The nutrient management programs in Pennsylvania have historically been highly coordinated to make it easier for farmers to comply with the different state and federal requirements and to minimize duplication of efforts. Consequently, the Pennsylvania law, Act 38, which regulates concentrated animal operations (CAOs), the federal Concentrated Animal Feeding Operations (CAFOs) regulations, and the Natural Resources Conservation Service (NRCS) Nutrient Management Practice Standard 590 all utilize the same core nutrient management plan. The Pennsylvania Clean Streams Law requires that all other agricultural operations land-applying manure to also have a plan that is based on similar principles. Thus, all of these nutrient management plans have similar requirements for managing nitrogen.

What Does This Mean for You?

The primary law is Pennsylvania Act 38 of 2005, or the Pennsylvania Nutrient and Odor Management Law. Under Act 38, CAOs are required to develop an approved nutrient management plan, and those plans must address any potential nitrate leaching on the farm. See Agronomy Facts 54: Pennsylvania’s Nutrient Management Act (Act 38): Who Is Affected? (pubs.cas.psu.edu/FreePubs/pdfs/uc149.pdf) and Agronomy Facts 40: Nutrient Management Legislation in Pennsylvania: A Summary of the 2006 Regulations (pubs.cas.psu.edu/FreePubs/pdfs/uc111.pdf).

Under the federal Clean Water Act, CAFOs, which are farms with large numbers of animals regardless of the land base, must have a National Pollutant Discharge Elimination Permit (NPDES), which also requires an approved nutrient
management plan. In Pennsylvania, the nutrient management plan requirements for a CAFO NPDES permit are the same as the Pennsylvania Act 38 requirements (www.pabulletin.com/secure/data/vol35/35-43/1945.html).

With the 2013 revision of the NRCS Conservation Practice Standard Code 590: Nutrient Management, nitrogen must be managed for leaching risk on all fields by meeting criteria and guidance in the Act 38 regulations, the Act 38 Technical Manual, and Penn State Extension guidance in the Penn State Agronomy Guide and related technical fact sheets. The 590 standard is available in Section IV of the NRCS Field Office Tech Guide at efotg.sc.egov.usda.gov/treemenuFS.aspx.

The Pennsylvania Clean Streams Law requires that all farms that produce or utilize manure to have a written Manure Management Plan. These plans can be farmer written and do not have to be approved, but they must be kept on the farm and fully implemented with records to document implementation. Guidance for these plans is provided in the Pennsylvania Manure Management Manual (panutrientmgmt.cas.psu.edu/pdf/mmp/L_and_20Application%20of%20Manure%202011-10.pdf). Plans written to meet Act 38, CAFO regulations, or NRCS 590 requirements satisfy this requirement.

**Nitrogen Management Requirements**

The details of the nutrient management requirements for N, as found in the Act 38 regulations and utilized by the other programs described above, are provided below, followed by numbers in brackets to indicate a reference in the regulations. All of these requirements can be found in Act 38 at panutrientmgmt.cas.psu.edu/pdf/1r_Act38_Regulations.pdf. More detailed guidance on these requirements can be found in the Pennsylvania Nutrient Management Act Program Technical Manual (panutrientmgmt.cas.psu.edu/main_technical_manual.htm).

- Never exceed nitrogen-based manure rates [83.293 (a) (1)]. The rate may not exceed the amount of nitrogen necessary to achieve realistic expected crop yields or the amount of nitrogen the crop will utilize for an individual crop year.
- Time manure and fertilizer applications as close to crop uptake as practical [83.294(a & b)]. Nutrients shall be applied to fields during times and conditions that will hold the nutrients in place for crop growth, and protect surface water and groundwater using best management practices (BMPs) as described in the plan.
- For fall- and winter-applied manures, cover crops are encouraged to be planted [83.294(f & g)]. For fall applications, manure should only be applied if a cover crop will be planted and grow enough for nutrient uptake, or if the manure is injected (or other no-till incorporation methods) within five days. For winter applications, fields must have at least 25 percent cover by crop residue or an established cover crop.
- Setbacks and buffers [83.294(f)]. Manure may not be applied within 100 feet of a stream or intermittent stream bed unless a 35-foot permanent vegetative buffer is established. It may not be applied within 100 feet of an open sinkhole (meaning there is direct access to the water table at the bottom) unless a 35-foot permanent vegetative buffer is established. Manure also cannot be applied within 100 feet of private wells or public drinking water sources.
- Use the PSNT or chlorophyll meter to determine supplemental nitrogen needs [83.293 (d)]. Recommendations based on these tests may be used in place of supplemental N needs in a nutrient management plan.
- Incorporate manure as soon after application as practical or use low disturbance manure injection [83.291 (d) and 83.293(f)(5)(i)]. The planned incorporation time is used to determine the amount of N available from manure.