

## Managing Nitrogen to Protect Water Quality

John A. Lory and Steven Cromley

Division of Plant Sciences and Commercial Agriculture Program

Nitrogen is a highly mobile nutrient that can be lost to the air, in runoff and through the soil. The high mobility of nitrogen creates unique nutrient management requirements to ensure fertilizer remains in the soil long enough to benefit your crop.

A significant proportion of a poorly timed nitrogen fertilizer application can be lost before the target crop has a chance to use it. For example, if nitrogen for a corn crop is applied in early fall losses from winter and spring rains can deplete much of the nitrogen fertilizer from the soil before the plant can use it during the growing season.

There are three water quality concerns associated with loss of nitrogen from agricultural fields:

- Using high nitrate-nitrogen drinking water to make milk formula can reduce the oxygen carrying capacity of blood in babies and young livestock.
- Nitrogen in runoff can contribute to eutrophication in some freshwater streams and lakes.
- Nitrogen is the primary contributor to the hypoxic (low oxygen) “dead zone” that forms in the Gulf of Mexico each summer. Nitrogen lost from Missouri fields ultimately reaches the Mississippi River, contributing to the hypoxia problem in the Gulf.

Improving nitrogen management improves both water quality and the effectiveness of fertilizer nitrogen for meeting agronomic goals.

### How to prevent nitrogen losses

#### Avoid overapplication of fertilizer nitrogen

Research has shown that nearly all nitrogen applied in excess of crop needs can be lost from the root zone in humid regions of the United States, including Missouri. To avoid overapplication of nitrogen

- Base nitrogen applications on a fertilizer nitrogen recommendation using an accurate yield goal.
- Adjust fertilizer recommendations for the nitrogen value of previous legume crops such as soybean and alfalfa.
- Adjust fertilizer nitrogen recommendations for the nitrogen value of any manure applications.

#### How is nitrogen lost from the soil?

Nitrogen is primarily lost by three pathways:

- **Nitrate leaching** happens when excess rainfall moves water through the soil. As the rainwater moves downward in the soil, it carries nitrate nitrogen below the root zone. Nitrate leaching is most likely to occur during wet periods of the year when the crop is not actively growing, such as late fall through early spring. All nitrogen fertilizers convert to nitrate-nitrogen in warm soil.
- **Ammonia volatilization** happens when urea fertilizers and liquid manures are surface-applied. The nitrogen is lost as ammonia to the atmosphere. Volatilization is enhanced when the applied nitrogen coats plant and plant residues without contacting the soil. Nitrogen is also lost as ammonia when anhydrous ammonia injection slots fail to close during application.
- **Denitrification** happens when warm soils are waterlogged for more than a day or two when there is nitrate in the soil. These conditions are most likely to occur during wet spells in May or June. During denitrification, nitrogen is lost as a gas to the atmosphere.

- Consider using a preplant nitrogen test on corn and wheat fields with a history of manure application or other situations where you expect large but unknown amounts of available nitrogen in the soil (see MU publication G9177, Preplant Nitrogen Test for Adjusting Corn Nitrogen Recommendations).
  - Soil nitrogen tests may be useful after fall or early spring applications of manure or other nitrogen fertilizers when weather patterns may have promoted significant losses of nitrogen.

#### Apply nitrogen during periods of active uptake

- There are significant differences among crops in the timing and the duration of active nitrogen uptake and utilization (Figure 1). Applying fertilizer nitrogen close to or during the period of active uptake reduces the possibility of nitrogen losses.
- In cornfields nitrogen applications are equally effective at producing high yields from planting to nearly tasseling time. The biggest obstacle to side-

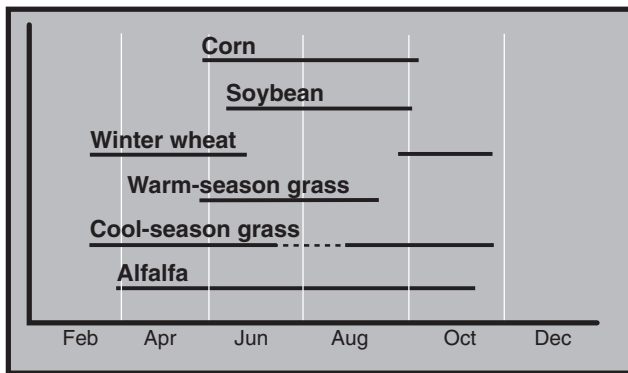


Figure 1. Active growing season of common Missouri crops.

dress nitrogen applications is access to the field when there is a standing crop.

- In winter wheat fields, splitting nitrogen applications between fall and spring will increase yields and reduce nitrogen losses.
- Cool-season forages and winter wheat are best suited for fall and early spring manure applications because they continue active growth into cool weather. Active growth uses nitrogen and water, reducing leaching potential.

### Prolong the time nitrogen is held by the soil

There are a number of strategies for extending the window of opportunity for applying nitrogen fertilizer.

- Inject anhydrous ammonia and manure into nearly frozen soils in late fall.
  - Injection into nearly frozen soil (below 40 degrees F) will hold nitrogen in the ammonium form, preventing nitrate leaching until after soils warm.
- Use an inhibitor with your fertilizer nitrogen.
  - When using urea, apply with a urease inhibitor such as Agrotain.
  - When injecting anhydrous ammonia or manure with lots of ammonium nitrogen (e.g., swine lagoon effluent), use a nitrification inhibitor such as N-Serve.
  - These products inhibit the activity of soil microorganisms or enzymes for two or more weeks, preventing conversion of the fertilizer into mobile forms of nitrogen. The effectiveness of these products is longer in cold soils that slow breakdown of the inhibitors.
  - Decisions on adding inhibitors are rarely driven by the cost of the product relative to the potential value of the conserved nitrogen.

### More on ammonia volatilization

Specific chemical conditions are needed for ammonia volatilization to occur. High pH conditions (greater than 7) promote ammonia volatilization.

- Almost all Missouri soils have a pH below 7 so most ammonium-containing fertilizers do not promote volatilization. Volatilization is not a problem with ammonium sulfate and ammonium nitrate.
- Surface-applied urea is prone to ammonia volatilization because the fertilizer temporarily raises soil pH near the urea particles as they convert to a form of nitrogen usable by the plant.
- Many manure types have a pH above 7 that promotes ammonia volatilization until the manure equilibrates to the soil pH.
- Missouri soils naturally adsorb ammonia. We take advantage of this characteristic when we inject manure and anhydrous ammonia under the soil surface.

### Minimizing nitrate leaching

- Do not overapply nitrogen fertilizers.
- Time applications close to crop nitrogen need.
- Avoid fertilization strategies that leave substantial amounts of nitrate nitrogen in the soil over winter.
- Avoid summer applications of manure on wheat stubble for next year's corn crop.
- Avoid fall anhydrous or urea nitrogen applications into warm soil without the appropriate inhibitor.
- Nitrate leaching is more likely on soils that have a high infiltration rate such as sandy soils.
- Overwatering of irrigated soils also causes nitrate leaching.
- Nitrate leaching is less likely on cool-season forages and winter wheat that extend their growing season into the late fall and early spring.
- Apply fall anhydrous ammonia after soil temperature is below 40 degrees F.
- Consider the use of inhibitors to slow the conversion of spring-applied nitrogen to nitrate.

### Minimizing ammonia volatilization

- Inject liquid manure into the soil. This is particularly effective for manure with high ammonium-nitrogen content, such as unagitated lagoon effluent.
- Avoid urea fertilizers in high residue conditions unless steps are taken to ensure contact of the fertilizer with the soil.
- Significant rainfall will leach urea into the soil if it falls soon after application.
- Make sure anhydrous ammonia injection slots fully close.