

NUTRIENT MANAGER

Newsletter of the Maryland Cooperative Extension Agricultural Nutrient Management Program

FOCUS ON NITROGEN



Excess nitrogen in a cropping system can contaminate surface water and ground water and waste farmers' money. Management and conservation of nitrogen are complex tasks, but they have economic and environmental payoffs.

Nitrogen is difficult to manage because it is continually being changed by chemical reactions and microorganisms in the soil. At any time, it will exist in many different chemical forms. These forms fall into two categories, inorganic and organic nitrogen.

Inorganic nitrogen forms, specifically **nitrate** (NO_3^-) and **ammonium** (NH_4^+), are immediately available for plant uptake. Most crop plants prefer nitrate to ammonium, but ammonium can be transformed into nitrate in the soil through microbial action.

Organic nitrogen is not immediately plant available. It must be **mineralized**, changed into an inorganic form, before it can be taken up by a plant.

The nitrogen cycle illustrates the series of changes that nitrogen undergoes (Figure 1).

THE PROBLEM

Inorganic, plant-available forms of nitrogen (nitrate and ammonium) are easily lost from the cropping system. Nitrate escapes from the root zone by **leaching**, that is by moving with the water in the soil. Both nitrate and ammonium can be **volatilized**, lost to the atmosphere in gaseous forms: nitrate, by conversion to nitrogen gas through microbial **denitrification**, and ammonium, by conversion to ammonia gas.

Leaching, volatilization, and denitrification are means by which nitrogen can be permanently removed from the system.

Immobilization is the temporary transformation of nitrogen from its plant-available, inorganic form into microbial biomass, an organic form. As the microbes die and decompose, they release the nitrogen, in an inorganic form, back into the soil.

Normally the quantity of inorganic nitrogen in soil is low, approximately 1 to 2 percent of the total soil nitrogen. The naturally occurring level of inorganic nitrogen is not sufficient for intensive crop growth; therefore, farmers add nitrogen by growing legumes or supplementing with manure, chemical fertilizers, or sewage sludge. By understanding the nitrogen cycle, growers can optimize strategies that balance nitrogen inputs and outputs and reduce potential environmental impact and economic loss.

How Nitrogen Is Lost

It is important that growers understand how nitrogen is lost from the cropping system, so that they can minimize economic loss and possible environmental degradation.

Leaching. Nitrate is a negatively charged ion, similar to the negative end of a magnet. Like a magnet, negatively charged nitrate is not attracted to soil's clay and humus,

which are also negatively charged. When rain or irrigation water percolates down through the soil profile, it can take nitrate along with it—out of the root zone, down to the ground water and, potentially, out to the Chesapeake Bay. Ammonium, on the other hand, is a positively charged ion, attracted to the soil's clay and humus and, therefore, is less likely to leach.

Volatilization. Ammonium present in fertilizers, such as urea-ammonium nitrate, urea, and

manures, can be changed to ammonia gas and lost to the atmosphere (volatilized) if the fertilizers are not incorporated into the soil.

Immobilization. Immobilization is the temporary capture of nitrogen by soil microbes, the regulators of the nitrogen cycle. Tilling in materials with a high carbon and low nitrogen content, such as small-grain straw, will stimulate microbial growth temporarily and immobilize the available soil nitrogen. Because of this, corn planted after incorpo-

ration of small-grain straw may display temporary signs of nitrogen deficiency.

Denitrification. Denitrification is the loss of nitrogen from the soil to the atmosphere under extremely wet conditions. In soil that is waterlogged due to excessive rainfall, a depression in the field, or poor drainage, soil microbes will quickly change nitrate (NO_3^-) to nitrous oxide (N_2O) and nitrogen gas (N_2). These forms of nitrogen are not plant available and, because they are gases, may be lost to the atmosphere.

How Nitrogen Is Provided

To produce crops efficiently, it is necessary to understand not only how nitrogen is lost, but also how it is provided and can be manipulated in a well-managed system. Nitrogen sources and management strategies are summarized here.

Mineralization. The first step in the process that changes organic nitrogen to inorganic nitrogen is mineralization. Organic nitrogen from soil organic matter (microorganisms, crop residue, manure, and sewage sludge) must be mineralized, transformed to a simpler inorganic form (ammonium) before it can be plant-available. This form can then be changed to nitrate.

The transformation of the organic form to the inorganic form is controlled by the activity of soil microorganisms and, therefore, mineralization happens more quickly with warm temperatures, moist aerobic conditions, and a moderate pH. It virtually ceases when soil temperatures fall below 35 °F.

When manure is applied to a crop, only a portion of the organic nitrogen in it is available (through conversion to plant-available nitrogen) in the first year. Manure mineralizes slowly, providing inorganic nitrogen over several years in decreasing quantities. The amount of nitrogen available depends on the type of manure used.

As the nitrogen is made plant-available through the mineralization process, either it can be used by a crop or it can be lost through leaching, volatilization, and denitrification.

Biological Nitrogen Fixation. The Earth's atmosphere, including the air we breathe, is almost 80 percent nitrogen gas. Some microorganisms capture and trans-

Even if manure employed, no and ammonia removed from by harvest time efficient in Research shows economically rates, recover nitrogen by exceeds 50 often n

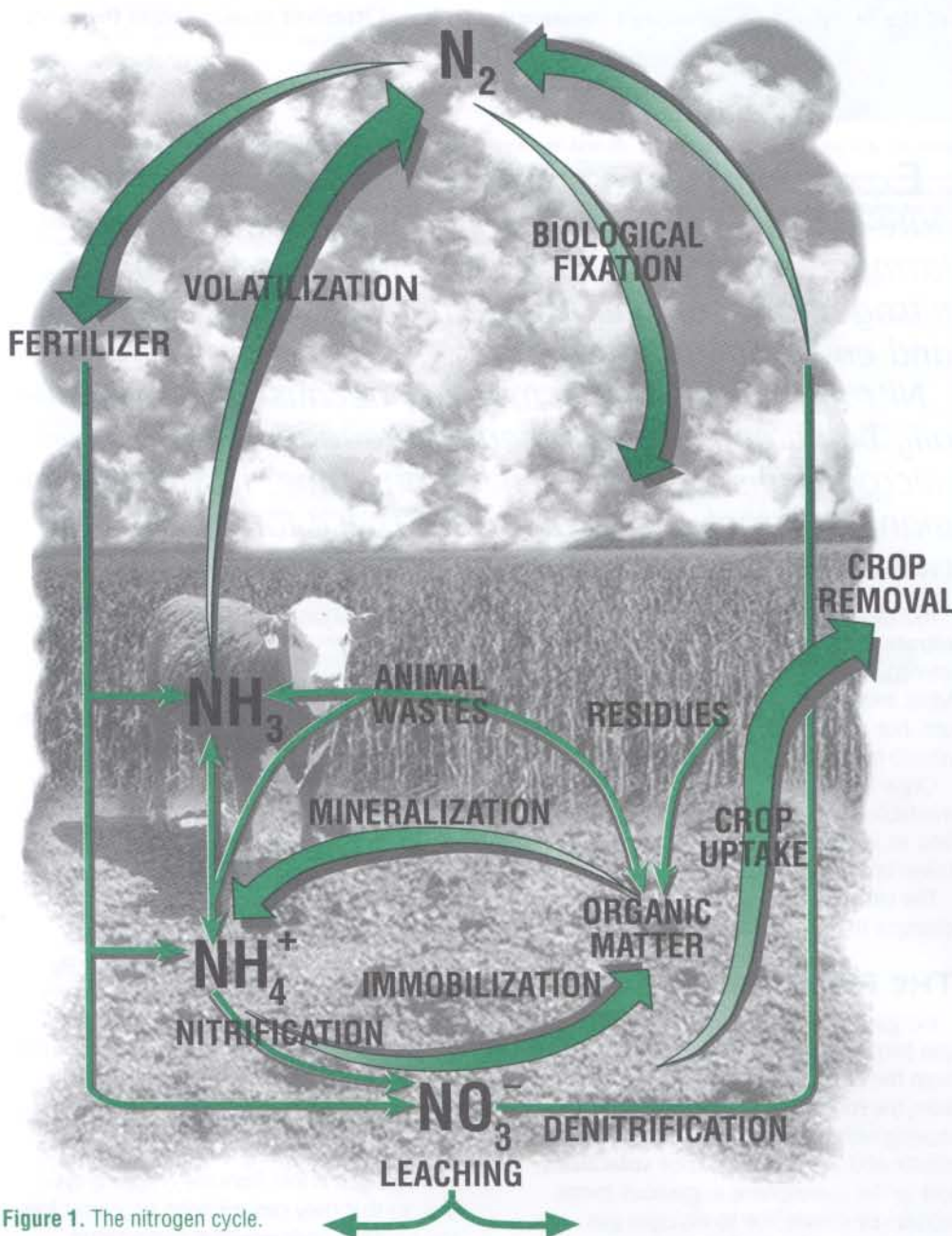


Figure 1. The nitrogen cycle.

Unavailable for plants: Organic N (manure, sewage sludge); N_2O (nitrous oxide); N_2 (nitrogen gas); NH_3 (ammonia)
Available for plants: NH_4^+ (ammonium); NO_3^- (nitrate)

form or "fix" nitrogen gas into the proteins they need to live and then release it as plant-available nitrogen when they die. One group of nitrogen-fixing microorganisms are bacteria called *Rhizobia*. *Rhizobia* live within the roots of legumes, such as alfalfa, clover, soybeans, peas, and vetch, and provide nitrogen for these crops. Alfalfa, for example, with the help of *Rhizobia* bacteria, typically fixes approximately 150 to 250 pounds of nitrogen from the atmosphere per acre per year.

Residual Nitrogen and Cover Crops. Residual nitrogen refers to inorganic nitrogen (nitrate and ammonium) that remains in the soil after the crop has been harvested. Nitrate and ammonium might remain in the soil for several reasons: the general inefficiency of plant uptake, excess fertilizer application, or summer drought causing reduced crop uptake.

Cover crops are grasses, legumes, or mixes grown during the late fall and winter to take up excess nutrients, reduce soil erosion, and improve soil tilth.

Some cover crops can be used to absorb residual nitrogen during months when field crops are not grown. Studies in Maryland have shown that a rye cover crop can reduce nitrogen leaching by 66 percent. A future issue of this newsletter will discuss some of the management issues concerning cover crops, including choice of species

and effects of planting and kill dates.

BALANCING SUPPLY AND DEMAND

Split-Application: Timing Is Everything

In the spring, a corn seedling uses the nutrients stored in the seed to

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grow. For approximately a month after planting, corn has a shallow root system and grows at a relatively slow rate. During this early period, seedlings do not take up much nitrogen from the soil. When the corn is approximately a month old, it begins to grow rapidly. It is at this time that the crop requires an adequate supply of nitrogen and has the root system needed to absorb it.

Synchronizing the presence of nitrogen and the period of rapid crop uptake can maximize nitrogen's use and minimize its potential for loss. Split-applying nitrogen fertilizer, applying a small quantity (≤ 50 pounds per acre) as a starter and the rest as a **side-dress** at the appropriate crop stage, synchronizes the time that the nitrogen is supplied with the time that the crop's nitrogen is needed.

Soil Tests

Because nitrogen changes forms according to microbial activity, and microbial activity is favored by the relatively moist, mild environmental

conditions of Maryland, a soil test before planting cannot reliably predict how much nitrogen will be available at the time of rapid crop growth.

Instead of soil tests, nitrogen fertilizer recommendations are based on

1. Yield potential of the crop and soil; and
2. Nitrogen credit for previous legume crops or organic nutrient sources like manure.

PSNT: Fine-Tuning the Nitrogen Requirement

How is an adequate amount of nitrogen determined? The **pre-sidedress nitrate test (PSNT)** is an inseason soil test for corn that is done prior to sidedressing.

In the spring, the corn has been planted, has grown to between 6 and 12 inches (approximately 30 to 45 days), and is approaching its peak uptake period (see Figure 2). Meanwhile, as the soil warms, microbial activity increases and organic nitrogen begins to mineralize. All the sources—mineralized nitrogen and residual nitrogen from previous fertilization and crops—contribute to peak inorganic nitrogen levels. But will there be enough nitrate in the soil to satisfy the growth and yield requirements of the crop?

This period, immediately before rapid nitrate uptake and coinciding with peak soil nitrate levels, is the window of opportunity to perform a PSNT. A PSNT taken at this time will accurately measure the quantity of nitrate present in a specific field at a specific time and will allow a grower to determine if sidedressing is actually necessary. Then, if the PSNT shows that the soil nitrate level is inade-

There is no pre-plant soil nitrogen test for the Middle Atlantic States.

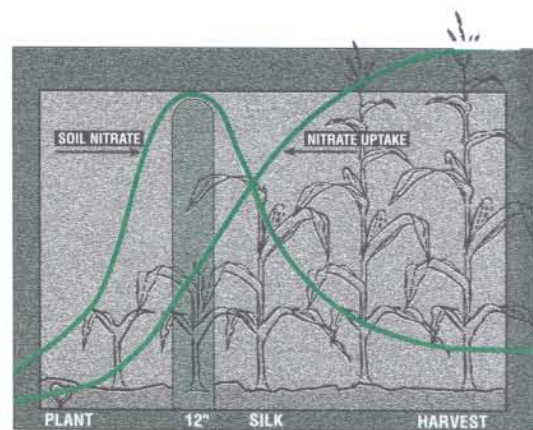


Figure 2. In the spring as soil nitrate levels peak and corn nitrate requirements increase, a pre-sidedress nitrate test (PSNT) taken during the PSNT window of opportunity (shaded area) can help a farmer determine if sidedressing is necessary for corn production.

quate for corn production, the test can be used to determine the appropriate sidedress nitrogen rate.

The goal of good nitrogen management is to synchronize the period of rapid crop uptake with the availability of an appropriate amount of inorganic nitrogen and to end the season with little residual nitrogen, thereby minimizing what is lost to the environment.

A PSNT does not account for the ammonium already present in soil or for organic nitrogen that will be mineralized later in the season. Because of this, a PSNT cannot recommend too little nitrogen.

Keeping Track of What Is Out There

Dave Herbst of Misty Meadows Farms in Washington County grows corn, soybeans, and small grains and raises 100 dairy cows that produce approximately 2 million gallons of manure per year. He has been using manure tests since they became available at the University of Maryland in 1985. Five

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years ago, in an effort to use the residual nitrogen supplied by soybean crops and animal manure more efficiently, he started using PSNT.

In the past, "We were going on with 120 to 130 pounds of nitrogen," says Herbst, "and then we put herbicide down with additional fertilizer. To a large extent, we were disregarding the manure and legumes." Mr. Herbst found that the PSNT "really fine-tuned things" and gave him a good indication of the nitrogen level already in the field. Then, because he trusts the PSNT, he tends to follow his recommendations closely. "It's proven to me time and time again that...it's reliable enough to use."

PSNT REQUIREMENTS

- *Corn crop, 6 to 12 inches tall*
- *Sidedress fertilizer management*
- *No more than 50 pounds of nitrogen as commercial nitrogen fertilizer per acre applied at or before planting*
- *1-foot sample depth*

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