



# Nitrogen Basics – The Nitrogen Cycle

## Nitrogen, Crops and the Environment

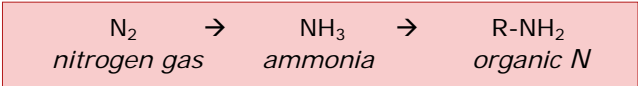
Nitrogen (N) is essential for the development of field crops. When N is deficient, root systems and plant growth are stunted, older leaves turn yellow and the crop is low in crude protein. Too much N can delay maturity and cause excessive vegetative growth at the expense of grain yield. Nitrogen fertilizer is expensive and losses can be detrimental to the environment. Efficient use of N by meeting crop needs while avoiding excessive applications of N is an important goal. This fact sheet provides a brief overview of the important components of the N cycle to aid in reaching that goal.

## Nitrogen Cycle

The N cycle illustrates how N from manure, fertilizers and plants moves through the soil to crops, water and the air. Understanding the N cycle will help you make the best use of manure and fertilizers to meet crop needs while safeguarding the environment. In general, the N cycle processes of *fixation*, *mineralization* and *nitrification* increase

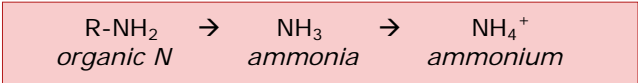
plant available N. *Denitrification*, *volatilization*, *immobilization*, and *leaching* result in permanent or temporary N losses from the root zone. Read on for specifics about each of the N cycle processes.

**Fixation** refers to the conversion of atmospheric N to a plant available form. This occurs either through an industrial process, as in the production of commercial fertilizers, or a biological process, as with legumes such as alfalfa and clover. Nitrogen fixation requires energy, enzymes and minerals, so if a plant available form of N is present, the crop will use it instead of fixing it from the air.



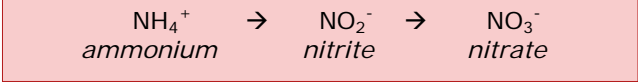
- When legumes are tilled into the soil, the N stored in their roots is released and made available to the next crop or lost to the environment, depending on management.
- In mixed legume-grass stands, the grass can utilize N fixed by the legumes. If the stand has 25% or more legume, no additional N is needed.

**Mineralization** is the process by which microbes decompose organic N from manure, organic matter and crop residues to ammonium. Because it is a biological process, rates of mineralization vary with soil temperature, moisture and the amount of oxygen in the soil (aeration).

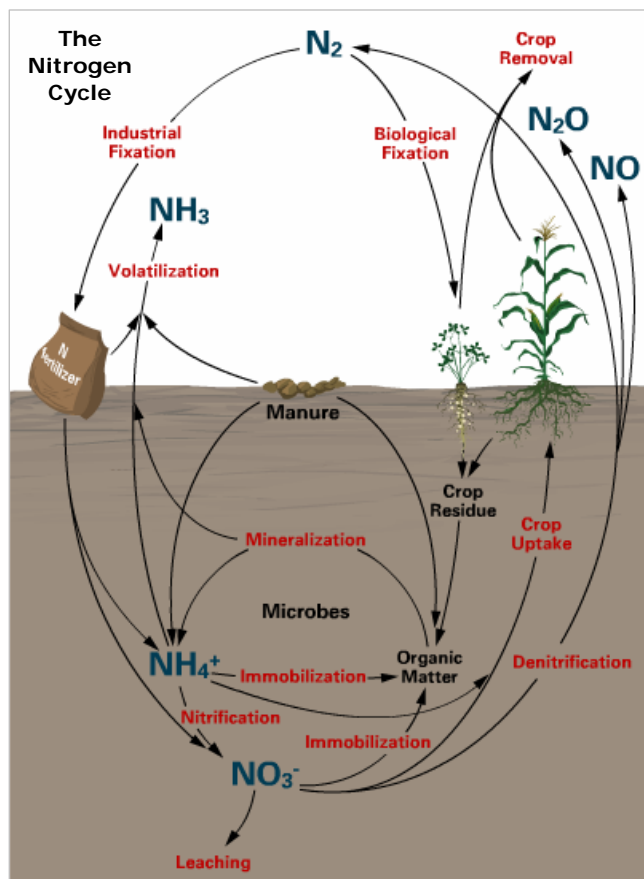


- Mineralization readily occurs in warm (68-95°F), well-aerated and moist soils.
- In New York State, approximately 60–80 lbs of N per acre is mineralized on average from soil organic matter each year.

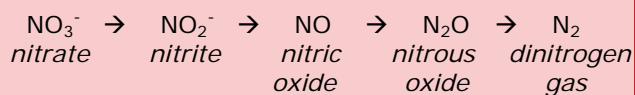
**Nitrification** is the process by which microorganisms convert ammonium to nitrate to obtain energy. Nitrate is the most plant available form of N, but is also highly susceptible to leaching losses.



- Nitrification is most rapid when soil is warm (67-86°F), moist and well-aerated, but is virtually halted below 41°F and above 122°F.

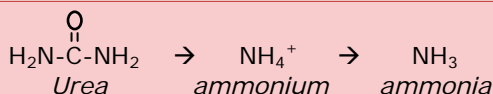


**Denitrification** occurs when N is lost through the conversion of nitrate to gaseous forms of N, such as nitric oxide, nitrous oxide and dinitrogen gas. This occurs when the soil is saturated and the bacteria use nitrate as an oxygen source.



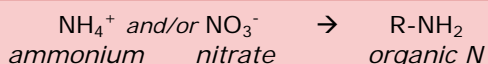
- De-nitrification is common in poorly drained soils.

**Volatilization** is the loss of N through the conversion of ammonium to ammonia gas, which is released to the atmosphere. The volatilization losses increase at higher soil pH and conditions that favor evaporation (e.g. hot and windy).



- Volatilization losses are higher for manures and urea fertilizers that are surface applied and not incorporated (by tillage or by rain) into the soil.
- Manure contains N in two primary forms: ammonium and organic N. If manure is incorporated within one day, 65% of the ammonium N is retained; when incorporated after 5 days the ammonium N will have been lost through volatilization. Organic N in manure is not lost through volatilization, but it takes time to mineralize and become plant available.

**Immobilization** is the reverse of mineralization. All living things require N; therefore microorganisms in the soil compete with crops for N. Immobilization refers to the process in which nitrate and ammonium are taken up by soil organisms and therefore become unavailable to crops.



- Incorporation of materials with a high carbon to nitrogen ratio (e.g. sawdust, straw, etc.), will increase biological activity and cause a greater demand for N, and thus result in N immobilization
- Immobilization only temporarily locks up N. When the microorganisms die, the organic N contained in their cells is converted by *mineralization* and *nitrification* to plant available nitrate.

**Leaching** is a pathway of N loss of a high concern to water quality. Soil particles do not retain nitrate very well because both are negatively charged. As a result, nitrate easily moves with water in the soil. The rate of leaching depends on soil drainage, rainfall, amount of nitrate present in the soil, and crop uptake.

- The EPA has set the maximum contaminant level for drinking water at 10 ppm N as nitrate.
- Well-drained soils, unexpected low crop yield,

high N inputs (especially outside of the growing season) and high rainfall are all conditions that increase the potential for nitrate leaching.

**Crop Uptake** is the prime goal of N management on farms. The greatest efficiency occurs when adequate N is applied at a time when the crop is actively taking it up. Efficient N use also depends on a number of other factors including temperature, soil moisture, pest pressure, and soil compaction.

- In the moist Northeast climate, nitrate remaining in the soil after the growing season will be lost to leaching or denitrification between crop harvest and the next planting season.
- Efficient N use during the growing season and the use of cover crops can minimize such losses.

**Summary** The ultimate goal of N management is to maximize N efficiency by increasing crop uptake and minimizing N losses to the environment. Crop N needs can be met through existing N sources (e.g. from soil organic matter, past sods and previously applied manure) and supplementary applications of N through manure and fertilizers. To make the most of existing N sources and purchased fertilizers, consider the N cycle facts, below:

- N released from killed sods, via mineralization and nitrification, can supply enough N for most, if not all, of the N needs of the following corn crop.
- The timing and method of manure and fertilizer applications determine the availability of nitrogen to the crop, but also the potential for loss. Spring applications with immediate incorporation will conserve ammonium from volatilization losses.
- Fall cover crops act as a “nutrient savings account” by taking up residual N from the growing season or fall manure applications and, thereby, reducing leaching losses. The nutrients in the cover crop become available for the next crop (by mineralization) after the sod is rotated.

For more information about N management in field crops (N guidelines, N calculators, etc.), see the “Nutrient Guidelines” section of the Nutrient Management Spear Program web site, below, or contact your local Cornell Cooperative Extension field crop educator.

For more information



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Cooperative Extension

Nutrient Management Spear Program  
<http://nmssp.css.cornell.edu>  
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