

MANAGING NITROGEN

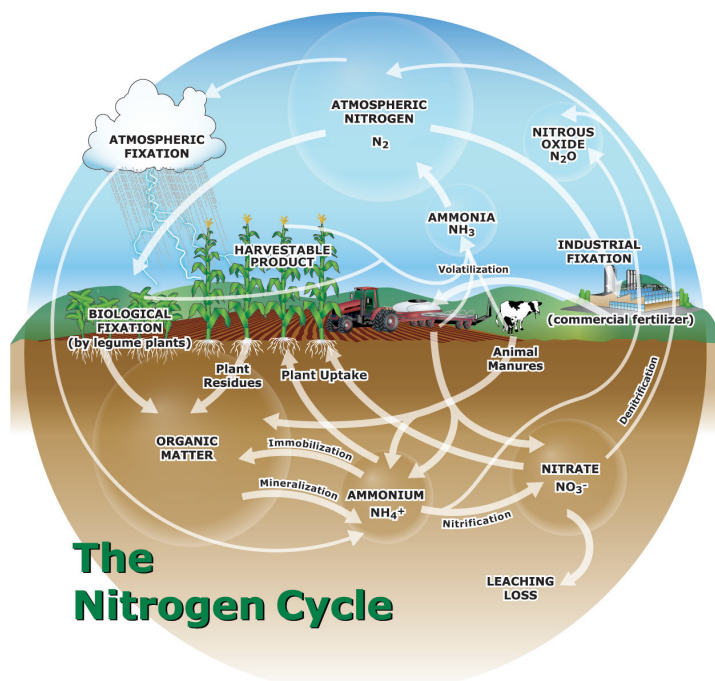
The early 20th century discovery of how to synthesize nitrogen (N) fertilizer was a transformational event in human history. The ability to capture relatively inert N₂ gas and convert it to the more reactive ammonia (NH₃) form ultimately led to dramatically increased agricultural productivity. It is estimated that about half of the world's population now depends on N fertilizer inputs for their food supply. In addition to growing crops, N fertilizer is required to sustain activities such as animal production, biofuel crops, and timber growth.

Only a portion of N fertilizer added to fields is removed in harvested crops. The remaining N is involved in a set of complex biological, chemical, and physical reactions that can be challenging to predict and manage. This unrecovered N can cascade through soil, microorganisms, plants, fresh water and ocean ecosystems as it continues to react. The goal of responsible stewardship is to use N fertilizer as efficiently as possible and minimize preventable losses from the soil system.

A basic understanding of the reactions of N in soils provides a solid foundation for making wise nutrient stewardship decisions. This series of factsheets, outlined below, covers the major N fertilizer transformations that occur in crop production. Due to the wide range of conditions that are found on farms, these guides provide only general information that must be adapted to local conditions with the aid of experienced professionals.

Nitrification - Soil bacteria convert ammonium (NH₄⁺) to nitrate (NO₃⁻) within a few days or weeks when soils are warm and moist. There are many sources of ammonium in soil such as composts, manures, crop residues, and commercial fertilizers. Regardless of the source of N, the resulting nitrate is identical and subject to the same soil processes. Most agricultural and horticultural crops use nitrate as their major source of N nutrition.

Denitrification - Nitrate can be lost to the atmosphere when it is converted to gas by soil microbial reduction reactions. Denitrification occurs most rapidly when soils are saturated with water and the oxygen content of soil is low, but the process continues even in moist, unsaturated soils.



The Nitrogen Cycle

Depending on the soil conditions, the gas produced may be N₂, N₂O (nitrous oxide), or NO (nitric oxide). These last two gases have detrimental effects on the atmosphere.

Urea transformations - Urea is the most commonly used N fertilizer in the world. When applied to soil, it is first subject to breakdown by a naturally occurring enzyme (urease) into ammonium. The ammonium is subsequently converted to nitrate through nitrifying bacteria. Understanding these transformations helps with management decisions to use urea most efficiently.

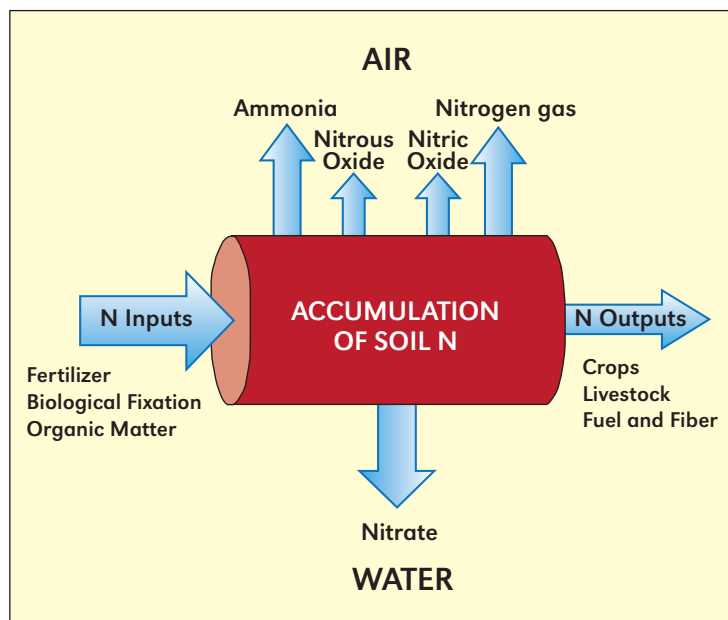
Ammonia volatilization - In alkaline soil, ammonium in fertilizer and manure is chemically transformed into ammonia gas which can be lost to the atmosphere. This is not only an economic loss of a valuable nutrient, but can be detrimental for air quality. A number of practical management techniques

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Nitrogen NOTES



Nitrogen is the plant nutrient that most commonly limits crop growth and yield. A lack of N is often visible by stunted growth and pale green leaves.



Nitrogen losses to air and water can be viewed as holes in a pipe. The pipe represents the soil system containing many forms of N, including N immobilized or “sequestered” by organic matter. The goal of N stewardship is to convert as much of the N input into recoverable N outputs by minimizing these “leaks” from the system.

are available to minimize ammonia loss and maximize its recovery by crops.

Nitrate leaching - An adequate supply of nitrate is critical for supporting plant growth, but it is vulnerable to leaching through soil. Minimizing nitrate leaching from the root zone requires simultaneous management of two essential factors

for plant growth; N and water. Careful nutrient management planning and irrigation techniques are required to minimize nitrate-leaching losses.

Mineralization - Soil organisms convert organic N-containing compounds into ammonium and nitrate before they can be used as major sources of plant nutrition. The rate of mineralization determines how quickly nutrient sources such as compost, manure, crop residues, and soil organic matter can be useful for plant nutrition. A variety of environmental factors and the properties of the organic material largely determine the speed of this process.

Immobilization - Soil microbes frequently require more N than is contained in decomposing organic materials, so they incorporate inorganic N into their biomass. The incorporation of ni-

trate and ammonium into organic compounds will temporarily reduce their concentration in soil and leave less inorganic N available for plant uptake for a period of time.

Dynamics of N uptake by plants - A key for efficient crop nutrition is to provide N at the time when plants are capable of using it. Many crops have distinct periods of maximum uptake, and other times during the growing season when less N is taken up. Matching the timing of N fertilizer applications to these peak demand periods can both improve N recovery and minimize the potential for nitrate leaching. Understanding the pattern of N uptake for each species is important for developing efficient fertilization strategies.

Using nitrate in irrigation water - Nitrate in irrigation water can serve as a valuable source of crop nutrition. Properly using this nitrate requires an accurate chemical analysis of the water and an estimate of the amount of water applied. Plants only take up nitrate when the crop is transpiring. Irrigating with nitrate-rich water when the plants are small or when transpiration is low does not use nitrate efficiently. Good irrigation practices are required to properly apply water and effectively use this nitrate source.

Cover crops - Crops that provide a vegetative soil cover but are not harvested offer several benefits for nutrient management. A legume cover crop will provide additional N to the following crop when it is terminated. Non-legume cover crops can remove nitrate and water from the soil, often resulting in less nitrate leaching. Cover crops can provide many other benefits such as protection from erosion and a habitat for wildlife and insects. Management of cover crop residues requires advance planning. ❖