

Improving the Bottom Line Through Climate Friendly Nitrogen Application

The Scoop on Using Nitrogen

Nitrogen (N) is an essential macronutrient needed for plant growth and development. Nitrogen from fertilizers, composts, animal manures or plant residues provides nutrients that may not be readily available in soil, often increasing yield and farm profitability (Figure 1). Despite over 50 years of agricultural research to improve the use of N, globally crops typically utilize 50-80% of the N that farmers apply, with the rest lost via microbe consumption, leaching, runoff, or off-gassing. It is challenging to synchronize the uptake of N in its plant-available form *when and where the crops need it*.

The overapplication of N increases financial costs, degrades soil, water, and air quality, and acts as a significant source of agricultural greenhouse gas (GHG) emissions. Improving the efficiency of N fertilizers by utilizing management practices that maximize N uptake by the crop and minimize the loss of N from agricultural lands can benefit the farm's bottom line, while helping the environment.



Figure 1. Manure spreading in for potato production (photo credit: S. Smukler)

What is Nitrogen Use Efficiency?

Nitrogen use efficiency (NUE) estimates how much of the applied N actually contributes to crop production. Low NUE values often indicate inefficient plant uptake, while very high NUE suggests plants are depleting soil N. NUE estimates are based on ratios of N content of the source applied, the nutrient needs of the crop, and soil characteristics. Strategies to calculate NUE can range from very complex, requiring multiple analyses of the crop and soil throughout the production season, to a simple estimation of the ratio of crop yield to the amount of N applied. NUE is also influenced by the form of N that is applied, the location, the timing, environmental factors, plant physiology, and soil biochemical processes. Crops mainly take up mineral forms of N, ammonium (NH_4), and nitrate (NO_3) — together we can refer to these as plant available nitrogen (PAN). Fertilizers containing N can be derived from rocks/minerals or synthetically manufactured through industrial processes or chemical reactions and are rapidly released after application as PAN. Alternatively, N applied through compost, animal manure, and plant residues tend to release PAN slowly as they decompose. Effectively improving NUE requires planning for the location and timing of the release of PAN, ideally accounting for all its sources.

How is Nitrogen Lost to the Environment?

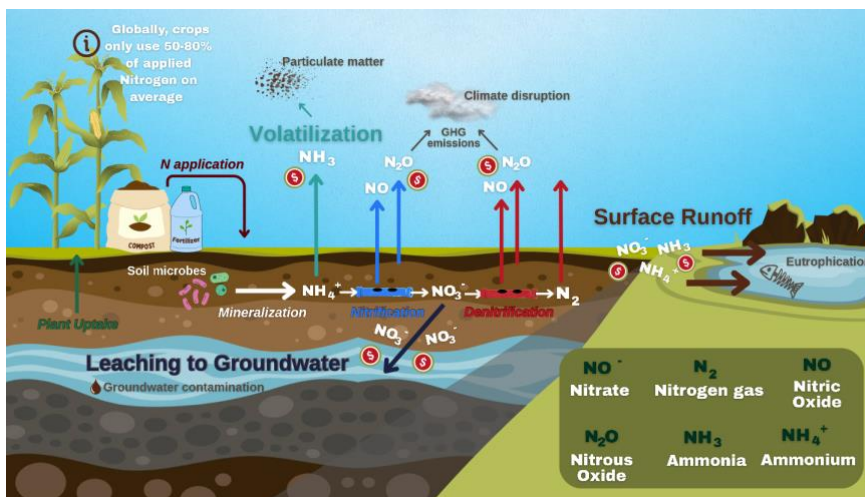


Figure 2. Diagram showing the most common pathways where nitrogen is lost to the environment.

NO₃, which is water soluble. Additionally, N can be transformed to NH₄ which is then lost through volatilization of ammonia (NH₃) gas. As N is transformed through nitrification from NH₄ to NO₃, it is lost to the atmosphere. NO₃ can then be converted into N₂O and nitrogen gas (N₂). Critically, N₂O is a GHG 273 times as powerful as carbon dioxide and is one of the primary sources of emissions from agriculture, highlighting its impact on the climate system.

When N is applied to soil, regardless of its source, it is susceptible to losses to the environment (Figure 2). These losses are generally controlled by microbial activity and environmental conditions that affect them, such as temperature and moisture. N that is applied without soil incorporation is especially prone to being lost. N in all its forms is susceptible to surface runoff through erosion and leaching, which can contaminate groundwater, particularly as

Improving NUE and Results through 4R Nitrogen Management

Improving NUE can help mitigate N loss and increase crop yields and profits, as NUE is directly linked to the conversion of available N into plant biomass. This can be done by using a 4R Nutrient Stewardship approach: **Right source, Right rate, Right time, Right place** (see [4R Nutrient Stewardship to Reduce Nitrogen Use and Greenhouse Gas Emissions, While Improving Farm Profitability](#) for details). Using the 4R approach has been shown to increase NUE across a wide range of agricultural systems. In a study evaluating NUE on a national scale across the United States, researchers found that a simulated 20% increase in NUE would result in an increase in **farmer profits of 1.6% per year**. Considering a sizable amount of applied N is lost to the environment, reducing initial application rate is economically beneficial as well. In a study based in Ontario, researchers used a representative corn farm model to calculate that reducing the N application rate from 170 to 150 kg N ha⁻¹ would result in an **increase in net return of \$22.32–\$36.25 ha⁻¹yr⁻¹**.

Key Takeaways

On both a global and local scale, farmers are currently overapplying N. This overapplication not only affects a farm's bottom line but also has impacts on the environment and climate. To address these issues, efforts should concentrate on improving NUE, which will simultaneously increase farm profitability and reduce agricultural GHG emissions.

References

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