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Improving Nitrogen Management in Atlantic Canada

Nitrogen Loss Pathways

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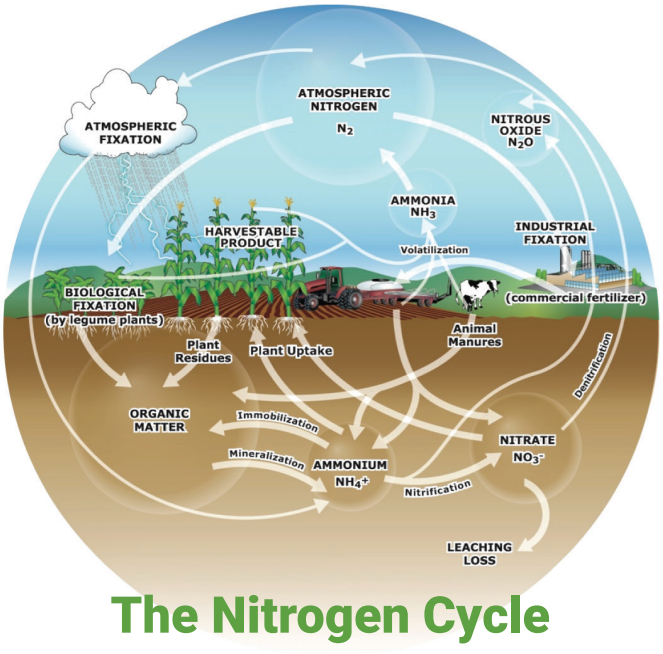
Nitrogen (N) is a critical nutrient for plant growth. Inefficient N management can lead to environmental concerns, including water pollution and greenhouse gas emissions. In Atlantic Canada, the climate, soil types and cropping systems necessitate careful N management to optimize efficiency and minimize losses.

Nitrogen Loss Pathways

Understanding the pathways through which N can be lost from agricultural systems is crucial for developing strategies to minimize these losses. The primary pathways include:

Leaching: The movement of nitrate (NO_3^-) through soil with water is a significant concern in sandy soils or during periods of heavy rainfall. Nitrate that accumulates in the soil after harvest is particularly sensitive to leaching as there is no longer a crop to take up the N or use water and thus the movement of water through the soil leaches most of this nitrate to groundwater. The leaching of nitrate represents 10 to 30 per cent of the N applied to the crop each year.

Denitrification: The conversion of nitrate to nitrogen gas (N_2) or nitrous oxide (N_2O) by soil bacteria under anaerobic conditions, results in N loss to the atmosphere. There is particular concern with N_2O as it is a potent greenhouse gas and represents approximately one third of Canadian agriculture's contribution to global warming.



The Nitrogen Cycle

Graphic: International Plant Nutrient Institute

Denitrification can result in 10 to 30 per cent loss of applied N. Generally N_2O emissions represent one to three per cent of applied N.

Nitrogen Immobilization: Plant available mineral N (NH_4^+ and NO_3^-) can be immobilized by soil microorganisms to form organic N compounds. This is not really a loss pathway but rather a short-term storage of N in a form not easily accessed by the plant. Depending on soil conditions this N will become plant available in weeks to months.

Ammonia Volatilization: The loss of ammonia (NH_3) to the atmosphere when N is applied as urea or ammonium-based fertilizers, especially under alkaline conditions or when left on the soil surface without incorporation. This is of concern when sources of N that produce alkaline conditions (urea, liquid manure) are applied to the soil surface and are not quickly

incorporated into the soil. Ammonia volatilization losses can be very large if manure or urea N sources are applied to the soil and not incorporated. As much as 75 per cent of the ammonium content of liquid manure can be lost within a few days if it is left on the soil surface.

Runoff: During rainfall or snowmelt events, there can be surface movement of N, as nitrate, ammonium, or organic N, which can contaminate surface water bodies. This is of particular concern when manure is applied to frozen ground, not incorporated into the soil late in the fall or applied early in the spring.

Improving Nitrogen Management

Effective N management in Atlantic Canada requires an integrated approach, combining various practices to reduce losses while ensuring crop productivity. In response to concerns relating to the potential for fertilizers to impact the environment, the fertilizer industry developed the *4R Nutrient Stewardship Program* to promote improved fertilizer management. The *4R Nutrient Stewardship Program* refers to four key practices in nutrient management:

Right Source: Choose supplemental N sources that ensure optimum plant availability while limiting the risk of N loss. Nitrate is the primary form of N lost to the environment. As a result, N management should limit the amount and duration of NO_3^- accumulation in the soil to minimize the risk of N loss. The use of ammonium (NH_4^+) based N fertilizer, or a fertilizer that generates NH_4^+ such as urea, delays the formation of NO_3^-, reducing the potential for loss. Urea or ammonium-based fertilizers can be treated with N stabilizers (e.g. urease and nitrification inhibitors) or coated with polymers to further delay the formation of NO_3^-. These are referred to as Enhanced Efficiency Nitrogen Fertilizers (EENF). These products slow down the conversion of urea to ammonia (via hydrolysis) and/or ammonium to nitrate (via nitrification), reducing the potential for leaching and volatilization losses.

Key Messages

Right Source
Consider an enhanced efficiency N source at a reduced rate of N.

Right Rate
Fertilize for the crop yield you are getting, not the one you wish you were getting.

Right Time
Consider split N application.

Right Place
Do not leave unprotected urea on the soil surface.

Right Rotation
Consider increasing the frequency of legumes in your rotation and the potential for cover crops to manage fall nitrate accumulation.

Right Rate: Ensure adequate, but not excessive, amounts of all limiting nutrients are applied to meet plant requirements in relation to yield and quality goals. The selection of the right rate is the most critical of the "4Rs" in improving N management practices. The other "Rs" cannot correct for the negative economic and environmental impacts of applying excess N. Right rate is one of the core principles in 4R nutrient management. Considerations in selecting the right rate include assessing plant N demand, the cost of N fertilizer relative to economic value of the crop and assessing all available N sources

including assessing soil N supply. Traditionally in Atlantic Canada, quantifying all the N sources providing the plant has been complicated by the lack of a soil N supply test and limited information on manure and legume N credits. Progress has been made in these areas and now there is a soil N supply test and additional information of the N credits associated with manure and legumes.

Right Time: For most crops there is a relatively narrow six to eight week period where most N is taken up. The choice of the source of N and the timing of its application should ensure that N is available during that period and ensure that excess nitrate does not accumulate in the soil prior to or following that period. There are several tools that can be used to influence the timing of N availability to match plant N demand. N fertilizer applications can be applied at multiple times during the growing season. An initial amount applied at planting, and subsequent amounts applied in crop depending on the ability to access the crop. A split application at planting and approximately four to six weeks after planting is used in row crops. The use of foliar N application can also be used when irrigation or spray equipment is being used. Applying N in multiple smaller doses can match crop uptake more closely, reducing the potential for leaching and denitrification losses. The timing of N availability can also be influenced by the use of enhanced efficiency fertilizer sources.

Right Place: Placing ammonium-based N sources like urea or manure in the soil rather than on the soil surface reduces the potential for ammonia volatilization and thereby can result in considerable improvements in crop N use efficiency. The soil buffers pH and therefore avoids alkaline conditions that cause ammonia volatilization and the soil cation exchange capacity helps to hold on the ammonium, further reducing the potential for ammonia volatilization. Whenever possible N fertilizer or organic amendments should be either injected in the soil or incorporated immediately after application. Another aspect of right place can be achieved by tailoring the rate of N application to variation in crop yield potential within the landscape.

The potential for crop yield and the risk of N loss all vary within the landscape - lower, wetter portions of the landscape often perform poorly and represent a high risk of N loss. The use of management zones or variable rate N fertilizer application approaches can ensure that N fertilizer is applied in areas with a high yield potential and is reduced in areas of low yield potential or high risk of N loss.

Right Rotation: Use diverse rotations including legume crops to reduce supplemental N fertilizer requirements, build soil health and increase the capacity of the soil to supply N to the crop. Cover crops can be planted in the fall to recover nitrate present in the soil to avoid over winter N losses.

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