NITROGEN IS AN ESSENTIAL ELEMENT to both crop production and animal husbandry. Ideally, agronomic and nutrition consultants can work together as a team as we continue learning and improving whole-farm precision and performance.

Keep nitrogen on the farm . . .

Or, optimize how it leaves the operation. Evaluate areas where nitrogen might be leaving, where you're paying to add it back and how you can better balance the two.

by Dustin Sawyer and John Goeser

MANAGING nitrogen (N) differently can lead to greater whole-operation efficiency. How often do we think about N-fertilization and milk protein in the same conversation? We rarely make this link, yet we should; they're intimately connected.

Nitrogen from the soil and atmosphere is converted by soil microbes and plants into amino acids and usable feed protein. The protein in forages and farm-grown feeds then makes up a substantial amount of your total mixed ration (TMR) protein, which cows convert to muscle, fetal growth or, more importantly and valuable, milk protein.

Adding the extra effort to precisely manage crop nitrogen can improve total farm conversion of crop nitrogen into milk protein, animal health and dairy profitability. Falling short of ideal in-crop N management can mean declining yields and poor crop protein. Lower crude protein levels mean your nutritionist must supplement expensive protein into the diet for health and performance.

A closed-loop system

There's no shortage of options when it comes to nitrogen management, and it can be anything but simple. However, the underlying ideology that drives our decisions about management can be. There is no simpler philosophy that yields profit and environmental stewardship than keeping "N" on the farm. Or, to state it more basically, optimize how N will leave the farm.

By looking at the entire farming operation as a closed-loop nitrogen system, we can start to see places where nitrogen may be leaving, where we're paying to add it back in, and how these losses and additions can be controlled.

Traditionally, agronomy and animal nutrition exist in two worlds on the same farm. To agronomists, nitrogen means fertilization strategies, and to the animal nutritionist it means ration balancing to meet protein requirements. Combining these worlds, looking just at nitrogen, we can start to envision the nitrogen molecule as it enters the soil, makes its way into the plant, passes through the animal and becomes meat, a newborn calf, milk protein or manure.

Of course, that is not the path that every nitrogen molecule takes. There are many exits from the system. Some of these exits are beneficial, such as nutrient uptake, and some are detrimental, such as leaching. Focusing on and closing the detrimental pathways can help to reduce the need for inputs.

Find the exit points

The soil system has a number of detrimental exits such as being carried out of the soil profile (leached) with water. Through a process called denitrification, soil microbes can convert nitrate to N_2 gas, making it unavailable to plants. Competing organisms can take it up, or it can simply float away in the form of ammonia gas. These are not ways that we want N to leave, as they cost money and can create environmental concerns.

There is one really good way, however, that N can leave the soil. It can be taken up by a crop, stored as hay or silage and then consumed by cattle. By understanding conditions that favor crop uptake and hinder unfavorable losses, we can move toward keeping N on the farm.

Let's focus first on the losses that we don't want. When we talk about nitrogen fertilization, the three most commonly used fertilizer types are nitrate (NO_3^-), ammonia (NH_3) and urea ($CO(NH_2)_2$). Most all applied nitrogen, regardless of form, is eventually converted to nitrate.

Ammonia, commonly used in its anhydrous form, exists as a volatile gas. Being a volatile gas, ammonia can be lost to the atmosphere. If using anhydrous, it's important to close the furrows, ensuring soil contact, to minimize volatilization. By trapping NH_3 in the soil, the gas is allowed to interact with soil water, forming ammonium (NH_4+), which is less volatile and binds to soil exchange sites. This binding helps to prevent ammonium from leaching out of the soil profile.

Nitrate is different, being very soluble in water. Leaching, therefore, is the primary unwanted loss that occurs. This can be a very rapid process in a porous soil under saturated conditions. If cropping sandy soils, it's important to apply N several times at lower rates, as a sudden rain could wash unused N from the soil. Nitrate is also the form of N that is most readily taken up by the plant. By applying when the plant most needs N, we can help to maximize uptake and optimize crop yield and crude protein.

Urea is an organic form of N that is the best of both worlds. It is more slowly available to plants as it needs to go through a three-step conversion process before the N can be taken up. Urea is water soluble, though, and can still be lost through leaching.

Manure is a combination of nitrate, ammonia and urea. A manure test will provide the percentage breakdown of each of these nitrogen forms. The results of the test will help to understand the best way that the manure is applied. For example, for liquid manure with high ammonia, injection will make sure that the N is most available to the system.

Determine what's there

The aim is to optimize yield and crop protein levels. There are a few important tools that can help to maximize the chances of nitrogen uptake to do just this. Soil nitrogen tests are among the best. The preplant and presidedress nitrate tests help to determine how much nitrogen is already in the soil system. The results of these tests will help to ensure that any leftovers from previous applications are accounted for and that the nitrogen dollar is not flushed out the drain tile.

Plant tissue testing is also a great way to determine the nitrogen use efficiency of the growing crop. Corrective action can be taken before harvest to fix any deficiencies. If the crop is deficient in nitrogen at harvest, and your nutritionist adds supplemental protein to the diet, you wind up paying for nitrogen twice.

After harvest, we must focus on carrying the crop nitrogen (in the form of crude protein and amino acids) to the feedbunk and then into the rumen. In addition to possible field losses, nitrogen can also leave the farm as ammonia through poor forage preservation at feedout. For high-protein crops, the goal is to have less than 10 percent of crude protein converted by fermentation into ammonia.

After nitrogen is consumed by the cow, many complex digestion processes take place breaking down crude protein and building muscle and milk protein. Urine and manure are also sizable sinks for feed N. Urinary (and fecal) losses are the final area where N can leave the farm in the cycle we've described here. The best cattle convert roughly 40 percent of feed protein into body reserves and milk. N being reapplied to fields as manure can be a good thing to be recycled by plants, but negative losses can take place through ammonia in urine. This is an intense area of focus with much opportunity for whole-farm dairy performance.

Crop and animal nutrition factors must be balanced accurately as part of your total farm nitrogen strategy, to minimize losses through leaching and volatilization, along with manure and urine, to ultimately optimize crop yield, nutritional value, milk volume and protein yield. Your consulting team is invaluable in helping you manage these areas.

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