Illustration by Corey Lewis.

Can your soil cash your forage's checks?

Dustin Sawyer for *Progressive Forage*

AT A GLANCE

Forage production is an intensive remover of soil nutrients and needs intensive management.

It may seem simplistic to analogize soil with a checkbook, but it works and is more apt than perceived. Matter can be neither created nor destroyed. It's a simple truth that drives everything in the universe and holds true in the soil as it does in the cosmos – giving rise to the soil nutrient balance. The idea is as simple as the aforementioned checkbook – every molecule in the soil must be accounted for, just as every penny in the checkbook must be accounted for. The balance must equal the initial level, plus deposits, minus expenditures.

It's no secret that forage production has the highest nutrient expenditures of nearly any cropping system. The removal of the whole plant means that vital soil nutrients in stalk, stem and leaf are not returned to the soil as they would be in a grain harvest. On top of that, the relatively early harvest season means that the mobile nutrients in the plant have not had a chance to move back through the root system into the soil. This is great from the livestock feeding standpoint, as those nutrients in the forage will be available to the animals, but from the agronomic standpoint, it means that forage crops require relatively greater nutrient management than grain crops.

Soil nutrient management takes on several forms and has many tools in the toolbox. The term is most often used in reference to a regulatory standard that primarily focuses on phosphorus (P) or nitrogen (N). However, nutrient management at its core is just what the name implies – it's the management of soil nutrients. Soil testing is certainly the most commonly used tool for nutrient management, but it has limitations. Using soil testing alone may tell an incomplete or even misleading story. Meanwhile, a less commonly used tool, the nutrient balance calculation, can help to see the three-dimensional picture.

What is a nutrient balance calculation? Simply put, it's balancing the checkbook of nutrient inputs and nutrient removals, and it can provide insight into the soil nutrient pools that soil testing alone cannot. For the purposes of this article, the term "nutrient" will refer to mineral nutrients such as nitrogen, phosphorus, potassium, calcium, sulfur, copper, manganese, iron, boron and zinc. In fact, any element that can be tracked can be balanced.

Why should anybody go through the bother of calculating a nutrient balance if they are already soil testing? Because soil testing may not be the ideal tool to use when trying to track soil nutrient changes over time. The original intent of a soil test was to determine the probability of seeing a yield response to added fertilizer. It was not intended to measure, track or monitor soil nutrient pools. As such,

the relationship between the calculated nutrient balance (the "actual" change in soil nutrient levels) and the soil test has not been much studied and is not well understood. Even now, there are researchers using data from long-term soil experiments to try and gain a better understanding of how soil testing tracked with nutrient balances over years or even decades.

Conducting a nutrient balance calculation is quite easy if the data are available. The calculation itself is straightforward: nutrient balance = inputs from fertilizer - removals from harvest. The only challenge lies in recordkeeping. Having reliable spreading logs for manure and fertilizer applications is a must and is hopefully already happening. Coupling the application rates with the nutrient values of the fertilizer or manure will yield the amount of a given nutrient applied. In the case of manure application, it's also important to send a representative sample of the manure to your agricultural testing lab. While book values for various manure sources are available and can be plugged into the equation, there is a surprising amount of variability, and book values aren't useful for a nutrient balance calculation. Of note, the University of Minnesota maintains the only manure analysis proficiency program in the U.S., and a list of reputable manure analysis labs can be found on their website (www.mda.state.mn.us/pesticide-fertilizer/certified-testing-laboratories-manure-soil).

An example calculation for nutrient inputs

• Manure analysis shows 7.5 pounds of P as P_2O_5 per 1,000 gallons

• Manure was applied at the rate of 8,000 gallons per acre

• (8,000 gallons x 7.5 pounds P_2O_5) / 1,000 gallons = 60 pounds P_2O_5 per acre input

At first blush, nutrient removals through harvest may seem like difficult data to pull. However, if the forages are being sent to an animal nutrition laboratory, the nutrient content will be known. The only other piece needed is the per-acre yield. By multiplying the nutrient content by the yield, tons of corn silage per acre can be converted to tons of phosphorus (for example) per acre.

An example calculation for nutrient removals

• Forage analysis shows 0.24% P on a dry matter (DM) basis

• Corn silage yield was 20 tons per acre at 65% moisture (35% DM)

o Convert corn silage yield to 100% DM

o 20 tons per acre x 0.35 = 7 tons dry matter per acre

• Combine forage analysis with DM yield

o 7 tons dry matter per acre x 0.0024 = 0.0168 ton P per acre

• Convert units so that they match the nutrient inputs

o Convert P to P_2O_5

▪ The conversion factor between elemental P and P_2O_5 is 2.29.

▪ 0.0168 ton P per acre x 2.29 = 0.0385 ton P_2O_5 per acre

o Convert tons per acre to pounds per acre

▪ 0.0385 ton P_2O_5 per acre x 2,000 pounds per ton = 76.9 pounds P_2O_5 per acre

The example calculations show that the farm put in 60 pounds and harvested 77 pounds of P_2O_5 per acre, thus running a deficit of 17 pounds per acre, if no additional phosphorus inputs were made through purchased fertilizer. It will only take 37 pounds of diammonium phosphate (DAP) to correct the deficit, which may not seem like much. However, there are two other important factors to consider when comparing this nutrient deficit to using soil testing alone. First, soil testing may not pick up on this deficit. As mentioned earlier, the relationship between a soil test result and the actual nutrient flux in the soil is poorly understood. Variables such as weather, soil moisture, tillage, etc., all have an impact on soil test results. Second, soil testing is typically conducted only once every four years. That means that if the 17-pound deficit holds for each year between sampling events, now there is a 68-pound deficit over four years. That will require 147 pounds of DAP just to get back to the baseline. That's a heck of a lot of P going down at one time.

The above example calculations focused on phosphorus, which is important from the standpoint of environmental stewardship. From the economic standpoint, however, the potassium balance is a much bigger deal. Using the same manure application rate and yield as the example above, but focusing on potassium instead, 152 pounds of K_2O were removed per acre, but only 66 pounds went on through the manure. That's a nutrient deficit of 86 pounds of K_2O per acre, requiring 143 pounds of potash just to get back to the baseline! Let that deficit run for four consecutive years and now it takes 572 pounds of potash per acre just to get back to the initial soil level.

There is one more huge benefit to calculating a soil nutrient balance: micronutrient management. Most of the plant nutrition research that underpins modern agriculture has been conducted on the big three: N, P and K. Soil test interpretations and application rates for micronutrients are all but nonexistent. Using the micronutrient analysis of manure and harvested forage offers the best insight on the management of these key minerals.

Forage production is an intensive remover of soil nutrients and needs intensive management. If all the data are readily available, a nutrient budget calculation is a fast and easy tool that can replace the book values from nutrient management with real data from your farm. If the data from your farm are not readily available, it's time to begin working with an agricultural lab and use whole-farm data to dial in your operation and take your management to the next level.

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