NUTRIENT CREDITS FOR MANURE--
DIFFERENCES BETWEEN THEORY AND REALITY

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It has been a mainstay recommendation for many years--take credit for the nutrients in the manure you spread on your fields. While it may seem that everyone is referring to an identical procedure, there are numerous strategies to crediting nutrients contained in manure. Although it appears to be simple, the complexities involved in crediting have resulted in few livestock and crop producers properly crediting nutrients from manure. Research and educational efforts have sharply increased in the past several years; however, the gap is expanding between what is known and what is practiced with regards to manure management and crediting. The following discussion will address crediting methods and the potential shortcomings that result in poor adoption of proper crediting by producers.

CREDITING METHODS

Estimated Credit

Recommendations state that manure crediting should be determined by *estimating* the quantity of nutrients that are contained and available from the manure. While educators and advisors commonly use this method in determining proposed manure application rates, the method can also be used after the manure applications to determine amount of nutrients applied. Equation 1 can be used to determine a proposed application rate, based on a nutrient recommendation, whereas Equation 2 can be used to determine applied nutrients after a given application. The difference between Eq. 1 and Eq. 2 is simply a rearrangement of variables to solve for the variable of interest.

Eq. 1 Rate = Nutrient recomm./(Manure nutrient analysis x Availability)

Eq. 2 Nutrient credit = Rate x (Manure nutrient analysis x Availability)

This *estimated* credit method is commonly used for current year nutrient credits. In most nutrient management plans, residual nutrient credits from past manure applications are also estimated in this same manner. The main difference between estimating current year and residual credits is the availability coefficients, primarily nitrogen (N).

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The primary advantage of the *estimated* method of nutrient crediting is that immediate credit can be given for a manure application. Commercial fertilizer rates can be then adjusted accordingly. The shortcoming of this method is that most producers do not have enough information to make these calculations. Lacking information may include; a) manure application rate in terms of gallons or tons per acre, b) the nutrient analysis of manure, and/or c) N availability coefficients specific to the method of application.

Measured Credit

In contrast to the *estimated* credit method, which can be completed using a calculator or computer in one's office, the *measured* credit method requires that soil samples be collected after the manure has been applied to a field. As a result of these analytical measurements, an index of nutrient sufficiency can be determined that will be representative of the nutrients available from the previously applied manure.

This *measured* credit can be used in many types of scenarios. For N credits, manure could be applied in the fall or spring before planting corn, then the producer could take an in-season soil N test. Based on the principles of this procedure, the N test results, and corresponding credits, should be indicative of the previous manure application. Credits for previous manure applications can be determined with fall, spring preplant, or an in-season soil N test. Phosphorus and potassium credits, using this measured method, are simply determined by analysis of the next routine soil sample. The soil test should change according to the rate of nutrients applied, and these changes are then accounted for in the recommended fertilizer rate.

The main benefit of the *measured* credit method is that the nutrient additions are analytically assessed. Although there is less concern about knowing the actual application rate or nutrient analysis, this method does require more labor/effort during the growing season, which can be a drawback. Plenty of cores/subsamples are required so that any injection or application pattern will be representatively accounted for by the tested samples. Another potential drawback may be the uncertainty of the immediate availability of the manure. The *measured* credit method also assumes that the inorganic N transformations have somewhat stabilized.

A combination of both methods may be the most practical and reliable for the producer. The *estimated* credit method can provide an initial estimate of available nutrients, and the *measured* credit method can assess if the estimates were too high or low. Thus, a producer would estimate manure application rates using manure analysis and nutrient recommendations, but then would follow up with soil tests to quantitatively measure the need for supplemental fertilizer.

ASSUMPTIONS AND SOLUTIONS

Regardless of the method, there are always countless assumptions required for crediting available nutrients in manure. Several key issues will be addressed, each with their underlying assumptions, the disparity between theory and reality, and the opportunity for solutions.

Manure Analysis

Advisors sometimes assume that the manure's nutrient content, or analysis, is known. One number is often used for the whole farm, or an analysis from one manure storage facility is extrapolated to every storage facility. Survey data indicate that three-quarters of producers have not had their manure analyzed, thus it can be assumed that, at best, any manure management planning on these farms relied on manure analysis from standard tables.

Theoretically, a "tabled" manure nutrient value is better than no value, however, a large variation in manure exists on a farm-by-farm basis. This variation creates certain risks depending on the method of manure crediting. If one is solely using the *estimated* manure credit system, then manure with much lower nutrient contents than expected could result in dire consequences. Most often, the crop will be limited in yield due to a shortage of a nutrient. This same scenario would not be as great a risk with the *measured* credit method because preseason or in-season tests should indicate this shortage.

When manure samples are collected and analyzed, the emphasis has always been placed on collecting a representative sample of the storage facility. An important agronomic question might be how representative was that sample for each load going to the field. Load to load, or top to bottom storage, variability of nutrients may be far greater than perceived.

Theoretically, the solution for this real problem is the development of an in-line nutrient monitor as part of the manure application equipment. Prototypes of this kind of measuring device have been developed, but the perceived need and costs have limited their adoption. Until this practice sufficiently evolves, producers must rely on manure sampling procedures, with intensity of sampling being varied based on the predicted heterogeneity of the manure.

Nutrient Availability

A simple mathematical formula is the theoretical link between the total nutrient concentration in manure and the available nutrient concentration. In reality, the relationship between these two components is a complex biological and chemical process that is quite dynamic.

Nutrient availability is primarily an N issue. Recommended formulas for calculating available N from a manure application can be grouped into three categories based on N components and possible coefficients used in conjunction with the N components. The category represented by Equation 3 uses total N, with the availability coefficient being a function of several N processes. The assumption in using this formula is that the availability coefficient includes estimates of the inorganic/organic N partition of the manure and that this represents all the significant N processes. In the second category, represented by Eq. 4, ammonium-N and organic-N must be determined, and a mineralization coefficient is then used to calculate the portion of organic N that will be available. This category assumes that all of the ammonium-N (or inorganic-N) is plant available. Only one biological process is estimated by the components of Eq. 4--mineralization of the organic N. The third category involves estimating the mineralization of the organic-N portion and also determining the portion of the inorganic-N that will be available (Eq. 5). Compared to Eq. 4, the additional assumption with Eq. 5 is predicting the loss of ammonium-N due to method of manure application. This assumption, as well as the assumption of predicting mineralization rates, is inherent in the overall availability coefficient in Eq. 3.

Eq. 3 $\quad PAN^{1} = (\text{Total N x Avail. coeff.}^{2})$

Eq. 4 $\quad PAN^{1} = [NH_4\text{-N} + (\text{Org-N x Min. coeff.}^{3})]$

Eq. 5 $\quad PAN^{1} = \{(\text{Org-N x Min. coeff.}^{3}) + [NH_4\text{-N x (1- Loss coeff.}^{4})]\}$

[1]-PAN represents plant available nitrogen.
[2]-Availability coefficient is a function of animal specie, application method, and time until incorporation.
[3]-Mineralization coefficient is a function of animal specie and method of storage/handling.
[4]-Loss coefficient is a function of method of manure application.

With all of these N availability formulas, the perception to the end-user is that any one method of determining plant available N is fairly accurate. Yet, there are various formulas with different assumptions among Extension recommendations. This leads to the questions how accurate can one predict N availability, and/or can all the formulas be correct?

Two of the three formula categories require ammonium-N analysis of the manure. In a survey of Upper Midwest laboratories that analyze manure, only 3 labs (representing 10% of the samples) routinely analyze for ammonium-N. A total of 4 labs (representing 20% of the samples) do not offer ammonium-N analysis. And 7 labs (representing 70% of the samples) offer ammonium-N analysis as a special request/extra charge. This same survey also reported that of the labs conducting ammonium-N analyses, three different analytical procedures were used.

Strong arguments can be made that each of the formula categories can be most appropriate. However, the necessary components of each formula must be known or measured and this is sometimes lacking. All coefficients are not interchangeable depending on the category of formula and, as noted, all laboratories do not supply each N component. Any formula predicting N transformation processes in the soil are at risk of being misinterpreted. Climatic conditions have such a great influence on some of these processes that until in-field measurements are included in prediction formulas, there is a risk of under- or over-predicting nutrient availability.

Rate Calibration

Management advisors routinely calculate and make recommendations to producers for determining rate of manure applications for specific fields. Or conversely, a specific rate is applied and the available nutrients are subsequently determined. A key component to either of these approaches for estimating manure credits is the producers ability to deliver a specific application rate (Eq. 1 and 2). The reality is that few people know their rate of manure application. Data from one Minnesota survey of over 400 pork producers indicates that less than 1 in 5 producers have ever calibrated their manure spreaders.

There are two primary components to ensure successful delivery of a specific manure rate: 1) an accurate measurement of manure applied, and 2) even distribution. Advising people to calibrate their applicators is not a complete solution to the crediting dilemma. While weigh pads, load cells, or weigh bars can help determine more accurate manure application rates, the next obstacle is to accurately apply a given rate of manure. A producer can sometimes vary their tractor speed, the gate or orifice opening position, and/or delivery pressure of the manure at the gate or orifice by adjusting apron speed or tank pressure, but how precise or reproducible is each adjustment.

Liquid and slurry manure present greater opportunities for accurate rate control through equipment technology. Hydraulically-driven screw pumps can be used to deliver specific rates of manure after a calibration curve is calculated for the pump. Extra costs and some initial calibrations are needed with this option, but excellent results in terms of delivery rate is the end product. Another similar solution is a flow meter to measure manure output. With this system, a gated valve and impeller pump speed vary the manure rate that is constantly being measured by the flow meter. This system has extra costs, but is convenient and not time-consuming.

Application Uniformity

If one knows the nutrient content and availability, and the manure application rate, then a specific nutrient credit should be subtracted from an overall nutrient recommendation. The unstated assumption is that the manure is uniformly applied over the entire field. Most producers can list several concerns that limit the belief in this assumption. Issues such as: 1) uniform tractor speed; 2) constant manure output; 3) uniformity in spread pattern across the effective discharge width; and, 4) consistency in manure rate as different loads stop and start, all contribute to this application uniformity concern.

Application uniformity is a management practice that the producer can most easily control. Radar speed interfaces and controls are becoming commonplace on many tractors. Tool-bar attachments and distributor mechanisms are improving the uniformity across the tool bar. Driving patterns and markers all can contribute to improved uniformity. Uniform application is the basis for all nutrient credits and is fundamental to improving the economic return to livestock manure.

SUMMARY

Crediting for nutrients in animal manure is challenging for many producers attempting to fully utilize manure. Manure crediting procedures are either laden with numerous assumptions or include practices seldom used. These assumptions include known nutrient analysis, known availability coefficients for the nutrients, knowledge and control of application rate, and uniform application. The practices not widely used are integration of advanced technology in manure application equipment and/or soil sampling procedures after the manure has been applied; yet, before final sidedress applications can be made.

While we wait for spreader equipment to be improved, research to be conducted, etc., one management strategy that should receive top priority is to improve spacial uniformity of manure application throughout a field. Application uniformity is of tremendous importance. Whether we have gaps in our present crediting methods or whether manure credits become very precise, uniform application is critical to capitalize on the nutrient value in manure.

Manure management educational efforts must continue for producers. However, in planning educational programs, all educators/advisors must evaluate the most limiting issue for implementing manure credits for their region and develop their program accordingly. Different programs may need to emphasize different issues, such as; a) application logistics; b) research data on nutrient availability; c) manure management planning; d) manure testing, as well as countless other issues. The better everyone understands manure crediting methods and assumptions contained within these methods, the better we can do in properly crediting manure.

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