INTEGRATING FERTILIZER AND MANURE NITROGEN SOURCES IN IRRIGATED AGRICULTURE

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BACKGROUND

Sharp increases in fertilizer prices are pushing growers to consider alternative nutrient sources for their crops. For growers in the western U.S. who produce crops in regions that also contain intensive animal production, manure can be a very affordable alternative nutrient source to chemical fertilizers. However, manure does not have the appropriate balance of nitrogen (N), phosphorus (P), potassium (K), and other nutrients to meet the nutrient needs of most crops. The goal of this article is to provide recommendations on the most effective methods for supplementing manure applications with fertilizers without under- or over-applying any one nutrient.

INTEGRATING MANURES AND FERTILIZERS

The integration of fertilizers into a manure application program is the most effective when one or more nutrient amounts in the manure does not meet the needs of the crop. Manure is typically applied on a phosphorus basis to prevent overloading the soil with phosphorus, which usually causes nitrogen to be applied at significantly lower rates than is needed by most crops. This nitrogen deficit is most extreme in cases of low N content (as seen in cattle manure) or high P content (as seen with poultry litter). As nitrogen is the most limiting nutrient in most agricultural systems, it is imperative to apply N sources that don’ts contain phosphorus or other not-needed components, such as sodium, copper, excessive potassium, heavy metals, pesticide residues, etc.). The most obvious option is supplementing manure applications with nitrogen fertilizers. In the western U.S., Urea is most commonly used nitrogen fertilizer, although other N fertilizers (ammonium sulfate, anhydrous ammonium, and ammonium nitrate) would also suffice. Mono-ammonium phosphate and di-ammonium phosphate would not be ideal, as they would be introducing additional phosphorus, which would decrease the amount of manure that could be applied. To successfully integrate fertilizers into a manure application program, we recommend following five key steps:

- Step 1. Get a manure/compost test done.
- Step 2. PSNT soil sample
- Step 3. Understanding the availability of nitrogen in manure
- Step 4. Determine exactly how much supplemental fertilizer is needed

STEP 1. GET A MANURE/COMPOST TEST DONE.

Possibly the most critical, yet overlooked, step toward effectively integrating fertilizers with manure applications is having an accurate and recent nutrient analysis of the manure. Manure can vary widely from one pile to the next, due to factors that include feedstock, age of manure, cattle type, bedding type, number of turns, pile temperature, and dairy management practices. As an example, we noticed in a recent compost application study that soil test K concentrations in two separate fields at two locations varied significantly between each other, despite the fact that dairy compost was applied at the same rate and time from the same composting facility (table 1). After closer inspection, we noticed that the field that responded strongly in terms of soil test K had almost twice the concentration of K in the compost compared to the compost applied to the other field. This finding served as a clear reminder as to the importance of testing manure for nutrient content prior to application.

Table 1. Soil test K (ppm) differences, as affected by compost K content and rate (four replications and RCBD design at both locations) (*unpublished data: Falen, Hunter, Kinder, and Moore*)

Compost Rate (ton/acre)	**Blaine (Compost had 40 lb K_2O/ton)**	**Camas (Compost had 28 lb K_2O/ton)**
0	82	121
5	121	144
10	151	148

STEP 2. PSNT SOIL SAMPLE

Finally, if N content information is not available to the grower, or if they are looking for an alternative to the calculator, we recommend conducting a second soil sampling for ammonium and nitrate at the time that potatoes are just beginning to flower in your area, or when corn plants are between 6 and 12 inches tall. This is often referred to as the PSNT (Pre-Sidedress Nitrate test). The idea behind this is that warmer temperatures from April to June will trigger N mineralization in the soil, which release significant amounts of plant available N from the organic N compounds in the soil. While the N mineralization process still continues into the warmest months of the growing season, plants will also be at their most efficient point of taking up every bit of nitrate in the soil, and you will no longer be able to pick up the mineralized N in a soil test. The PSNT soil test values can help you to determine how to manage in-season applications of N.

STEP 3. UNDERSTANDING THE AVAILABILITY OF NITROGEN IN MANURE

To be able to understand how to integrate manures and fertilizers, it is imperative to first understand the nutrient value of manure as a nutrient source. This is a very complex topic, especially in terms of nitrogen value and availability. For example, of the 90 crop consultants surveyed at the 2013 Idaho Far West Chemical Conference in Twin Falls, only 23% knew that N availability from dairy compost is typically 0 -10% in the first growing season (the remaining 77% selected 10-40% plant available N). Over-estimating plant available nitrogen in manure will cause growers to supplement with less fertilizer N than is needed by their crops for optimal growth, which could easily cause reduced yield and crop quality.

One factor that has a major influence on N availability from manures is the type of organic N (table 2). For example, manures containing primarily unstable and readily mineralizeable N compounds, such as poultry litter and swine manure, will release the compounds to plant available N forms (ammonium and nitrate) rather quickly. The majority of the N released in the same growing season as the manure application. Alternatively, the N in manure from ruminant animals (beef and dairy cattle) is 44-49% in stable organic N forms which can take several years to decompose. Cattle manure contains significantly more lignin than chicken or pig manure (table 3). Lignin is an extremely stable organic compound and very difficult to decompose, contributing the lower plant availability of N from cattle manure. This is a topic that needs to be explored further to enhance prediction of plant available N.

Table 2. Composition of organic N compounds in manures from various animal species. (Havlin et al., 2005)

Animal species	**Amino acid**	**Urea**	**NH4+**	**Uric acid**	**Other (Stable organic N compounds)**
Poultry	27	4	8	61	1
Beef	20	35	0.5	0	44
Dairy	23	28	0.5	0	49
Swine	27	51	0.5	0	22

Table 3. Comparing typical lignin contents of various manures to wheat straw. http://compost.css.cornell.edu/calc/lignin.html#txt14

Substrate	**Lignin**
Wheat straw	8.9
Cow manure	8.1
Chicken manure	3.4
Pig manure	2.2

One useful tool currently available to growers is the Oregon State University (OSU) Organic Fertilizer Calculator, available at website address http://smallfarms.oregonstate.edu/calculator/. The OSU organic fertilizer calculator was created to allow Oregon growers to quickly and easily predict N availability from manure, compost, and other amendments, based on N content, and dry matter content. The equation supporting the calculator is a linear-plateau segmented regression between N content of the manure and plant available nitrogen in the soil. The regression was developed from incubation studies, where manures of varying N contents were mixed with soil, incubated for 70 days at room temperature, and analyzed for ammonium and nitrate content. The development of this calculator has greatly improved growers’ abilities to predict PAN from manure applications.

Another tool is the calculator imbedded in the extension article “Estimating Plant Available Nitrogen from Manere” (EM-8954-E) (http://extension.oregonstate.edu/catalog/pdf/em/em8954-e.pdf). While the OSU calculator is useful for predicting N for the season following a one-time application, the Nitrogen availability calculator also takes into account factors like ammonium content of the manure, incorporation timing after manure application, and release of N from manure application 1-9 years prior. While requiring a few more inputs, this calculator would be of great use on a field that has a history of manure applications. This calculator will likely give a more precise estimate of N release, especially for non-composted manure materials.

STEP 4. DETERMINE EXACTLY HOW MUCH SUPPLEMENTAL FERTILIZER IS NEEDED

When applying fertilizer to manured fields, it is important to take the time to determine exactly how much fertilizer is needed, otherwise it is likely that the fertilizer will be under- or over-applied. While this can be calculated by hand, online tools like the Minnesota Manure Calculator (http://www1.extension.umn.edu/agriculture/manure-management-and-air-quality/manure-application/calculator/) can help growers to quickly and easily estimate how much supplemental fertilizer is needed to supplement a manure application. To insure the most accurate estimate of fertilizer amount, be sure to use your own NPK values and estimates for N availability. Estimates suggested in the calculator are likely drastically different from the manure that you are working with, and will likely cause you to under- or over-apply fertilizer.