

**Organic Nitrogen Soil Supplement Recommendations
for BSI Brokers, Dealers and Customers
Based on Spring 2009 Research**

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April 29, 2009

Kyle Farr
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Dear Mr. Farr,

Here is the report on recommended ways to organically supply additional nitrogen to the soil and plants. These recommendations are intended to be used along with your existing program to naturally promote healthy soil and plants as well as increase plant productivity.

I enjoyed researching these recommendations and learned a considerable amount about the nitrogen cycle myself. I hope that my findings will be a benefit to you and your customers.

If you have any questions or would like to discuss my findings contained in this report, please feel free to contact me at (435) 817-0741 or email me at webmaster@biologicalservices.com.

Sincerely,

Kevin C. Hunt

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Executive Summary

Based on my findings I have determined several things. First that there are several sources that could possibly provide additional nitrogen to the soil.

However not all possible sources are viable. The sources that I determined to be viable are:

- Manuring
- Using crop residue, either through cover crops or green manure
- Implementing a crop rotation plan
- And continuing to use your microbial life promoting products

My recommendations for you are these:

1. Reduce and ultimately eliminate the use of commercial fertilizers, if it is being used.
2. Continue to apply The Bio-N-Liven Answer® and The Carbon Answer® as you have been doing and/or according to recommendation.
3. Increase nitrogen levels in one or more of the following ways
 - a. Apply animal waste products as a fertilizer after determining what type would best fit your needs
 - b. Consider using cover crops and green manure crops to provide added nutrients. Determine what crops will provide the benefits your operation needs and use those crops.
 - c. Implement a crop rotation plan that will aid in soil health and increase deficient nutrient levels.

The Problem and the Plan

Incidentals of Authorization and Submittal

On March 3, 2009 Kyle Farr, Chief Executive Officer of Biological Services International, LLC, requested that Kevin C. Hunt conduct a research project to collect information about how to naturally increase usable nitrogen levels in the soil and to present his findings in a collective work that would give suggestions and recommendations to be available to and used by BSI Brokers, Dealers and Customers.

Purposes of this Report

The purpose of this report is to present my findings and recommendations on how to naturally supplement nitrogen into the soil. The intention is that by collecting this information it will be available to you and your customers. Hopefully you will then be able to use this information to recommend a method of natural nitrogen supplementation that works best for each individual customer and their current needs as a BSI representative and farmer. I would also hope that this information would further increase your production yields and overall crop and soil health.

Research Methods

In doing my research I sought to find sources that were authoritative for the information I might find contained therein. Specifically, websites searched were limited to educational, governmental or non-profit organizations. I also used peer reviewed, scholarly journals found in JSTOR and EBSCOHost databases available through Dixie State College. Most importantly, however, I relied heavily on conversations I had with you and the research done by Dr. Jackson.

Preview of the Presentation

I begin my report by giving a brief description of the nitrogen cycle because I feel this is a critically necessary understanding to obtain in order to discover how nitrogen could be added to your soils naturally.

I then discuss the know nitrogen sources, as discovered through understanding the nitrogen cycle, and determine whether or not they are viable, controllable options.

After reviewing each possible source I conclude by giving my conclusions and recommendations based on the findings presented in the previous sections.

Nitrogen

There is much to know and understand about farming and plants. I know that you have much more knowledge on the subject than I do. However, I will attempt to reveal my findings on the importance of nitrogen to plants and farmers.

The importance of Nitrogen

As you know nitrogen is one of the essential elements necessary for healthy plants to thrive. Dr. Jackson stated in his book, "Organic Soil Conditioning;" "modified or converted nitrogen is used by plants to manufacture or synthesize amino acids, which in turn form proteins."¹ This is a critical process to all organic life. To fully understand nitrogen and its importance it is necessary to understand the nitrogen cycle.

The Nitrogen Cycle

This next section was all new to me when I started doing my research. Figure 1 in the appendix section gives a pretty good overview of how nitrogen fits into the big picture. I will try and explain it the best that I can.

Atmospheric Nitrogen

The Earth's atmosphere is made up of about 80% nitrogen. So there is a plethora of nitrogen "available", potentially, to the plants. However, atmospheric nitrogen (N₂) is in an unusable state for plants. In order to become usable, atmospheric nitrogen must "be converted" or "fixed". This fixation can occur in several different ways.

Nitrogen Fixation

The first possible method for nitrogen fixation occurs in lightning storms. The electrical charge produced by lightning induces a chemical bond between the nitrogen and water particles in the air. The result of the chemical reaction is nitrous or nitric acid.

¹ Jackson, William R. Humic, Fulvic and Microbial Balance: Organic Soil Conditioning. 1st ed. Evergreen: Jackson Research Center, 1993. Pg. 406

Similarly sunlight can cause a chemical binding between nitrogen and oxygen in the atmosphere, also creating nitric acid or nitrous. Nitrogen compounds, formed through these two methods, are then washed to the earth's surface by the rain or snow. The water, now carrying the nitrogen compounds, is then absorbed in to the soil. It is farther broken down into nitrate (NO_3^-) by nitrogen fixing bacteria in the soil.²

Another nitrogen fixation process is the application of artificial fertilizers. In this process a bond with the nitrogen and hydrogen is forced creating ammonia (NH_3), this is the most commonly converted to ammonium nitrate which is applied to the soil. Most artificial fertilizers would also need to be broken down by the bacteria to produce the necessary nitrate compound. There are concerns with this way of fixing nitrogen, however, which are discussed under the heading "Potential Problems with Commercial Fertilizers" on page 6.

The processes described above combined, however only produce about 10% of the total nitrogen that is fixed per acre per year.³

The remaining 90% is produced by nitrogen fixing bacteria in the soil that extract nitrogen from the air and fix it. This can be done through symbiotic plant/bacteria relationships in nitrogen nodules on root hairs or by non-symbiotic bacteria in the soil itself.

Organic Matter Decomposition

The final nitrogen source in the nitrogen cycle is organic matter. This could be animal waste, plant residue, or decomposing animals including micro and macro biology life forms. This organic matter usually contains high levels of nitrogen. It is broken down and fixed by bacteria in the soil and becomes ammonia and ammonium. This process is represented in figure 2 in the appendix.

All of these sources of nitrogen exist in the nitrogen cycle. Ultimately when the nitrogen compounds reach the soil, through whatever means, they are converted to nitrites (NO_2^-) and then into nitrates (NO_3^-) by the microbial life in the soil.

Some nitrates are absorbed by the plants which use them internally. The plants are eaten by animals and thus restart the cycle. Other Nitrates are considered excess and undergo the denitrifying process. Denitrifying bacteria reverse the

² IBID

³ IBID

process of nitrifying bacteria and convert nitrates back into inert nitrogen gas which is released into the air. This also brings the cycle full circle.

Excess nitrites and nitrates can also be lost by leaching. Which is to say that, because nitrites and nitrates are not bound to soil particles (because of the negative charge) they can be dissolved in the soil water and thereby follow the flow of the water. Leaching means they are lost and no longer available to the plant. This happens when the water goes below the plant roots or plows into other areas. This produces concerns of water contamination, which is out of the scope of this report.

Now that we have reviewed the nitrogen cycle I will discuss different nitrogen sources and their potential as a natural supplement to your products to promote the overall health and production of crops you treat.

Possible Nitrogen Sources

In this section I will revisit some of the information mentioned in the above section but this time in the context of whether or not the nitrogen source is a viable natural possibility for supplementation of organic farming.

As you know, and I discussed above, there are several possible nitrogen sources. Let's take a closer look at each.

Commercial/Artificial Fertilizer

Dr. Jackson gives a brief history of commercial fertilizer in chapter 9 of his "Organic Soil Conditioning" book, he states:

In 1909 the German chemist Fritz Haber discovered that nitrogen from the atmosphere could be combined with hydrogen, a forced courtship with another plentiful element, under special conditions, nitrogen and hydrogen are brought into a union of ammonia, the beginning point for the production of a wide range of nitrogen compounds.... Ammonium nitrate ($\text{NH}_4 \text{NO}_3$), a salt of ammonia and nitric acid, is the most common nitrogen component of artificial fertilizers....Artificial fertilizer production has served many crop yield benefits in the past. The industry fixes several million tons of nitrogen each year in the form of various nitrogen fertilizers.⁴

⁴ IBID Pg. 407

As Dr. Jackson mentions, commercial fertilizer has been around a while and has become very prevalent in today's farming operations. There are concerns that arise from the use of these commercial fertilizers.

Potential Problems with Commercial Fertilizers

I again refer to the words of Dr. Jackson to illustrate the concerns about artificial fertilizers. On page 408 he lists several concerns, they are:

1. Cost of production, including the excessive involvement of fossil fuel in the production process of the fertilizer;
2. Possible damage to the original microorganism base; and
3. The application of artificial fertilizer, which has been proven to contribute to potential water pollution.⁵

I think these concerns are pretty self explanatory. Along with these are other concerns. Commercial fertilizer typically causes a fast action growth spurt in plants and then less and less effect until the next application of it occurs. This seems to be a more steroid type approach. Also the benefits are short term ones. Over an extended period of time the commercial fertilizers tend to reduce the aggregation of the soil causing the soil to become more and more clay like. The soil particles start binding together and compacting until the soil is virtually unusable

We already understand these concerns which is what has caused the need for an alternative fertilization method that your company seeks to provide. I presented the above information to reiterate and confirm the fact that commercial fertilizers are not a viable nitrogen source for your field operations that are or are trying to be organically based.

Organic Matter

There are many options for nitrogen supplementation through organic matter. I will cover animal waste and crop residue.

Animal Waste

Using animal waste as a nutrient supplement has existed and been implemented for a very long time. "However not all manures are created equal and will vary depending on the animal, feed, bedding, and manure-storage practices employed."⁶

⁵ IBID Pg. 408

⁶ "Soil Health." The Natural Farmer 2.80 (Spring 2009):11-3.

Different levels of nitrogen can be obtained from different types of animal waste. Important factors to consider:

1. How much nitrogen is needed for the crop you are growing?
2. How much is available in your soil already?
3. What type of manure can provide the amount of nitrogen desired/needed?
4. How readily available is the nitrogen?

Table 1, below, illustrates the amount of nitrogen obtained from different types of manures.

Table 1. Average Nutrient Analyses (as is)* of Major Types of Manure in Oklahoma

<i>Manure Type</i>	<i>Dry Matter %</i>	<i>Total N</i> -----lbs./ton-----	<i>P₂O₅</i>	<i>K₂O</i>
Feedlot Manure	62	24	21	25
Broiler Litter	77	63	61	50
		-----lbs./1000gal-----		
Lagoon Effluent	0.5	4.2	1.0	5.0
Lagoon Sludge	7	15	16	11
Dairy Slurry	3	13	11	11

*P₂O₅ and K₂O are commonly used for fertilizer ingredients instead of P and K. Some laboratories may still report in elemental P and K content. To convert, use the following equations: K₂O = K x 1.2 or P₂O₅ = P x 2.29⁷

According to Zhang's averages broiler litter contains the most nitrogen per ton. Feedlot manure would also be a good option.

Due to the variability in nutrient content, manure analysis may be beneficial and take the guesswork out of estimating the nutrient content and characteristics of the manure....Manuring of the soil can also influence soil organic matter and fresh uncomposted manure is very effective at increasing soil aggregation.... Careful attention should be paid to the timing of application and optimizing application to meet the needs of the crop or cropping sequence.

⁷ Zhang, Hailin. "Fertilizer Nutrients in Animal Manure." OSU Cooperative Extension Service. Oklahoma State University. 23 Apr. 2009. <<http://www.poultrywaste.okstate.edu/files/f-2228web.pdf>>

Excessive or untimely application can cause plant damage and pose an environmental danger to water resources.⁸

Zhang also gives sound suggestions to know when and how much manure to apply. His works and suggestions can be found in the appendix Article 1.

Crop Residue

There are several ways to incorporate crop residue into an organic matter supplement. I will discuss cover crops and green manure crops.

Cover Crops

As described in the “Cornell Soil Health Assessment Training Manual”, cover crops provide:

...a canopy for seasonal soil protection and improvement between the production of the main crops. Cover crops usually are grown for less than one year....Cover crops have the potential for recycling nutrients which otherwise would be lost through leaching during off-season periods....Leguminous cover crops can also fix atmospheric nitrogen for the benefit of the crop that follows. Other benefits from cover crops include protection of the soil from water and wind erosion, improved soil tilth and suppressing soil-borne pathogens....Leguminous cover crops...include clovers, hairy vetch, field peas, alfalfa, and soybean while popular nonleguminous cover crops include rye, oats, wheat, oilseed radish, sudangrass, and buckwheat.⁹

Cover crops can be plowed under and used as a green manure for the production crop.

Green Manure Crops

Green manure crops are grown to add fresh, degradable organic material to the soil¹⁰ as defined in the Natural Farmer. This organic matter is then decomposed and provides nutrients, including nitrogen to the plants. These crops should be tilled into the top 6-8 inches of the soil

⁸ “Soil Health.” The Natural Farmer 2.80 (Spring 2009):11-3.

⁹ IBID

¹⁰ IBID

where most of the microbial organisms are located for maximum benefit¹¹. Elsa Sanchez at Penn State University stated, “Legume species are the best choice for adding nitrogen to the soil because they are able to establish relationships with bacteria in the soil that turn nitrogen in the atmosphere into a form that the plant can use.”¹² Elsa then lists a table showing legume crops and their nitrogen-fixing capacity. I have included it as table 2 for your reference.

Table 2

Legume Species	Nitrogen-fixing Capacity
Alfalfa	High*
Hairy vetch	High
Cowpeas	High
Crimson clover	Moderate
Field peas	Moderate
White clover	Moderate
Red Clover	Moderate
Common Bean	Low

*High = greater than 150 lb/acre/yr; moderate = 50 to 150 lb/acre/yr; low = less than 50 lb/acre/yr. Table adapted from Northeast Cover Crop Handbook.

According to this table, alfalfa, hairy vetch and cowpeas fix the most nitrogen per acre per year. These green manure crops would be a good source and natural supplement to your operations.

Another similar method to get additional nitrogen into the soil is by using a good crop rotation.

Crop Rotation

Determining a good crop rotation can be a complex endeavor to undertake. However, it need not be complex. It can be as simple or complex as you want to make it. “Crop rotations can be as simple as rotating between two crops and planting sequences in alternate years or they can be more complex and involve numerous crops over several years.”¹³

¹¹ Sanchez, Elsa. "The Organic Way - Selecting Green Manure Crops for Soil Fertility." Virginia Cooperative Extension. Virginia Tech. 3.4 (Jul. 2004). 24 Mar. 2009.

<<http://www.ext.vt.edu/news/periodicals/commhort/pulledarticles/july04-3.html>>

¹² IBID

¹³ “Soil Health.” The Natural Farmer 2.80 (Spring 2009):11-3.

There are great benefits to using a crop rotation, they include:

- Help prevent depletion of soil nutrients
- Resist pests better
- Reduce plant disease
- Reduce weed pressure
- Improve organic matter content
- Increase yield through the “rotation effect”¹⁴

These are all great benefits, the ones we are concerned about are prevention soil depletion and increased organic matter content and by extension increased soil nitrogen levels. You can achieve these benefits as you create a crop rotation plan for your customers. This plan will depend on their individual needs and abilities. In the “Natural Farmer” it was put this way, “Developing successful crop rotation sequences is farm specific and depending on the unique combination of location and climatic factors, as wells as economic and resource limitations”¹⁵

Overall I would say that using organic matter and crop rotations would be a great way to increase nitrogen levels in your soil.

Atmospheric Nitrogen

As mentioned above the Earth’s atmosphere is a great and plentiful source of nitrogen let’s review how it is turned into a usable form and see if there are ways we could use it more fully.

Lightning and Rain

I mentioned how lightning and the sun could cause nitrogen fixation and then how rain could deliver the resulting nitrogen compounds to the soil. This is a great option, however there is a reason why it is one of the smallest nitrogen contributors. This process is entirely out of our control. It would be very convenient, especially for you, if we could control the thunderstorms and rain. My only suggestion for using this nitrogen source would be to pray for cooperation. Beyond that I would say that this is not a sufficient nitrogen source option.

Nitrogen Fixation in the Soil

This source is more promising than the last as a viable supplement option. The ability to benefit from this natural process is almost wholly dependent on the number of organisms in the soil.

¹⁴ IBID

¹⁵ IBID

It is not very feasible to add organisms into the soil manually. However, you can affect the number of organisms by the other things you do to ensure soil health. Your products, the Bio-N-Liven Answer® and the Carbon Answer® are designed to wake up and stimulate the organisms in the soil. They also provide a necessary food source for the microbiology that enables them to reproduce very rapidly. I would submit that continuing to use your current products is the best option for promoting and increasing microbial activity in the soil. This will hopefully create the nitrogen-fixing, microbial army necessary to fix more and more nitrogen from the atmosphere and thus have more available to your crops.

Other things to consider for overall soil health and increased soil nutrients are:

- Maintain proper pH level
- Reduce tillage
- Control plant disease (as much as possible)
- Eliminate soil pollutants

These are all things you know about but would definitely contribute to soil health and increased nitrogen levels in the soil.

Nitrogen Fixation in Nitrogen Nodules

This would be a great way to increase nitrogen levels. But the obvious limitation is that not all plants are susceptible to the symbiotic relationships that create these wonderful little nodules. Until a way is discovered for all plants to develop nodules that fix atmospheric nitrogen you are limited to utilizing the plants that do. The plants that do this are primarily legumes that could be used as a cover crop or green manure as discussed above.

Conclusions and Recommendations

Conclusions about nitrogen sources

Here are my conclusions about the possible nitrogen sources discussed in detail above.

Potential and viable natural sources of nitrogen include:

- Manuring
- Using crop residue, either through cover crops or green manure
- Implementing a crop rotation plan

- And continuing to use your microbial life promoting products

Insufficient, not viable natural nitrogen sources are:

- Commercial fertilizers
- Nitrogen fixed by lightning or sunlight
- And nitrogen nodules on plants that cannot currently produce nitrogen nodules

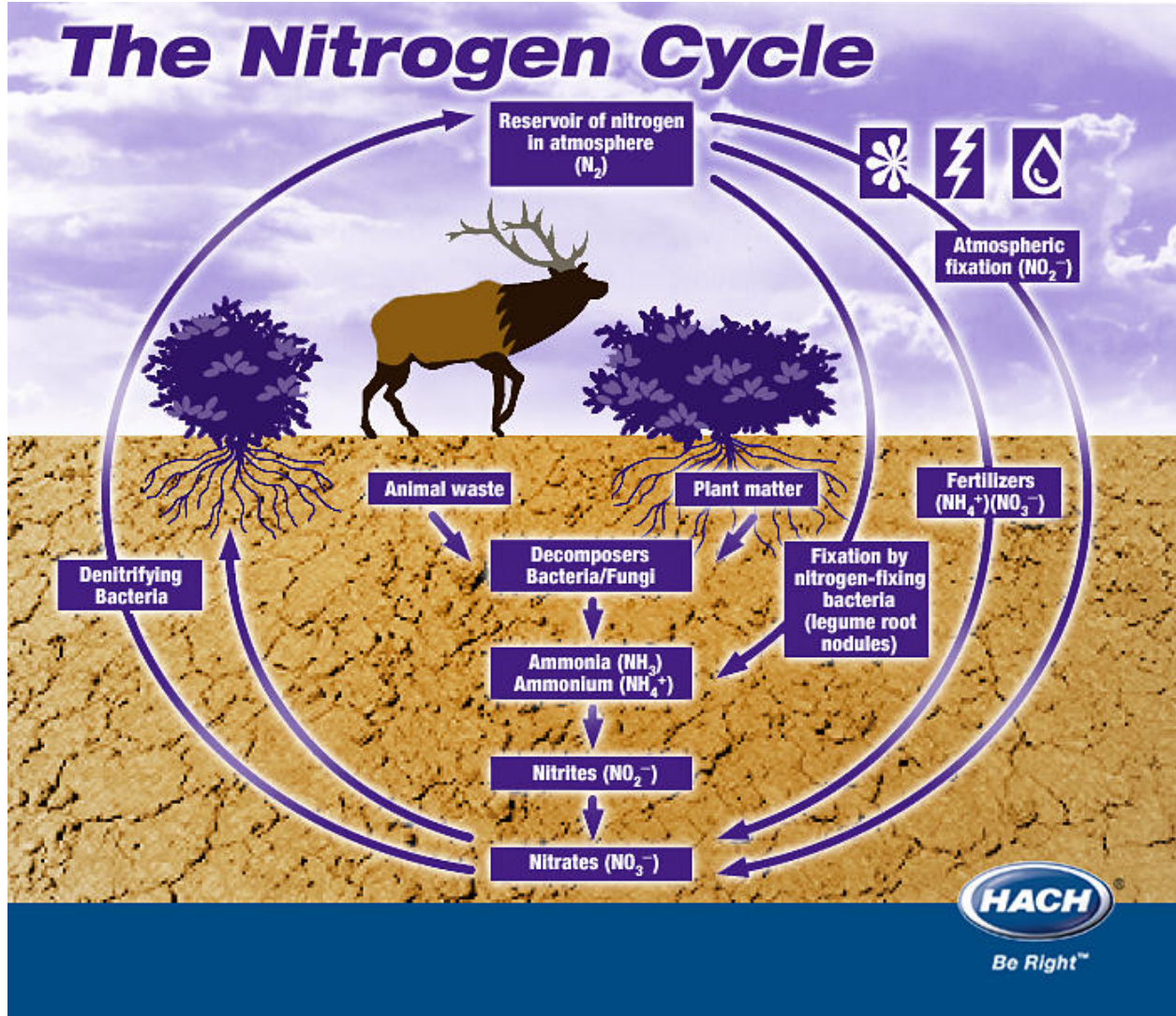
Recommended Methods

Based on the above conclusions I have developed the following recommendations.

1. Reduce and ultimately eliminate the use of commercial fertilizers if it is being used.
2. Continue to apply The Bio-N-Liven Answer® and The Carbon Answer® as you have been doing and/or according to recommendation.
3. Increase nitrogen levels in one or more of the following ways:
 - a. Apply animal waste products as a fertilizer after determining what type would best fit your needs
 - b. Consider using cover crops and green manure crops to provide added nutrients. Determine what crops will provide the benefits your operation needs and use those crops
 - c. Implement a crop rotation plan that will aid in soil health and increase deficient nutrient levels

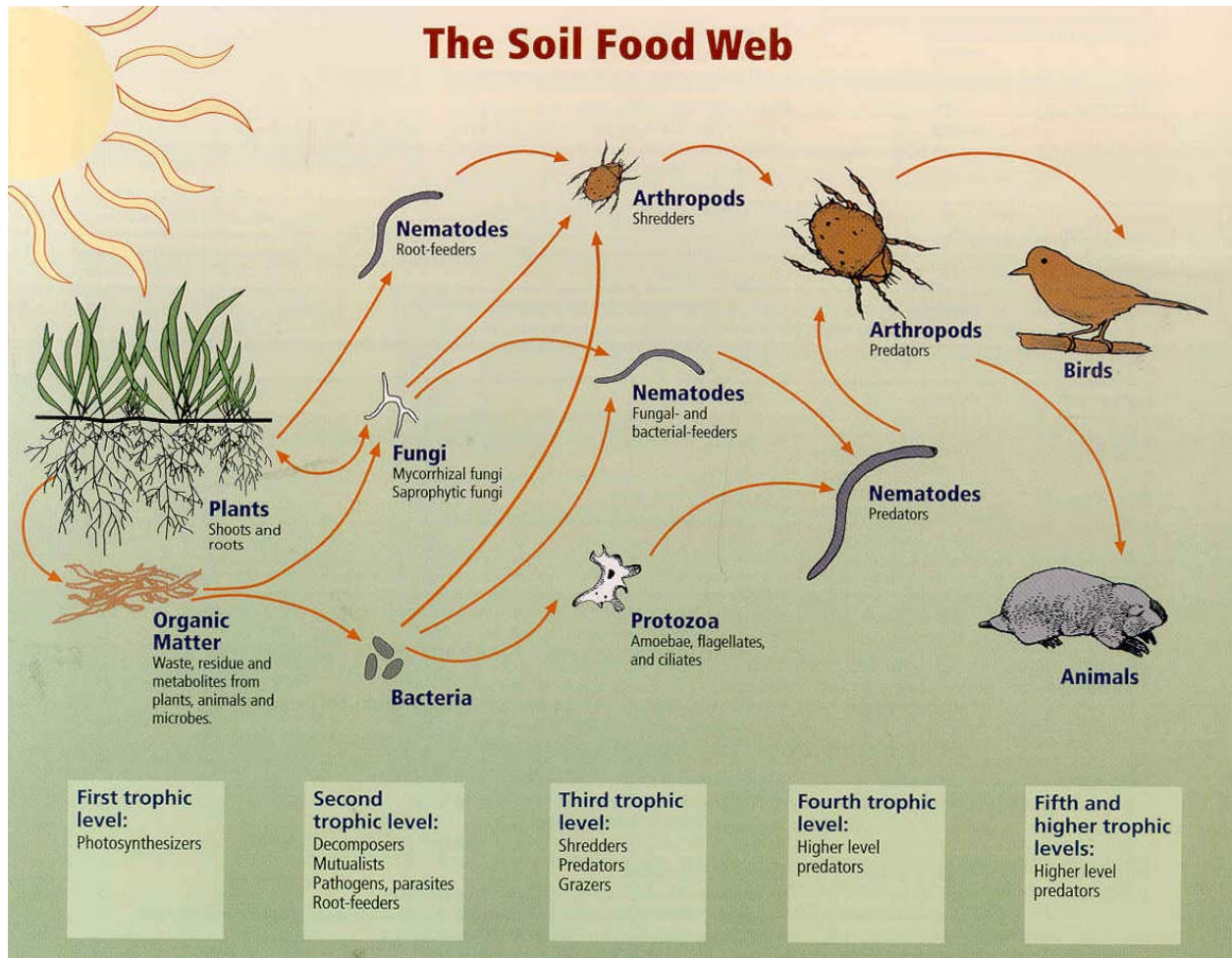
Appendices

Figure 1. The Nitrogen Cycle¹⁶



¹⁶ "The Nitrogen Cycle." H2O University. Hach Company. 16 Aug. 2006. 22 Apr. 2009. <<http://www.h2ou.com/h2nitrogencycle.htm>>

Figure 2. The Soil Food Web¹⁷



¹⁷ "The Soil Food Web." Magic Soil. 22 Apr. 2009 <http://www.magicsoil.com/MSREV2/soil_food_web.htm>



Fertilizer Nutrients in Animal Manure

Hailin Zhang

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Oklahoma Cooperative Extension Fact Sheets
are also available on our website at:
<http://www.osuextra.com>

In addition to meat, livestock and poultry operations produce another valuable commodity—manure. Manure is a by-product containing many plant nutrients and organic matter. Animal manure can be an asset rather than a liability for producers when effectively managed and properly used on field crops. Besides providing valuable macro- and micronutrients to the soil, manure supplies organic matter to improve the soil's physical and chemical properties. It also increases infiltration of water and enhances retention of nutrients, reduces wind and water erosion, and promotes growth of beneficial organisms.

Each year in Oklahoma, an estimated 10 million tons of waste produced by animals in confinement is available for use as fertilizer. This translates into tens of millions of pounds of plant nutrients and organic matter available to enrich our soil. The key to capturing the benefits of this resource is good nutrient management.

Nutrient Contents in Manure

The actual nutrient value of manure from a particular operation will differ considerably with the method of collection, storage facilities, and species of animal. The approximate

Table 1. Average Nutrient Analyses (as is)* of Major Types of Manure in Oklahoma

Manure Type	Dry Matter %	lbs./ton		
		Total N	P ₂ O ₅	K ₂ O
Feedlot Manure	62	24	21	25
Broiler Litter	77	63	61	50
		lbs./1000gal		
Lagoon Effluent	0.5	4.2	1.0	5.0
Lagoon Sludge	7	15	16	11
Dairy Slurry	3	13	11	11

*P₂O₅ and K₂O are commonly used for fertilizer ingredients instead of P and K. Some laboratories may still report in elemental P and K content. To convert, use the following equations: K₂O = K x 1.2 or P₂O₅ = P x 2.29

fertilizer nutrient content for various manures is shown in Table 1. These are average values, and a chemical analysis on each sample should be obtained before applying manure to a field.



Figure 1. Land application of animal manure recycles nutrients back to the land. It is the most economical and environmentally sound method to handle by-products in meat and milk production.

Factors Affecting Nutrient Composition in Manure

Nutrients in waste may be lost or converted to other forms during treatment or storage and handling, affecting their availability for use by growing plants. The type of animal housing system and/or waste handling method is known to affect the final nutrient composition of the waste.

Bedding and water have a diluting effect on the final nutrient concentration of waste and result in less nutrient value per ton. In addition, the type of housing and waste handling system can decrease the final nutrient composition of waste materials. For instance, there can be considerable loss of nitrogen (N) to the air, and there is a potential for runoff and leaching when animal waste is exposed to weather conditions in an open lot system. In contrast, there is considerably less N loss from a completely covered feedlot with manure pack or a liquid lagoon.

¹⁸ Zhang, Hailin. "Fertilizer Nutrients in Animal Manure." OSU Cooperative Extension Service. Oklahoma State University. 23 Apr. 2009. <<http://www.poultrywaste.okstate.edu/files/f-2228web.pdf>>

Only about 5 percent to 15 percent of the phosphorus (P) or potassium (K) is lost with various waste handling methods, with the exception of the open lot and lagoon systems. Up to 80 percent of the P in waste can settle in lagoons, making it unavailable in the liquid used for spray irrigation of cropland.

Difference Between Nutrients in Manure and Commercial Fertilizers

Plant nutrients in commercial fertilizers are mostly water soluble and readily available for plant uptake. Not all the nutrients in manure are available to crops during the year of application because some are in their organic form, while others can be lost during application. Therefore, an availability factor (percent of nutrients available) is used for rate calculations based on the amount of nutrients available during the first year. The N availability can vary from 30 to 80 percent depending on the type of manure and application method.

Most nitrogen in lagoon effluent is in the ammonium form and is more subject to volatilization loss during storage and land application. The average N available in the first year of application and in subsequent years is listed in Table 2. The greatest response from animal manure application can be obtained by promptly incorporating the waste into the soil either by injection or cultivation. The practice of injecting, chiseling, or knifing liquid animal waste beneath the soil surface minimizes N loss to air or runoff. Therefore, use a lower availability factor if manure is surface applied and not incorporated within two days. Otherwise, a higher factor can be used. The time of manure application also affects the amount of nutrient available to a crop. Higher availability is expected when manure application matches the crop nutrient uptake.

The availability of P and K in manure is considered similar to that in commercial fertilizer since the majority of P and K in manure is in its inorganic form. For all manure types, 90% of P and K is considered to be available during the first year of application and 10% for future years.

Taking Credits From Manure

Nutrients in animal manure are as effective as commercial fertilizers for improving crop production if used properly.

Table 2. Estimated Ranges of Nitrogen Availability in Animal Manure.

<i>Manure Type</i>	<i>1st Year Availability</i>	<i>Future Availability</i>
Feedlot manure	50% - 70%	10% - 20%
Poultry litter	50% - 70%	10% - 15%
Dairy manure	50% - 70%	10% - 20%
Swine lagoon effluent	30% - 50%	5% - 10%

Producers should subtract the available nutrients in the manure from their regular fertilizer program so they can reduce fertilizer cost and avoid nutrient buildup in soils. Follow these steps to take credits from manure:

- 1. Test soils:** Know what nutrients the soil already contains, including residual N, available P and K, as well as soil pH. Take soil samples before land application. A soil test report indicates the amount of nutrients that the soil can supply and recommends the amount needed from other sources.
- 2. Analyze manure:** Take samples before spreading manure. Results should include dry matter contents as well as N, P, and K contents.
- 3. Determine when to apply:** Applying manure just before planting or at peak growing stages gives plants the best chance to use the nutrients. It also reduces the chance of nutrient runoff.
- 4. Determine how much to apply:** To best calculate application rates, balance the nutrient levels in the soil and manure with the needs of the crop. This will ensure you apply enough nutrients for your yield goal but not more nutrients than the crop needs.
- 5. Calibrate manure spreader:** By calibrating the equipment, you can guard against applying too much or too little manure per acre. Too much manure may be harmful to the water supply, and too little could hurt crop yields.
- 6. Use supplemental fertilizer as needed:** Extra N may be needed if application rates are based on P. Phosphorus and K can build up in the soil if manure is used to meet the N needs of a crop.
- 7. Consider conservation measures:** Maintaining grass waterways, buffer strips, and other water quality practices will help prevent nutrients from reaching nearby water supplies.
- 8. Review nutrient management plan frequently:** As the operation changes, so will your nutrient needs. Changes in land use, numbers of livestock, feeding programs, and application methods all affect the amount of nutrients available for crop use.

Other Related Extension Publications

- F-1734 - What is a Waste Management System?
- F-1736 - Lagoons for Livestock Waste Treatment
- F-1739 - Movement of Odors Off-Farm
- F-1740 - Measuring Farmstead Odors
- F-2207 - How to Get a Good Soil Sample
- F-2225 - OSU Soil Test Interpretations
- F-2236 - Knowing When to Fertilize
- F-2245 - Using Lagoon Effluent as Fertilizer
- F-2246 - Using Poultry Litter as Fertilizer
- F-2248 - Sampling Animal Manure
- F-2249 - Managing Phosphorus From Animal Manure
- F-2250 - Using Stockpiled Feedlot Manure as Fertilizer
- F-2251 - Selecting Forages for Nutrient Removal from Animal Manure

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