Soil Fertility Management

Adding livestock manure, either from animals on the farm or purchased nearby, is a common practice on fields in the Midwest. Eventually, that organic material breaks down and becomes stable soil organic matter (SOM). Good SOM levels allow less use of purchased fertilizer and other purchased soil amendments. Good SOM levels also help drought-proof the soil. SOM is like a sponge: it absorbs up to six times its weight in water (1). Increasing SOM helps the soil retain and hold water that can be used by crops.

It does make a difference whether manure or synthetic fertilizers are used to manage soil fertility. According to the Leopold Center for Sustainable Agriculture at Iowa State University, "Manure is a biologically active substance; synthetic fertilizers are not. Since soil is a living system itself, with millions of living organisms in each spoonful, it will react better to manure than to synthetic fertilizers (2)." Synthetic fertilizers are produced using fossil

Your Living Soil

Healthy soil includes:

Minerals – bits of sand (coarse), silt (finer), and clay (finest)

Organic matter – carbon-based materials that come from the breakdown of plant, animal, and microbial matter.

Humus – Organic matter that has been thoroughly broken down and changed by passing through microbes or by chemical reactions in the soil. Humus is how soils store carbon.

Roots – The healthiest soils are those that have living plants on them all the time. (Including winter! Dormant plants are still alive!) Living roots wind through spaces between soil particles and larger soil clumps called "aggregates," and help bind those clumps together.

Living organisms – Healthy soil is home to an entire unseen network of:

- Bacteria
- Fungi
- Protozoa (microscopic animals)
- Earthworms and other worms called nematodes
- Arthropods: millipedes, mites, beetles, spiders, ants

The sheer number of organisms in soil is hard to imagine: healthy soil contains 100 million to 1 billion bacteria per teaspoon. The living things in the soil feed on dead plant and animal material, living plant roots, and each other. In the process, they release nutrients that can be taken up by plants.

Reference:

***Soil Biology Primer* [online].** Available: http://soils.usda.gov/sqi/concepts/soil_biology/biology.html (accessed 5/21/13)

fuels, so if reducing fossil fuel use is an important part of the vision for the future of your farm, then encouraging use of manure for fertility is an important option to consider. Manure produced by large confined animal feeding operations (CAFOs) and by small farms can become a problem and a pollutant unless it is spread on land as a fertilizer, using good management techniques. Encouraging use of manure as fertilizer is a way to turn a potential pollution problem into a good resource for crop production.

Manure application is something that many cash grain farmers choose not to do because it takes different equipment and requires more labor and management than use of purchased synthetic fertilizer. Synthetic fertilizer has specific, known amounts of each nutrient in it. Manure is more variable, so farmers who use it need to get it tested to learn the nutrient levels and then make calculations of the amount of manure needed. Sometimes synthetic fertilizer may be needed in addition to the manure, to balance the levels of each nutrient needed by the crop that will be grown. That means the farmer may need to run two different sets of equipment across the fields, to apply the manure and the synthetic fertilizer.

Nutrients in Manure

The example manure application rate shown in this table is based on liquid swine manure. Manure used on your land might be a different type (solid instead of liquid), or from a different livestock species. Those things will change the calculations of how much manure should be used and the cost of application. See the references listed below to find information that matches the type of manure your farm will use.

In our example:

- The manure used is liquid manure from finishing swine, which has an estimated average nitrogen content of 58 lbs. per 1,000 gallons of manure (1).
- Corn nitrogen needs per acre range from 130 lbs. to 180 lbs.; we kept to the low side of that at around 140 lbs. of nitrogen per acre (1).
- 80% of the nitrogen applied in liquid swine manure is available to the crop in the first year that the manure is applied, if sweep injection technique is used for manure application(1).

continued on next page ...

Nutrients in Manure, continued (pg. 2)

The calculations:

- 3,000 gallons of manure x 58 lbs./1,000 gallons = 174 lbs. of nitrogen applied in manure.
- 80% availability, so 174 x 0.8 = 139.2 lbs. of nitrogen/acre available to corn crop.
- Cost of application: liquid injection method at $11.90/acre(2), so cost for 3,000 gallons/acre = $35.70/acre.

Value of nutrients in liquid manure from finishing swine, per 1,000 gallons of manure; in 2012 dollars.			
	Nitrogen	Phosphate (phosphorus)	Potash (potassium)
$/lb. of commercial fertilizer (3)	$0.60	$0.72	$0.54
Lbs. of nutrient/1,000 gallons of manure (1)	58	44	40
$ value/1,000 gallons of manure	$34.80	$31.68	$21.60
Total value of 1,000 gallons of manure to supply nitrogen, phosphorus, and potassium to a crop: $34.80 + $31.68 + $21.60 = $88.08			

References:

(1) **Manure Management in Minnesota.** 2012. Jose Hernandez and Michael Schmitt. University of Minnesota Extension publication # 03553. www.extension.umn.edu/distribution/cropsystems/DC3553.html.

(2) **2013 Iowa Farm Custom Rate Survey**. March 2013. William Edwards, Ann Johanns, and Andy Chamra. In *Ag Decision Maker*, Iowa State University Extension and Outreach. www.extension.iastate.edu/agdm/crops/pdf/a3-10.pdf

(3) **Fertilizer Use and Price**. Reports from the Economic Research Service, USDA. www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx#26727. (accessed 6/11/13)

How can a landowner make it possible for future landowners or operators to use manure for fertilizer? Using manure is generally cheaper overall than using synthetic fertilizer, so manure use is not likely to be a financial burden for the farmer. In a few cases, the distance to a source of manure may raise transportation costs to the point that its use is not feasible. The main drawback to manure is the time and management effort that the farm operator needs to invest in it. Synthetic fertilizer doesn't take as much time and management.

As with crop rotation, the choice to use manure depends partly on the determination of the landowner and the farm operator to use it. Both farm operator and landowner need to understand the benefits of manure use and agree to use it on the farm. The landowner may consider giving the farm operator a credit for the manure management efforts that contribute to long-term soil health. Specifying manure use can be accomplished through lease terms, and can be done with either an annual cash rental situation or a longer-term lease. See Conservation Financing for more details about lease terms.

Manure Management & Application			
	- Column	**+ Column**	
Qualitative Benefits of the Practice	**Cost of Implementation and Potential Income Loss**	**Potential Income Gain and Reduced/Avoided Costs**	**Your Judgment: Value Per Acre of This Practice on Your Land**
Encourages soil biological activity Provides a useful purpose for livestock manure, which could otherwise become a pollutant Raises soil organic matter levels and increases water-holding capacity of soil Avoids purchase of commercial fertilizers that are produced using fossil fuels	Application cost for liquid swine manure, about $36/acre *(See Nutrients in Manure text box)*; possibly higher if long haul distance. Manure testing, $27 for basic nitrogen, phosphorus, & potassium test; 1 or 2 tests/season (3) . Management time to collect and send in samples, calculate crop nutrient needs and manure quantities required: estimate at $20/hour and half an hour per field. Cost of manure purchase: frequently zero; cost is in getting it hauled and spread. Odor; personal value judgment on how offensive the manure odor is when it's being pumped and applied.	$15.70/acre/year of nitrogen, phosphorus, potassium, and sulfur for each 1% of soil organic matter; it takes about a decade of regular manure application to raise the SOM by 1%. (*See Value of Soil Organic Matter textbox)* $88.08 approximate value of the nitrogen, phosphorus, and potassium in 1000 gallons of manure *(See Nutrients in Manure text box)*. This is an avoided cost: you don't buy this amount of commercial fertilizer because you have the nutrients in the manure.	Costs avoided: + Costs to pay: - Your judgment on value to your farm of qualitative benefits: + Value to society or environment: + Add up the total net value per acre per year: Multiply by a time frame (5 years? 10 years?) Total value over time:

References:

(1) **Organic Matter Management**. In The Soil Management Series. Revised 2008. Ann Lewandowski. www.extension.umn.edu/distribution/cropsystems/components/7402_02.html (accessed 6/11/13).

(2) **Frequently Asked Questions about Cropping System Diversity and Profitability.** [online] Leopold Center for Sustainable Agriculture, Iowa State University. www.leopold.iastate.edu/faq-cropping-system-diversity-profitability. Accessed 6/10/13.

(3) **Dairyland Laboratories Manure Packaging & Pricing.** https://www.dairylandlabs.net/pages/m_packaging_pricing.php

Further Resources:

Soil Health, Profits & Resiliency. This Land Stewardship Project web page features ways Midwestern farmers are building soil organic matter and other biological attributes of their soils using cover crop cocktails, managed rotational grazing, perennial plant systems and no-till agriculture.
www.landstewardshipproject.org/stewardshipfood/soilquality

Sustainable Soil Management. 2004. Preston Sullivan. Appropriate Technology Transfer for Rural Areas (ATTRA).
https://attra.ncat.org/attra-pub/summaries/summary.php?pub=183
This publication covers basic soil properties and management steps toward building and maintaining healthy soils. It contains answers to why soil organisms and organic matter are important.

Drought Resistant Soil. 2002. Preston Sullivan. Appropriate Technology Transfer for Rural Areas (ATTRA).
https://attra.ncat.org/attra-pub/summaries/summary.php?pub=118
To minimize the impact of drought, soil needs to capture the rainwater that falls on it, store as much of that water as possible, and allow for plant roots to penetrate and proliferate. These conditions can be achieved through management of organic matter.

Soil Health. 2010. John Lamb, Sheri Huerd, and Kristine Moncada. In *Organic Risk Management*, Editors Kristine Moncada and Craig Sheaffer. University of Minnesota. www.organicriskmanagement.umn.edu/soil_health.pdf (accessed 8/30/13)
This online manual is intended as a guide for organic and transitioning producers in the Upper Midwest, but it includes a lot of good basic agronomy and soil science information that is useful for non-organic farmers as well.

Soil Fertility. 2010. John Lamb, Kristine Moncada, and Craig Sheaffer. In Organic Risk Management, Editors Kristine Moncada and Craig Sheaffer. University of Minnesota. www.organicriskmanagement.umn.edu/soil_fertility.pdf (accessed 8/30/13)
This online manual is intended as a guide for organic and transitioning producers in the Upper Midwest, but it includes a lot of good basic agronomy and soil science information that is useful for non-organic farmers as well.

The Cost of Soil Erosion. January 2013. Iowa Learning Farms, Iowa State University Extension and Outreach.
www.extension.iastate.edu/ilf/sites/www.extension.iastate.edu/files/ilf/Cost_of_Eroded_Soil.pdf (accessed 8/30/13).
Erosion costs the landowner because of lost farmland productivity and potentially decreased land sales price. This study is reported by the Iowa Learning Farms, which is a joint project of many of the agricultural organizations in Iowa; including Iowa State University, the Leopold Center for Sustainable Agriculture, and the Iowa Department of Agriculture and Land Stewardship.

Value of Soil Organic Matter

Increasing the Soil Organic Matter (SOM) in a typical acre by 1% can increase that acre's worth due to the nutrients stored in that organic matter. Soil organic matter releases nitrogen, phosphorus, potassium, sulfur, and carbon as it gradually breaks down, so every year, every 1% of SOM is a source of approximately $15-worth of nutrients that are available to plants.

It does take time to increase SOM. It takes about 10 pounds of added organic material to eventually break down and become one pound of soil organic matter. You would need 200,000 pounds of manure per acre, applied at smaller annual rates over a period of at least 10 years, to raise the SOM level of a typical soil by 1%.

This increase in SOM could happen faster if the crop residues were incorporated back into the soil, but even then, it would require a number of years. Building SOM depends on the living creatures in the soil, and it is a gradual process. You can't force it to happen faster by adding excessive manure at one time -- that just puts all of the nutrient levels out of balance and kills off the life in the soil that is needed to break down the manure. Over-application of manure could also be a pollution hazard.

Calculating the value of SOM:

Soil organic matter decomposes and releases nutrients at different rates depending on the texture of the soil, temperature, moisture, tillage, and other factors. Using an estimate from Minnesota of 3% SOM in the soil and a 2% annual decomposition rate (1), along with SOM nutrient level estimates from The Ohio State University Extension (2), the following table shows nutrients contained in the SOM and nutrients that become available to plants each year from the SOM.

Nutrient	Total amount per acre contained in 3% SOM*	Total amount available per acre per year with 2% annual decomposition of SOM
Nitrogen (N)	3,000 lbs.	60 lbs.
Phosphorus (P)	300 lbs.	6 lbs.
Potassium (K)	300 lbs.	6 lbs.
Sulfur (S)	300 lbs.	6 lbs.

*An acre of soil, 6 inches deep, weighs an average of 2,000,000 lbs. At 3%, the total SOM would be 60,000 lbs. This is assumed to be 50% carbon, and SOM typically has a 10:1 ratio of carbon to nitrogen, so nitrogen would be 5% of the total SOM. (1,2)

Value of Soil Organic Matter -- continued (pg 2)

Using fertilizer prices from 2012 (3,4), the SOM-supplied nutrients would have the following value per acre per year:

Nutrient	Lbs. supplied by SOM, per acre per year	Value/lb. in 2012 dollars (3,4)	Total value from SOM per acre per year
Nitrogen (N)	60	$0.60 (applied as urea)	$36
Phosphorus (P)	6	$0.72	$4.32
Potassium (K)	6	$0.54	$3.24
Sulfur (S)	6	$0.59	$3.54
TOTAL value of plant nutrients from 3% SOM, per acre per year:			$47.10

The SOM releases approximately these levels of nutrients every year, so over a 10-year period the value of 3% SOM is about $470 per acre.

Increasing SOM percentage in the soil will increase the amount of nutrients available from SOM. Based on the numbers in the tables above, a 1% increase in SOM would deliver:

$47.10/acre/year for 3% SOM, divided by 3 = $15.70/acre/year for each 1% SOM

References:

(1) **Organic Matter Management**. In *The Soil Management Series*. Revised 2008. Ann Lewandowski. www.extension.umn.edu/distribution/cropsystems/components/7402_02.html (accessed 6/11/13).

(2) **Understanding Soil Microbes and Nutrient Recycling**. 2010. James J. Hoover and Rafiq Islam. The Ohio State University Extension. www.northcentralsare.org/Educational-Resources/Project-Products/Understanding-Soil-Microbes-and-Nutrient-Recycling (accessed 6/11/13)

(3) **Fertilizer Use and Price**. Reports from the Economic Research Service, USDA. www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx#26727. (accessed 6/11/13)

(4) **2012 Sulfur Fertilizer Price Comparison for Alfalfa**. April 2012. Carrie Labowski, University of Wisconsin. http://ipcm.wisc.edu/blog/2012/04/2012-sulfur-fertilizer-price-comparison-for-alfalfa/. (accessed 6/11/13)