Soil Organic Amendments: How Much is Enough?

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Introduction

It is a common misperception that increasing soil organic matter (SOM) by addition of soil amendments is always a good practice. It is not a good practice if the amendments create excessive nutrient concentrations in soils and cause pollution of surface and ground water with nitrate and phosphorus.

Discussions with farmers, especially organic vegetable farmers, about management of SOM have resulted in the creation of the list below of the five most common misperceptions about SOM management.

1. Increasing SOM is always a good practice. False. Like the nutrient content of soils, SOM should only be increased if there is a need to increase it.

2. Soil organic matter content should be a minimum of some value, usually 3% or 5%. False. Soil organic matter content should be the content that provides optimum fertility and tilth – no more no less.

3. The greater the SOM content of the soil the better manager the farmer is. False. A soil with 3% SOM would pollute the environment if the native SOM content was 1%, and the 3-fold increase was caused by additions of manure-based compost.

4. Compost can never be applied in excess. False. Compost applied at rates commonly recommended often creates excess nitrate and phosphorus in soils.

5. Managing the fertility of a soil is easy, you only have to feed the soil carbon in the form of organic amendments and the soil microorganisms will manage the nutrient flow for you. False. If you supply the microorganisms with excess organic matter, they will supply excess nutrients.

The remainder of this article is formatted as a series of questions that provide details about the five common misperceptions noted above and information about how to manage soil organic matter to ensure that excessive amounts of nitrogen and phosphorus are not added to the soil.

Why increase SOM?

Soil organic matter is the main storehouse of nitrogen and micronutrients in the soil and increasing SOM improves aeration, water- and nutrient-holding capacity, and biological activity in soils.

Is increasing SOM always a good practice?
No. Increasing SOM on soils that already have a history of applications of organic amendments may not be a good practice.

What problem can be caused by adding excessive amounts of organic amendments to a soil?
Recommended rates of many commonly applied organic amendments often create excessive amounts of nitrate and phosphorus in the soil.

What problems are created by excess nitrate and phosphorus in soils?
Excess nitrate and phosphorus can contaminate ground water by leaching, and excess phosphorus in soils can contaminate surface water by runoff. Nitrate in excess of 10 parts per million in drinking water is a human health concern, and phosphorus that enters lakes and ponds can cause algal blooms that consume oxygen and kill fish and other aquatic organisms. The cost and labor to apply the excess nitrogen and phosphorus will also reduce your profits.

What rates of application of organic amendments accumulate nitrate and phosphorus in soils?
It is impossible to answer this question without knowing the type of organic amendment applied. It is important to differentiate among organic amendments based on their nutrient content. Poultry-based compost is quite different in its nitrogen and phosphorus content compared with leaf-based compost. Much less poultry-based compost can be applied to a soil before excess nitrate and phosphorus accumulates compared with a leaf-based compost.

How do I manage SOM without accumulating excess nitrate and phosphorus?
Testing your soil for phosphorus is the best way to monitor the nitrate and phosphorus content of your soil as you increase SOM. The soil test phosphorus value will reflect the amount of nitrogen and phosphorus contained in the organic amendments you apply to increase SOM. When the soil test phosphorus is optimum, you should apply only the amount of phosphorus removed by the crop, which usually means applying extremely low rates of organic amendments or applying the organic amendments only every few years. In most soils, excess nitrate will not accumulate if the soil test phosphorus value is optimum.

How do I ensure that increasing SOM does not create excess nitrate in the soil?
Test your soil for nitrate June through November. Sample the surface 1-foot layer of soil when crops are small and not removing much nitrate from the soil. For example, when corn is 6 to 12 inches tall or immediately before a vine crop begins to run. If the soil nitrate-N concentration is greater than 25 parts per million, your soil is producing excess nitrate.

What types of organic amendments are commonly applied to soils?
The most commonly applied organic amendments are manures and composts. The most commonly applied amendment for organic vegetable production is compost. The type of organic amendment applied greatly influences the amount of the amendment you can apply. We will use compost as an example of how different types of compost effect the amount you can apply.

How should you differentiate among composts?
The materials used to make compost greatly influence the nitrogen and phosphorus content. If you do not know the nitrogen and phosphorus content of your compost, you can use our rules-of-thumb shown below to estimate the content of your compost.
Low-P compost is typically made from only leaves and usually contains about 0.1% N and 0.05% P_2O_5.

Medium-P compost is typically made from dairy manure or landscape wastes such as grass clippings, garden waste, kitchen scraps and leaves. Medium-P compost usually contains about 1.0% N and 1.0% P_2O_5.

High-P compost is typically made from poultry manure and can contain up to 2.0% N and 2% P_2O_5.

How do I know for certain the nitrogen and phosphorus content of organic amendments?
Analysis of compost for the nitrogen and phosphorus content is the best way to know how much compost to apply. Compost can be analyzed by contacting your state soil testing laboratory. If they do not analyze compost, the lab will know where to send a sample for analysis.

How much nitrogen and phosphorus can accumulate in soils by application of 34 tons/acre of compost?
Large amounts can accumulate in only a few years. Table 1 shows the amounts of nitrogen and phosphorus that accumulate from application of 34 tons/acre of compost.

Table 1. Nutrient accumulations in the soil (pounds/acre) from application of low-P, medium-P and high-P compost at 34 tons/acre for 1, 5 and 10 years. Values in the table are adjusted for crop removal of 150 lbs N/acre and annual crop removal of 15 lbs P_2O_5/acre.

	Nitrogen			Phosphorus		
	Application of 34 tons/acre(or ½-inch thick or 68 cubic yards/acre)					
	% Nitrogen			% Phosphorus (P_2O_5)		
Years	0.1%	1.0%	2.0%	0.05%	1.0%	2.0%
	lbs nitrogen/acre			lbs P_2O_5/acre		
1	-246	61	197	19	665	1,345
5	-196	185	445	95	3,325	6,725
10	-160	275	625	190	6,650	13,450

Annual crop removal of phosphorus is cumulative. Crop removal for nitrogen is not cumulative; 150 lbs/acre subtracted only from years 1, 5 and 10. The subtraction accounts for the average amount of nitrogen and phosphorus removed from the soil by the plant parts typically harvested as vegetables. Assumes a 20:10:5 percent decay of the organic nitrogen in the compost.

What amount of accumulation of nitrogen could cause environmental problems?
Accumulation of any amount of nitrogen could cause environmental problems.

What amount of accumulation of phosphorus could cause environmental problems?
Accumulation of greater than about 1200 pounds of P_2O_5/acre would increase the soil test phosphorus value into the above optimum range for most soils. Soils test above optimum have a much greater potential for loss of phosphorus to ground and surface water

Why do compost applications rapidly accumulate nitrogen and phosphorus in soils?
Most crops remove little nitrogen and phosphorus from the soil in relation to the amount applied in a typical application of compost. Table 2 shows the typical amounts of nitrogen and P_2O_5 removed by harvest of the edible plant parts of popular vegetables. We assumed that you only remove the edible plant part. For example, the tomato fruit is removed and eaten and the tomato vine is made into compost that is returned to the soil.

Table 2. Nutrient removal (pounds/acre) by harvest of typical garden vegetables.

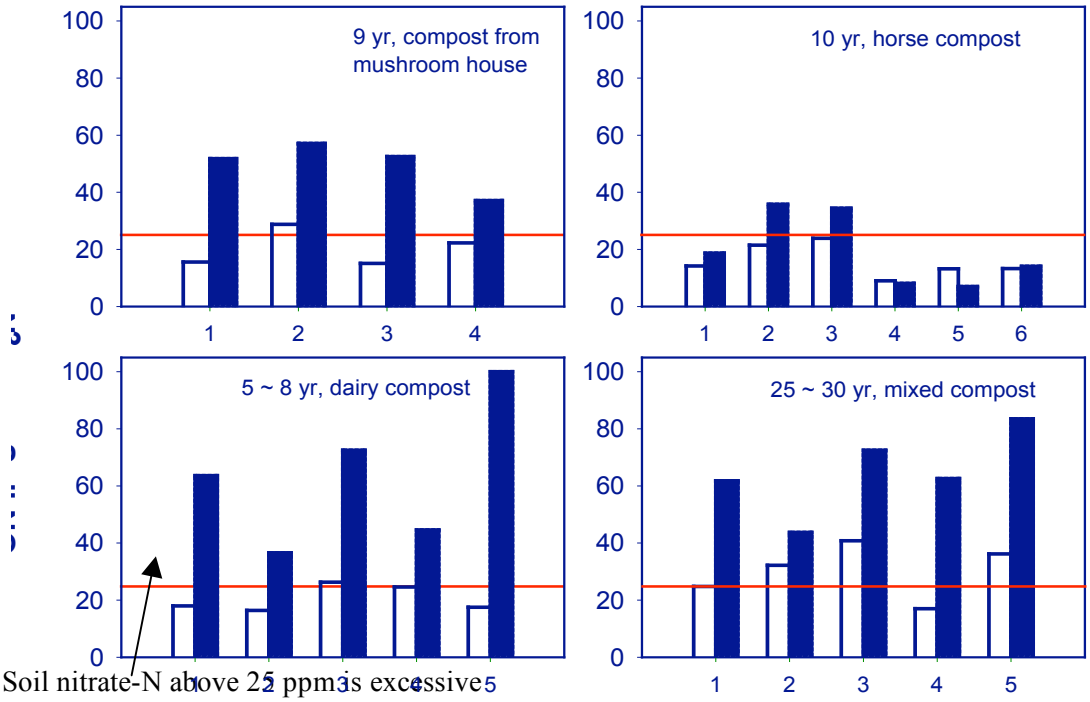
Crop	Nitrogen	Phosphorus (P_2O_5)
	lbs/acre	
Tomato	180	21
Sweet corn	155	20
Broccoli	165	10
Pepper	140	12
Lettuce	95	12
Average	150	15

Don't most organic amendments, like compost, release their nitrogen slowly so that accumulation of excess nitrate is not a problem?
Nitrogen in compost is almost all organic nitrogen, which is slowly released. But, application of too much compost can cause excessive nitrate concentrations in soils.

Why don't the microorganisms in the soil release the correct amount of nitrate for optimum plant growth when decomposing organic amendments?
The microorganisms respond to nutrient supply, temperature and moisture in the soil. They do not respond to the nutrient demands of the crop. The greater the amount of nutrients supplied in organic amendments, the greater the number and diversity of microorganisms in the soil. If the soil temperature and moisture are optimum for microorganism growth, they will decompose the maximum amount of SOM possible for the conditions you create in the soil. If you add excess organic nitrogen, the microorganisms will create excess nitrate.

What proof is there that organic amendments applied at typical rates create excessive concentrations of nitrate in soils?
Figure 1 shows soil nitrate concentrations at two organic vegetable farms in Connecticut and two in Massachusetts. The data for these four farms are part of a survey of the nutrient status of organic vegetable fields in the Northeast. Soil samples were collected from 34 farms and greater than 200 fields in 5 states from 2002 to 2004. The types and rates of compost applied in the fields shown below were similar to the types and rates applied to other fields in the survey. Most of the fields in the survey received compost as the main nutrient source. Most of the fields at the four farms shown in Figure 1 had excessive soil nitrate-N in 2004. Excessive soil nitrate-N is defined as soil nitrate-N concentrations greater than 25 ppm in June, which is when these soil samples were collected.

Figure 1. Soil nitrate-N concentrations in vegetable fields with various compost applications at four farms in June 2002 (clear bars) and June 2004 (filled bars)



Soil nitrate-N above 25 ppm is excessive

Why do most of the fields shown in Figure 1 in 2004 have excess nitrate?
In 2004 the nitrate produced by the soil from this year's and previous year's compost applications was not leached from the soil because of below-normal rainfall. The excess nitrate was probably leached from the soil by rainfall in the fall when the soil would most likely become saturated with water.

Why do most of the fields shown in the four graphs in Figure 1 in 2002 have adequate or low soil nitrate.
In 2002 the nitrate produced by the soil from this year's and previous year's compost applications was leached from the soil in May and early June by the above-normal rainfall. Most of the nitrate produced by the soil in May and June 2002 probably moved to ground water, so there was little nitrate in the soil in June.

Why are the fields at Farm 2 in Figure 1 lower in nitrate-N concentrations than the fields at the other three farms?
At Farm 2 the compost was made from horse manure, which usually has low nitrogen content and more carbon from sawdust or straw in the manure compared with compost made from other manures. Horse manure compost often has lower nitrogen availability than other types of compost. This is a good example of how the type of compost can have a large effect on the amount of nitrogen and phosphorus in the soil.

Recommendations for increasing SOM by applications of organic amendments

What is the best way to ensure that I do not increase SOM too much?
Test your soil for phosphorus annually by submitting a soil sample to a laboratory for a routine soil analysis for nutrients. Apply low rates of organic amendments, fewer than 15 tons/acre, until soil test results indicate the phosphorus level is optimum. Stop applying organic amendments when the soil test is optimum for phosphorus. Never apply more than ½-inch of a high-P amendment like a poultry-based compost.

Do different organic amendments require different application rates?
Yes. Organic amendments vary greatly in their nitrogen and phosphorus content. For example, composts made from manures or yard wastes are much higher in nitrogen and phosphorus content than composts made from only leaves with no manure added. If soils are in poor condition, adding leaf compost will increase organic matter but should not add excess nitrogen and phosphorus. Be careful, however, because the addition of composts with low nitrogen content like a leaf compost or an organic amendment like peat moss can create a temporary (1-4 week) nitrogen deficiency in the soil.