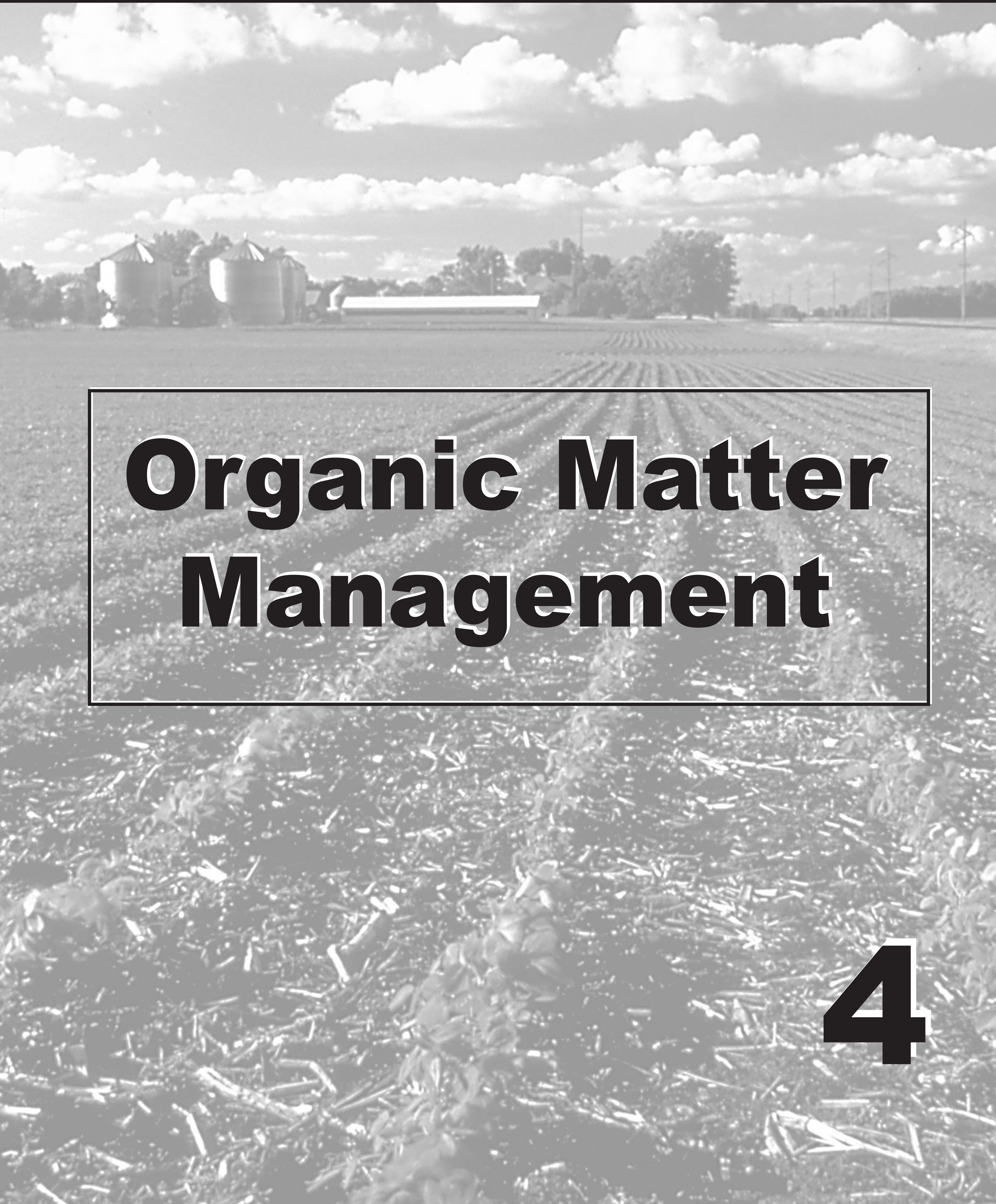
The Soil Management Series

Organic Matter Management



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THE SOIL MANAGEMENT SERIES:

Publications to help you get more from your soil

Whether you grow a few acres of vegetables for local markets, or two thousand acres of corn and soybeans for international markets, you depend on top performance from your soil. The Soil Management series is aimed at improving soil performance. Because each farm is unique, the series will not tell you the "best way" to manage your soil. Only you can decide that. Instead, it will help you make more effective use of recommendations from the university, consultants, and other advisors.

Agronomic recommendations are typically made for broad climatic regions or soil types, but farmers are increasingly interested in fine-tuning and customizing management practices to fit their unique situation and variability across the land. One example of this trend is precision agriculture technology. The goals of a "fine-tuning" approach to land management are to use resources more efficiently, improve profits, and preserve the profitability and health of the land into the future. To fine-tune agronomic practices, farmers need to monitor the variation across the land from year to year, treat different parts of each field differently, and perhaps run personalized experiments to learn what works best on an individual farm.

This series will help by providing the background science needed to monitor soil and to understand how you can modify general recommendations to suit the needs of your farm. Each publication consists of the following sections that feature basic information, practical applications, and places to look for more help:

THE SOIL MANAGER —explains management options for improving your soil.

THE SOIL SCIENTIST —reviews the soil science principles that are important to production agriculture.

YOUR FARM —helps you apply what you are reading to your own farm.

WHAT'S NEXT? —wraps up the chapter by helping you assess your operation and soil.

FURTHER RESOURCES —lists people and publications to consult for more information.

Titles in the Soil Management Series include:

1) Soil Management (BU-7399)
2) Compaction (BU-7400)
3) Manure Management (BU-7401)
4) Organic Matter Management (BU-7402)
5) Soil Biology and Soil Management (BU-7403)

Copies of the individual titles and the complete series (PC-7398) can be ordered from the University of Minnesota Extension Service Distribution Center, 405 Coffey Hall, 1420 Eckles Avenue, St. Paul, MN 55108-6068. To order by e-mail: order@extension.umn.edu
or by credit card: (800) 876-8636.

Organic Matter Management

WHY MANAGE SOIL ORGANIC MATTER?

If you were looking for productive farmland, you would want an ideal soil in which:

- crops would thrive, even through dry spells,
- roots would grow extensively,
- implements would pull easily, and
- the soil would resist erosion and compaction.

In other words, you would look for soil with high organic matter levels. Soil organic matter, and the soil organisms that live on it, are critical to many soil processes. It allows high crop yields and reduced input costs.

Yet some farmers neglect this valuable resource by tilling excessively or by not regularly adding back organic matter. Here is part of what happens to soil performance when organic matter levels decline.

Soil texture	If organic matter decreases from	Nutrient holding capacity may decrease by	Available water holding capacity may decrease by
loamy sand (5% clay)	2% to 1.5%	14%	12%
silt loam (20% clay)	4% to 3.5%	4%	7%

What are you doing to your soil organic matter?

Building soil organic matter may be the most important thing you can do to enhance long-term soil performance. This publication will help you understand the dynamics of organic matter and will examine how you could improve soil organic matter on your farm.

HOW DO I BUILD UP ORGANIC MATTER?

Increasing organic matter levels requires three angles of attack:

1) Add organic material.

2) Reduce losses.

3) Manage the new dynamics of the system.

1) Add organic matter

✔ **Grow** more organic matter. Plan a high residue rotation that includes:

- sod crops that leave lots of roots in the soil (small grains or forages),
- crops that leave a lot of surface residue (e.g., grain corn),
- cover crops that supply both.

✔ **Apply** livestock manure. Manure is an excellent way to build organic matter. See *Manure Management* (BU-7401 in this series).

✔ **Locate** off-farm sources of organic matter, such as food processing wastes or manure from neighbors.

2) Reduce organic matter losses

✔ **Reduce tillage.** Merely maintaining soil organic matter levels is difficult if soil is intensively tilled (such as with annual use of a moldboard plow.) Reducing tillage means leaving more residue, and tilling less often and less intensively than conventional tillage. No-till is the most extreme version of reduced tillage, but is not desirable on some soils and is not the only way to conserve soil organic matter.

✔ **Control erosion.** The soil that erodes from the surface of your land is the soil with the highest concentration of organic matter. Erosion is especially detrimental where topsoil organic matter is shallow.

3) Manage the changes in your new system

✔ **Plan** how to manage changes in weed or pest problems associated with increased surface residue. Weeds and pests are not necessarily greater problems with increased residue, but may require different management strategies.

✔ **Monitor** soil and keep records so you know what effects your practices are having. Include an organic matter test in your regular soil testing. Labs are beginning to offer tests (such as the particulate organic matter test) that measure the active fraction. Monitor changes in patterns of weed and pest problems.

Want to know more?

See Further Resources for contact information

About no-till

Conservation Technology Information Center (CTIC), produces publications about conservation tillage.

No-Till Farmer is a practical newsletter published by Lessiter Publications.

About soil monitoring

Soil Management (BU-7399 in this series) includes ideas for keeping records of your changing practices and soil conditions.

QUESTIONS AND ANSWERS

What are some sources of organic matter?

Crop residue. For most farms, roots and above-ground plant growth are the most important sources of organic matter. When choosing varieties and crop rotations, consider how much residue will be generated, and how many months each year plants will be growing and creating organic matter.

Green manure. Finding appropriate cover crops is difficult in regions with a short growing season, but there are options and the research and development of appropriate crops is expanding.

Livestock manure. Spreading manure over your land is an excellent way to enhance organic matter, supply nutrients, and prevent manure from becoming a pollutant. If animals are not part of your operation, neighboring farmers may be a source. See *Manure Management* (BU-7401 in this series) for more information.

Sewage sludge. Human wastes are also nutrient-rich. Spreading sludge on land is cheaper for communities than some other methods of treatment and disposal. If your local community will make it available to farmers, ask about the source and content of the sludge. Contaminants such as heavy metals are an important concern to investigate and test for.

Processing wastes. Vegetable processing plants, wood processing plants, breweries, and other industries generate organic wastes that can be useful soil amendments.

Don't forget the roots

Surface residue is only part of what plants contribute to soil organic matter. Roots can add half again as much material. One quarter of the organic matter produced by corn or soybeans is produced by the roots. In prairies, half of plant production is underground.

How does that translate into weight? Corn may produce 1/2 to 2 tons of root organic matter in each acre. Soybeans may produce 1/3 of a ton, and the prairie makes over 2 tons.

In no-till situations where, surface residue is not regularly tilled into soil, roots become especially critical as a source of soil organic matter.

How do I choose a source of organic matter?

For most people, the choice is determined by convenience and economics. Here are some other questions to ask when assessing a source of organic matter. These issues are addressed in the following pages.

Want to know more?

About composting
Manure Management (BU-7401 in this series) includes information in the Further Resources section.

About cover crops
Ask your Extension educator for the latest information about cover crops in your area.

Managing Cover Crops Profitably, 2nd Edition 1998. Describes characteristics of specific cover crops.

About sewage
Agricultural Utilization of Sewage Sludge: A Twenty Year Study at the Rosemount Agricultural Experiment Station.

This is a thorough description of one study of spreading sewage sludge on fields. The first chapter introduces the major concerns and issues surrounding the use of sludge. The trial concluded that sewage sludge is safe and beneficial if applied at rates based on the nitrogen needs of the crops. If applied excessively, it can cause problems with salt build-up or nitrate leaching.

Want to know more?

About Manure

Manure Management (BU-7401 in this series) discusses application rates, and nutrient content of manure.

About nitrogen credits for legumes

Fertilizer Recommendations for Agronomic Crops in Minnesota (BU-6240).

- What is the nutrient content? How much should I apply and will it allow me to reduce fertilizer applications?
- What is the C:N ratio? Will crops get the nitrogen they need if I use this material?
- In what form is the material? For example, is it a liquid that will decompose quickly, or coarse material that can help control runoff?
- Does it contain harmful components such as weed seeds, heavy metals, or chemicals that may inhibit crop growth?
- Will growth inhibitors produced as it decomposes affect the following crop?
- What is required for transportation and application? Consider equipment required, timing (relative to other farm activities), and whether incorporation into the soil is desirable.

Is it possible to add too much organic matter?

If the source of organic matter is green manures or crop residues from the same field where they are grown, adding too much is not a concern. However, it is possible to apply too much manure, sludge, or other imported materials. The consequences of over-application are

- inefficient use of your nutrient resources,
- excess soil nitrogen that harms plants or leaches into water,
- excess phosphorus or other nutrients that become an environmental hazard.

Normally, **application rates of manure and other organic amendments should be based on the nutrient needs of the coming year's crops.** This requires testing the nutrient content of the material and your soil. See *Manure Management* (BU-7401 in this series) for more information about this process.

Can I reduce fertilizer applications when I add organic materials?

Yes, nitrogen credits have been developed for some crop residues and organic amendments. (See references in margin.) Subtract the nitrogen credit from the fertilizer recommendation you receive from a soil testing lab.

Recommended nutrient credits account for the fact that not all of the nutrients in organic material will be available to plants in the first year. The organic compounds must be broken down by microorganisms and transformed into inorganic forms that plants can use. Generally, about half of fresh residue or manure will decompose in the first year, making half its nutrients available to plants. Smaller amounts are available in subsequent years.

Research suggests that **nutrient credits are lower if you reduce tillage.** As you reduce tillage, some of the nutrients in manure or legumes will go into building soil organic matter levels and not into your crops. The University of Minnesota Extension Service recommends that you determine the nitrogen fertilizer value of your manure or legume using standard tables. Then, decrease the nitrogen credit for legumes and manure by 20% if you do not use primary tillage (e.g., no-till, ridge-till, light spring discing).

Why is the carbon-to-nitrogen ratio important?

Each organic amendment has a characteristic amount of carbon in proportion to nitrogen. (See table below). A low carbon-to-nitrogen ratio means the material is high in nitrogen. Materials with a high C:N ratio (low nitrogen) decompose slowly and may trigger nitrogen deficiency in plants as they decompose.

How can adding organic matter trigger nitrogen deficiency?

Plants depend on microbes to break down organic matter and make the nutrients available to them. Most microbes get energy from carbon compounds such as sugars, carbohydrates, fats, and other substances. Mixing organic material into the soil triggers a feeding frenzy and a burst in microbial growth. To grow, microbes need carbon for energy and nitrogen to build proteins. For every twenty to thirty carbon atoms they consume, they use about one nitrogen atom. If that nitrogen is not available from the newly-added organic material, microbes will take it from the soil, and deprive growing plants of nitrogen.

As a rule-of-thumb, materials with C:N ratios less than 30:1 will not trigger temporary nitrogen deficiency.

The nitrogen is not lost from the soil—it is still present in the cells of microbes—but plants cannot use it. During this initial decay process, microbes are giving off large amounts of CO_2 to the atmosphere and the carbon-to-nitrogen ratio of the remaining organic material declines. Microbial activity slows because the remaining compounds are more recalcitrant (difficult to decompose). At this point, nitrogen from the dying microbes becomes available to plants.

Organic material	C:N when applied	
soil organic matter	10:1	
composted manure	10-30:1	
hen manure	3-10:1	
young sweet clover or alfalfa	12:1	If the ratio is less than 20:1, the residue has more than 2% nitrogen, and N will be quickly available to growing plants.
sheep manure	13-20:1	
cow manure	11-30:1	
barnyard manure	20:1	
horse manure	22-50:1	
green rye	36:1	
corn stover	60:1	If the ratio is more than 40:1, the residue has less than 1% nitrogen, and N will be tied up (unavailable to plants) for a few weeks, or much longer in the case of low-nitrogen woody materials.
timothy	80:1	
grain straw	80:1	
sawdust	100-400:1	

What about disease and other problems?

As with any new management practice, challenges can emerge with the benefits. Before switching your whole farm to a new practice, try out new organic materials or tillage practices on a small plot of land. Watch how the new system works and anticipate problems. The following are some problems you might look for and ask about.

Weeds

Some fresh manures may promote weed growth and may contain weed seeds. Test new manure sources on a small area before spreading on large acreage. Worse than manure with a lot of weed seeds is manure with new weeds that have never before contaminated a particular field or farm. For this reason, ask where the feed for the animals came from before buying manure from another farm.

Diseases

Some residues harbor disease that may affect the next crop. For example, white mold on sunflower hulls will affect beans. If you have a specific disease problem, and are considering adding a new crop to your rotation, ask whether the crop can host the disease organism.

Growth inhibitors

"Allelopathic" chemicals are chemicals produced as a plant grows (or as its residue decays) that can inhibit the growth of other plants. Allelopathy can be a benefit or a problem. For example, rye residue reduces weed germination and is sometimes used for weed control. On the other hand, replanted alfalfa may not grow well in alfalfa residue. Allelopathic effects are complex and depend on plant genetics, weather, and plant stresses. Unfortunately, there is not much practical guidance available for farmers at this time.

Contaminants

Municipal solid wastes and sewage may contain heavy metals and other contaminants. Test the material before application and monitor soil levels when using these products.

A more common contamination problem relates to phosphorus. Manure can lead to phosphorus build-up in the soil if used over an extended period of time. Apply manure at rates based on crop nutrient needs and soil nutrient levels.

Want to know more?

About allelopathy
Alleopathy and Agricultural Sustainability.

Allelopathy in Cropping Systems.

About disease
Ask your Extension educator about specific diseases that are a problem on your farm. For more general information, *Crop Rotations for Managing Plant Disease* (1993, North Dakota Extension Service) lists crops affected by 14 important disease organisms.

WHAT IS ORGANIC MATTER?

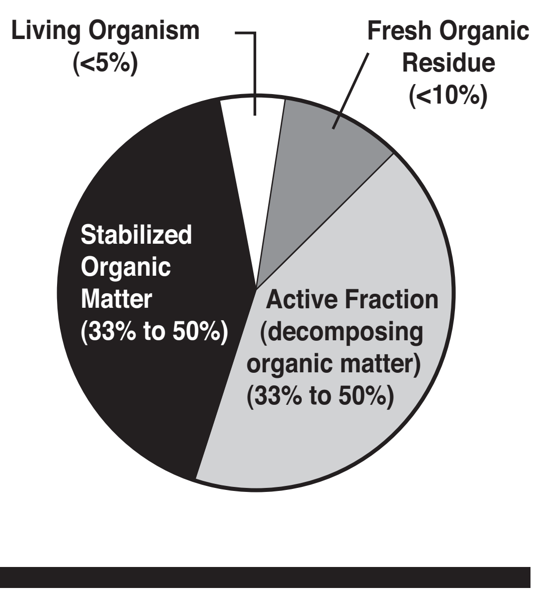
Organic matter is the vast array of carbon compounds in soil. Originally created by plants, microbes, and other organisms, these compounds play a variety of roles in nutrient, water, and biological cycles. For simplicity, organic matter can be divided into two major categories: **stabilized organic matter** which is highly decomposed and stable, and the **active fraction** which is being actively used and transformed by living plants, animals, and microbes. Two other categories of organic compounds are living organisms and fresh organic residue. These may or may not be included in some definitions of soil organic matter.

Stabilized organic matter

Many soil organisms decompose plant and animal tissues, and transform the organic matter into new compounds. After years or decades of these transformations, what remains are large, complex compounds that few microbes can degrade. Other compounds become bound inside soil aggregates where microbes cannot reach. These hard-to-decompose, or stabilized, substances make up a third to a half of soil organic matter. Scientists often divide stabilized organic matter into three chemical groups: humic acids, fulvic acids, and humins. Fungi and actinomycetes create many of the humic acids that combine in soil to become stable compounds. Much of the stabilized matter in your soil originated from plants that grew one or more centuries ago. Some of these old compounds are bound to clay, and are important in gluing together tiny aggregates of soil particles.

Stabilized organic matter acts like a sponge and can absorb six times its weight in water. In sandy soils, water held by organic matter will make the difference between crop failure or success during a dry year.

Both **organic and clay particles can hold on to nutrients** electrochemically—like a magnet holds on to iron filings. The amount of nutrients that the organic compounds and clay could carry and make available to plants is called the soil's cation exchange capacity (CEC). In Minnesota, a pound of stabilized organic matter can have five times as much CEC as a pound of clay. In other words, organic matter can hold five times as much nutrients for plants to use. Half or more of the CEC in Minnesota topsoil comes from organic matter. Although you cannot change the amount of



Organic compounds in soil

This pie chart represents organic matter in soil before cultivation. After land has been cultivated for one or two decades, much of the active fraction is lost and the stabilized organic matter makes up more than half of the soil organic matter.

> **Want to know more?**
>
> **About soil organisms**
>
> See *Soil Biology* (BU-7403 in this series).

clay in your soil, you can easily decrease or (with more difficulty) increase the amount of organic matter in your soil.

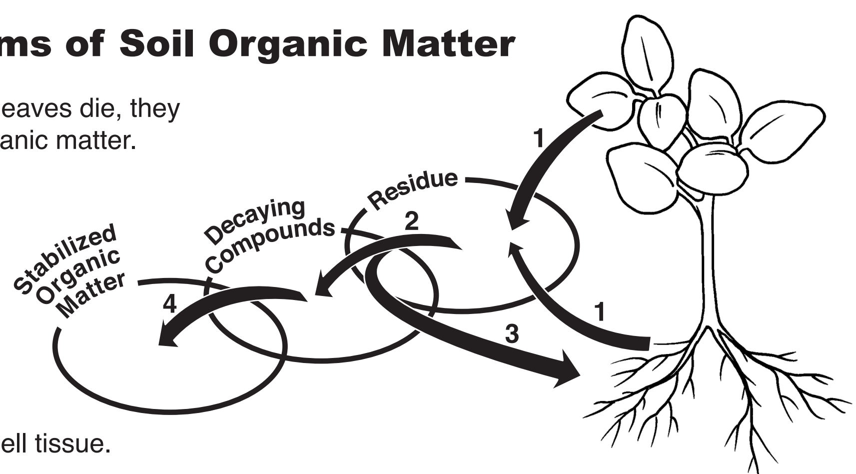
In addition to nutrients, stabilized organic matter holds on to pesticides. This prevents pesticides from moving into water supplies and improves the decomposition of the compounds, but it also makes pesticides less effective by preventing their contact with the target organism.

The active fraction

Up to 15% of soil organic matter is fresh organic material and living organisms. Another third to one half is partially and slowly decomposing material that may last decades. This decomposing material is the active fraction of soil organic matter.

The active organic matter, and the microbes that feed on it, are central to nutrient cycles. Many of the nutrients used by plants are held in organic matter until soil organisms decompose the material and release ammonium and other plant-available nutrients. Organic matter is especially important in providing nitrogen, phosphorus, sulfur, and iron. A soil with 3% organic matter contains about 3,000 pounds of nitrogen per acre. Depending on the rate of decomposition, 25 to 100 pounds may become available to plants in a year, but it is difficult to predict the decomposition rate. In Minnesota, decomposition rates are typically about 2%. This means that one acre of crop plants on a soil with 3% soil organic matter may get 60 pounds of their nitrogen and 6 pounds of their phosphorus from soil organic matter.

The Changing Forms of Soil Organic Matter



1) Additions. When roots and leaves die, they become part of the soil organic matter.

2) Transformations. Soil organisms continually change organic compounds from one form to another. They consume plant residue and other organic matter, and then create by-products, wastes, and cell tissue.

3) Microbes feed plants. Some of the wastes released by soil organisms are nutrients that can be used by plants. Organisms release other compounds that affect plant growth.

4) Stabilization of organic matter. Eventually, soil organic compounds become stabilized and resistant to further changes.

Organic matter also affects nutrient cycles by chelating (chemically holding on to) nutrients, and preventing them from becoming insoluble and therefore unavailable to plants. For example, humic substances help make iron available to plants, even in medium-to-high pH soils.

Regular additions of organic matter are important as food for microorganisms, insects, worms, and other organisms, and as habitat for some larger organisms. Soil organisms degrade potential pollutants, help control disease, and bind soil particles into larger aggregates. Well-aggregated, crumbly soil allows good root penetration, improves water infiltration, makes tillage easier, and reduces erosion.

Very fresh organic matter can cause problems to crops in two ways—nitrogen tie-up and allelopathy. A temporary nitrogen deficiency for crops occurs if the organic matter is low in nitrogen. "Allelopathic" chemicals are formed when some residues decay, and can inhibit plant growth. (See pages 5 and 6 for more information.)

Organic matter is more than fertilizer

Organic matter is not just N, P, K, and carbon. Two sources of organic matter with the same nutrient content or total organic matter content might not have equal effects on your crops and soils.

In one research trial, fields treated with animal manure had different microorganisms and enzymes than fields where green manure or mineral fertilizers were used. The importance of these differences are not well studied, but they probably affect nutrient cycling and pests. In your system, manure may mean positive effects such as reducing some diseases, or negative effects such as increasing weed growth.

Plant residues also differ greatly as a source of organic matter. Above-ground growth has a different action in soil than roots, even when it is tilled into the soil. All roots do not act the same. For example, tap-rooted plants such as alfalfa create vertical pores in the soil, whereas the finely branched roots of grasses enhance soil aggregation.

Your Farm

Considering the broad impacts organic matter has on soil, it is no wonder that improved organic matter management may be the most significant thing you can do to improve soil.

Think of a short list of soil problem areas on your farm, or go back to the list of problem areas you identified in the first *Soil Management* publication. Which of these might relate to low organic matter levels? Crusting, drought susceptibility, and even some pest infestations might be treated effectively by adding cover crops, reducing tillage, or increasing the amount of manure or residue added to a field. Which of these management practices would be feasible on your problem areas? If you began a preliminary management plan in *Soil Management,* add these specific management changes to your plan, and decide on measurements to monitor your progress.

THE SOIL SCIENTIST

What Does Organic Matter Do?

Nutrient cycling

- Increases the nutrient holding capacity of soil (CEC).
- Is a pool of nutrients for plants.
- Chelates (binds) nutrients, preventing them from becoming permanently unavailable to plants.
- Is food for soil organisms from bacteria to worms. These organisms hold on to nutrients and release them in forms available to plants.

Water dynamics

- Improves water infiltration.
- Decreases evaporation.
- Increases water holding capacity, especially in sandy soils.

Structure

- Reduces crusting, especially in fine-textured soils.
- Encourages root development.
- Improves aggregation, preventing erosion.
- Prevents compaction.

Other effects of soil organic matter

- Pesticides break down more quickly and can be “tied-up” by organic matter (and clays).
- Dark, bare soil may warm more quickly than light-colored soils, but heavy residue may slow warming and drying in spring.
- Many of the effects of organic matter are related to the activity of soil organisms as they use soil organic matter. See *Soil Biology* (BU-7403 in this series) for more information.
- Plant residues and other organic material may support some diseases and pests, as well as predators and other beneficial organisms.

WHAT DETERMINES SOIL ORGANIC MATTER LEVELS?

The amount of organic matter in soil is the result of two processes: the addition of organic matter (roots, surface residue, manure, etc.), and the loss of organic matter through decomposition. Five factors affect both additions and losses.

Management. Practices that increase plant growth on a field (cover crops, irrigation, etc.) will increase the amount of roots and residue added to the soil each year. On the other hand, intensive tillage increases the loss of organic matter by speeding decomposition. While tillage primarily burns younger organic matter, older, protected organic compounds can be exposed to decomposition if small aggregates are broken apart. In addition to changing the amount of soil organic matter, tillage practices affect the depth of soil organic matter.

Want to know more?

About tillage and organic matter

“Soil Organic Matter Changes Resulting From Tillage and Biomass Production.” by D.C Reicosky and others. (1995).

Soil texture. Fine-textured soils can hold much more organic matter than sandy soils for two reasons. First, clay particles form electrochemical bonds that hold organic compounds. Second, decomposition occurs faster in well-aerated sandy soils. A sandy loam rarely holds more than 2% organic matter.

Climate. High temperatures speed up the degradation of organic matter. In areas of high precipitation (or irrigation) there is more plant growth and therefore more roots and residues entering the soil.

Landscape position. Low, poorly-drained areas have higher organic matter levels, because less oxygen is available in the soil for decomposition. Low spots also accumulate organic matter that erodes off hill tops and steep slopes.

Vegetation. In prairies, much of the organic matter that dies and is added to the soil each year comes from grass roots that extend deep into the soil. In forests, the organic matter comes from leaves that are dropped on the surface of the soil. Thus, farmland that was once prairie will have higher amounts of organic matter deep in the soil than lands that were previously forest.

How do organic matter levels change?

To build organic matter levels in topsoil, more organic matter must be added than is lost to decomposition and erosion. Like a person trying to lose or gain weight, increasing organic matter is about changing the balance between how much energy goes in and how much is burned off.

Another way to think of soil is like a giant wood stove. You continually add organic matter (wood), and it burns to release energy and nutrients that will be

Differences in organic matter appear in the color changes across a bare field. Less organic matter is produced on the drier hilltops, and some is lost to soil erosion and deposited in low spots.

used by plants and microorganisms. Ideally, you want a slow, steady burn that releases nutrients to plants as needed.

Intensive tillage aerates the soil and is like opening the flue or fanning the flames. Decomposition is desirable because it releases nutrients and feeds soil organisms. But if decomposition is faster than the rate at which organic matter is added, soil organic matter levels will decrease.

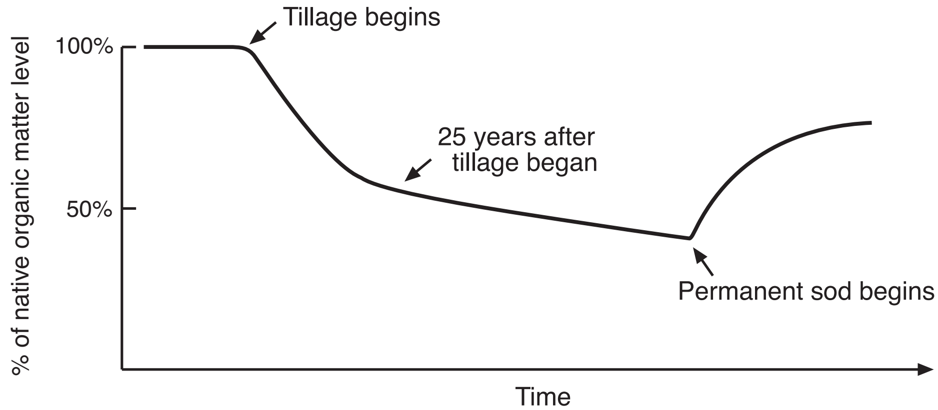
Reducing decomposition is only half the equation. It is just as important to increase the amount of organic matter added to the soil. Organic matter can be either grown in the field or brought to the field.

How long does it take? Building organic matter is a slow process. First, the amount of residue and active organic matter will increase. Gradually, the species and diversity of organisms in the soil will change, and amounts of stabilized organic matter will rise. It may take a decade or more for total organic matter levels to significantly increase after a management change. Fortunately, the beneficial effects of the changes appear long before organic matter levels rise. These improvements, however, can be reversed in a year or two by returning to previous practices.

Why does it take so long for organic matter levels to increase?
An acre of soil six inches deep weighs about 1000 tons, so increasing the proportion of organic matter from two to three percent is actually a 10 ton change. However, you cannot simply add 10 tons of manure or residue and expect to measure a one percent increase in soil organic matter. Only ten to twenty percent of the original material becomes part of the soil organic matter. Much of the rest is converted over several years into carbon dioxide.

An illustration of soil organic matter losses and gains in response to tillage.

Most organic matter losses in soil occurred in the first decade or two after land was cultivated. Native levels of organic matter may not be possible under agriculture, but many farmers can increase the amount of active organic matter by reducing tillage and increasing organic inputs.



WHAT'S NEXT?

Look back at the list of practices on page 2. Do you have some ideas for organic matter management changes? What would work for you?

WHAT IS THE BOTTOM LINE?

What is it worth to change to practices that enhance soil organic matter? Organic matter is one of the most important assets on a farm, yet it is difficult to attach a dollar value to it. Decreased fertilizer bills are measurable, but organic matter management touches on many aspects of the farm system that are not as easy to measure. Here is a checklist of costs and benefits to consider as you think about changing practices to improve soil organic matter.

✔ **Time –** How do the proposed changes affect your labor demands during each season?

✔ **Yield –** Yield changes are difficult to monitor because they vary with genetics and weather. As organic matter and biological activity increase, yield may increase as a result of decreased compaction, improved water availability and drainage, improved germination, improved root growth, improved availability of nutrients throughout the season, and reduced pests. Or yield may decrease, especially during the first few transition seasons, as a result of slower germination (due to increased residue delaying soil warming), or increased weed populations from decreased tillage.

✔ **Crop quality –** Feed or market quality may change as practices change.

✔ **Skills and information required –** Do you have the necessary knowledge or know where to find information about new practices?

✔ **Soil loss –** Practices that improve organic matter may also reduce erosion.

✔ **Pollution –** New practices will affect whether nutrients and pesticides leach through the soil or run off the surface.

✔ **Inputs**

equipment: New purchases or rentals may increase equipment costs

fertilizer: Organic matter additions may replace some fertilizer.

pesticides: Decreased tillage may increase herbicide use. New rotations may eliminate the need for some insecticides or fungicides.

seeds: A new cover crop may increase seed costs.

✔ **Financial security –** What is the reliability of the prices of new crops? How diverse is your income?

SET REALISTIC GOALS

Have appropriate expectations as you consider changing organic matter management practices. Don't expect rapid increases in total organic matter. Although an increase from two to three percent sounds small, it is a hefty fifty percent increase in organic matter, and will not happen quickly. But measurable increases in total organic matter can happen in the long term. Accept the upper limits of your soil and climate. For example, most sandy soils cannot hold more than two percent organic matter, but that two percent is valuable and important to protect.

As you monitor changes in organic matter, it may be less important to track total organic matter and more important to track evidence of improved active organic matter. Look for better soil structure, less crusting, or less susceptibility to drought. You may also see measurable improvements in pest problems or crop nutrient status. These changes may appear within two to three years of switching to new practices.

FURTHER RESOURCES

Agricultural Utilization of Sewage Sludge: A Twenty Year Study at the Rosemount Agricultural Experiment Station. 1995. Linden and others. University of Minnesota Extension Service SB-6523.
Copies are available from the Distribution Center at 1-800-876-7636.

Alleopathy and Agricultural Sustainability. 1989. S.R. Gliessman. Center for Agroecology and Sustainable Food Systems.
A free academic paper from the Center at 408-459-4140, or martha@zzyx.ucsc.edu.

Allelopathy in Cropping Systems. (Six articles) *Agronomy Journal*, vol. 88(6), p. 853-893.

Building Soils for Better Crops. 1993. Fred Magdoff. University of Nebraska Press.
A 170-page book about managing organic matter. Includes chapters on manure, cover crops, rotations, tillage, and composting. The first edition is out of print, but a second edition is expected soon. If you cannot find the first edition at your library, photocopies may be available from John Nelson, Northeast SARE, Hills Building, university of Vermont, Burlington, VT 05405.

Conservation Technology Information Center (CTIC).
CTIC publishes information for farmers and conservationists interested in crop residue management, conservation tillage, watershed management, water quality, wetlands, nutrient management, and pest management. For a list of publications, call 317-494-9555, or see their web site at www.ctic.purdue.edu/CTIC.html.

Crop Rotations for Managing Plant Disease. 1993. North Dakota Extension Service.
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