Organic Matters: Feeding the Soil and Building Soil Quality

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Close your eyes briefly and imagine your ideal garden or community or school garden plot or farm. Besides the healthy plants that make you hungry and healthy people that make you happy, what else draws your attention? Can you see soil that makes you want to reach down and grab a handful? Is it loose enough that you can easily grab a big deep handful? Does it look dark in color and smell good from lots of organic matter? Are there nice big earthworms? Good. Now let's make sure what you see with eyes closed is what you see with eyes open. Organic matter is at the very foundation of soil quality and healthy plants both of which lead to healthy animals and healthy people. Soil management starts with organic matter and feeding the microbes in the soil. There are several options for how to add organic matter to your soil.

What is Organic Matter?

We often use the term "organic matter" two different ways in gardening and farming. In one sense, we refer to plant material in the form of crops, green manures, animal manures, compost, or wood shaving / straw animal bedding all as examples of ***fresh organic matter*** *or* ***organic amendments*** that can be added to soil as mulch or food to increase or maintain soil biology. Sources of fresh organic matter may include weed seeds or available forms of nutrients that can be leached, and if incorporated into the soil at high rates may lead to rapid rates of breakdown and decay that can lead to short term reductions in nutrient availability.

The more common use of the term organic matter is for already decayed plant materials after they are no longer identifiable as the original plant and have been biologically degraded to a humus material or ***soil organic matter***. The amount of organic matter in mineral (sand, loam or clay) soils ranges from very low being 1% by weight, to average being 2 to 4%, and high being greater than 5%. There are also "muck" or organic or peat based soils that are 30 to 40% organic matter. The general consensus is the more soil organic matter the better. But there is more to the story than just how much organic matter. We need multiple types of organic matter.

We often define several types of soil organic matter including: 1) the living fraction of organic matter including plant roots, bacteria, fungi, actinomycetes, protozoa, etc; 2) the active component that is still breaking down quickly over weeks and months also know as "dead" organic matter; 3) the slowly available component that is breaking down over a period of years know as the "really dead" organic matter; and 4) the stable organic matter that is breaking down over decades and centuries known as the "really, really dead organic matter".

What does Organic Matter Do?

The formation of soil is a story of rocks and minerals being broken down to smaller and smaller pieces. Soil Organic Matter (SOM) is the glue that helps provide structure to all the smaller particles, helps prevent compaction, and can lead to an increase in root growth. As SOM and therefore soil structure increase, soil is capable of absorbing water faster, retaining more water, and resisting erosion by wind and rain.

Moisture absorption and retention are some of the most important contributions of soil organic matter. Researchers at the Rodale Institute have estimated that each pound of carbon in the soil can retain up to 40 lbs of water. If a soil has 1% organic matter, we can estimate that

there is 1% time 2,000,000 lbs of soil per acre (6 inches) deep or 20,000 lbs of organic matter. If we estimate that the organic matter is 40% carbon, that would be the equivalent of 8,000 lb of carbon. If 40 lbs of water for each lb of carbon, then 320,000 lbs of water or approximately 40,000 gallons of water per acre be 1% organic matter (8.3 lbs/gal water).

SOM also attracts and holds many soluble plant available nutrients so the nutrients are retained by the soil and are available to the plant. In addition, as soil organic matter breaks down or is consumed by microorganisms, a part of the nutrients are released. For example, if there is 1% organic matter and 10% of it is decomposed in a year that would be equivalent to 20,000 lbs of organic matter and 2,000 lbs decomposed. If the organic matter is 1% nitrogen, that will be 20 lbs of nitrogen per acre released for crop uptake.

The presence of SOM usually leads to an increase in the number and types of microorganisms which can lead to reductions in plant pathogens, diseases and plant pathogenic nematodes. All of the organisms together make up the *soil food web*. A healthy, biologically active soil can contain as many living organisms in one cup as there are people on the planet (6 to 7 billion). A balance of microorganisms maintained by a balance from crop rotation and of types of organic matter can prevent the development of one type of plant pathogenic organism.

Why do we need Organic Matter to break down?

As plants grow, the energy of the sun is trapped and stored. Just as we get energy from eating plants, microorganisms in the soil get energy by continuing to break down plant derived organic matter. When a horse eats hay, the horse gets energy, a part of the hay becomes the horse, part is lost as feces, and part is lost as carbon dioxide each time the horse exhales. In ecological farming and gardening, the soil is alive like the horse and needs to be fed regularly. The soil microorganisms include bacteria, fungi, protozoa, nematodes, and many other life forms that make up the *soil food web*. The soil food web is fed in part by plant roots which pass sugars out into the soil to support microorganisms which eventually die and provide new available nutrients and minerals for the plant. More organic matter leads to more microorganisms and leads to more available minerals and nutrients. Feeding the soil is the basis for organic farming.

How do we increase Soil Organic Matter?

There are many possible sources of fresh organic matter that can be added to soil for the creation of SOM:

1. ***Plants and weeds*** contribute sugars when alive or recently dead and roots and plant parts that remain in the soil and decay when dead.
2. ***Mulch materials*** like leaves, straw, hay, bark and wood shavings will help conserve water and reduce weed growth and eventually break down to organic matter.
3. ***Cover crops*** or ***green manure*** are crops grown specifically to provide food for soil organisms and ultimately soil organic matter.
4. ***Animal bedding(straw, wood shavings) and manure*** have been a primary source of organic matter added to the soil for thousands of years
5. ***Compost*** is an example of organic matter that has already been partially degraded or stabilized. Any of the previously mentioned sources of organic matter can be used to make compost.

Mulching Materials. In most communities in the Midwestern US there are plenty of shade tree leaves or pine needles available for garden mulch. Leaves and pine needles can be applied directly to the garden in the fall, but fencing may be necessary to keep them from blowing away. They can also be piled and allowed to decay over the winter and then spread as mulch in the spring or summer. In some gardening texts there are warnings of pine needles or oak leaves leading to undesirable acidic conditions in the soil. I have never had this experience and do not believe it is a concern.

In communities with or near farming activity, there is often either straw or hay available at a price ($2 to $4 per bale) which is well worth the benefits to the soil and garden. Hay will provide more nutrients, which is a positive, but also potentially more weed seeds. If it is obvious hay has weed seeds, piling and wetting to favor decay for several weeks or composting is recommended. Adding hay to leaves makes a nice hot compost pile (see below). Sometimes hay is rained on during harvest and storage making it unsuitable for feeding to some animals but great for using as mulch or for composting. Hay that has been wet will likely have mold spores that may be a problem for people with mold allergies.

Wood shavings or ground tree trimmings can also be used for garden mulch in some situations. Mulching walkways or areas where the wood can be kept on the surface of the soil and not incorporated is best. As fresh wood shavings break down, nitrogen will be taken from the soil and be less available to the plants being grown in the garden. Once the ground wood has aged, nitrogen removal from surrounding soil is less of a concern. Allowing piles to age or using the wood shavings in compost piles are other ways of stabilizing or aging the materials to increase effectiveness in the garden.

Green Manures and Cover Crops. Another very old, traditional source of organic matter and nutrients is growing plants on the land and then plowing them into the soil to decay and release nutrients for the next crop. Crops grown to add nutrients to the soil are called green manures. Some plant species are selected as *green manures or cover crops*, because of efficient, deep root systems that bring nutrients up to the soil surface, others because they are hardy or more tolerant of nutrient, moisture or environmental stresses.

When nitrogen is limiting, the most important green manures are plants that together with bacteria are able to capture nitrogen from the atmosphere and make it available in the soil. These crops are known as legumes and in the garden include white Dutch dwarf clover, red medium or mammoth clover, or yellow clover, alfalfa, or vetch. The plants provide soil bacteria around the plant roots sugars from photosynthesis. In “exchange” the bacteria provide nitrogen in a form the plants can use. The plants can grow larger with the nitrogen and provide more sugars. This nitrogen can be used by other plants as the original nitrogen fixing plant decays. Since these crops need to be productive for a year or more, a part of the garden is taken out of production of the normal crops. Another option is planting the aisle ways between crops to a clover that can be mowed and walked on. If there is not room on or in the garden, green manures can be grown elsewhere and the top growth harvested and then used fresh or dried as a fertilizer or as an addition to the compost pile.

Other commonly used green manure or cover crop species include cereal rye and winter wheat because they can grow in the cool temperature conditions of fall and spring and because they produce many roots as well as grassy growth that break down quickly and stem growth that leads to straw which decays more slowly. These cereal grasses are also larger seeded and easy to sow. The seed is also relatively inexpensive. Common rates of application are one to two bushels or 60 to 120 lbs per acre. A bushel of wheat weighs 60 lbs. A bushel is about 8 gallons. This corresponds to about 1 pint (2 cups) of seed weighing about 1 lb. A 100 square feet area (10' x 10' square) would require about 0.5 cup of seed for the 120 lb per acre rate.

Since garden space is often used less in the fall and early spring, that is also a time for covering the soil with living plants. Species in addition to cereal rye and wheat that can be used at cool times of the year also included crops like mustard and oil seed radish. During the warm time of the year, two common cover crops are oats and buckwheat. Oat seed is often available as animal feed and will germinate and grow quickly. Oats will be killed over the winter and the dead plants can provide a nice blanket or mulch for the spring garden. Buckwheat grows up and is ready to cut down and incorporate in six to eight weeks during the summer. If allowed to go too long, seed will form and germinate after incorporation.

When green plant material is incorporated directly into the garden soil, it is important to provide 10 to 14 days for the rapid phase of decay to occur before planting any new seeds or plants. There is a large burst of microbes feeding on the decaying plants which can be detrimental to young seeds and transplants which don't look much different then decaying plants.

An alternative for large scale agriculture is to kill the cover crop / green manure using a roller crimper pushed ahead of or pulled behind a tractor. The roller with edges attached pushes down the green crop and crimps the stems every 4 to 7 inches which causes the plant to die, particularly if it has started to bloom. It is possible to plant large seeded crops such as soybeans or corn through the matted layer of freshly killed material which acts like a mulch to prevent weed growth and evaporation of moisture from the soil.

Animal Bedding and Manure. Dairy and beef cow, horse, sheep, swine, and poultry bedding and manure have been a primary source of nutrients for hundreds if not thousands of years, up until the last century. There are recent concerns about the presence of certain bacteria in the manure that if allowed to contaminate crops may effect the food safety of fresh fruits and vegetables. Part of the more recent concern has to do with how animals are fed, housed and treated with antibiotics. Manure from factory animal production units is not acceptable for certified organic production. Even manure and bedding from local small animals or pets should be composted or aged to reduce risk. The USDA Organic standards require certain lengths of time (90 to 120 days) from the time of application of manure to the time of any crop harvest from the same land. Composting manure will stabilize the nitrogen and nutrient content, reduce the volume and make it easier to transport, and reduce if not eliminate the risk of pathogens related to food safety. The amount of nitrogen in manure sources from different animals and different handling methods can vary by a factor of 3 or 4. Poultry manure is used sparingly because it has more nitrogen. Materials with more straw or woodshaving bedding than manure is best for adding organic matter. Llama and alpaca manure tends to be a good, low nutrient manure source.

Compost. Compost is perhaps one of the less understood and less used contributors to SOM. The word "composting" or some derivative has been used for centuries to refer to the slow natural breakdown and degradation of organic matter such as the decomposition of leaves and litter on the forest floor. During the last century and particularly the last few decades, "composting" is most often used to refer to the process of mixing organic matter at specific ratios of carbon to nitrogen and managing moisture, aeration, and temperature through various methods of piling, turning or mixing to achieve the desired stable and biologically active end product we call "compost". Depending on many variables, the active composting process leading to a stable product can be completed in a matter of days, weeks or months and is then followed by a maturation phase of weeks to months that results in finished, mature compost. Depending on the feedstocks used in the composting process, the available minerals and nutrients can be low (<1% N), medium (1-2% N), or quite high (2+% N).

There are several potential benefits to justify the added time of producing compost including:

Volume reduction of bulky materials allowing easier transport and application.
Moisture reduction of manure or food processing byproducts for transport/application.
Homogenization or increased uniformity of a mixture of materials and particle sizes.
Stabilization of organic matter and nutrients to generally a less or more available form.
Weed seed reduction or degradation and plant pathogen inoculum reduction.
Herbicide, pesticide, antibiotic or other chemical contaminant degradation.
Development of a diverse and beneficial mix of active or dormant microorganisms.

The possible down side of composting includes:

Investment in time, labor and space to complete the process.
The loss of energy and carbon that could be used by soil microorganisms.
The loss of nitrogen as a gas depending on the formulation and management of the pile.

Application of compost to soil (depending on the rate applied) can provide an inoculum of microorganisms, slowly available nitrogen and nutrients, stable organic matter, and has been shown to reduce the infection rate and crop losses due to plant pathogenic root and foliar diseases.

When making compost, please consider that the basic process of composting is not complicated and can be done many ways. A special box or container is not necessary. However, there are several factors that influence the process of making compost. Important variables to consider include:

- carbon to nitrogen ratio: general rule of 3 parts "brown" to 1 part "green". "Brown" materials have a carbon to nitrogen content of greater than 30 to 1 and "Green" materials have a carbon to nitrogen content of less than 30:1
- inoculum of living organisms: nothing special needed, add some soil or old compost
- moisture: often a limiting factor, should be moist enough to allow squeezing out water
- aeration: usually available unless pile is compacted or too large (over 5 feet tall)
- temperature: in order to heat, the pile must be big enough – more than 3' tall & wide
- if no heat, add more water, or nitrogen (green grass or hay), or make the pile larger

- time of composting: influenced by particle size – smaller faster, larger longer
- mixing: need to get the entire pile hot if weed seeds are to be killed

More recommendations about getting started in composting are provided in the ***Compost Production and Use*** document or Composting for the Small and Midsize Farm available at the website: www.hrt.msu.edu/john-biernbaum/pg4 or www.hoophouse.msu.edu

How do we Conserve and Maintain Soil Organic Matter?

Environmental factors such as soil moisture, temperature and aeration that increase biological activity may lead to changes in organic matter degradation. Higher soil moisture, temperature and aeration lead to increased activity of microorganisms and more feeding on SOM. Since soil texture (particle size) and structure (particle arrangement) can effect soil aeration, they also influence soil organic matter break down (more breakdown in sandy soils than clay soils). While we need some organic matter to breakdown slowly to provide nutrients for our plants, some practices can lead to the undesired rapid loss of organic matter. Frequent or excessive tillage or cultivation can stimulate soil microorganisms to feed on organic matter by providing more oxygen. For this and other reasons that help reduce erosion, we want to minimize tillage and cultivation. Application of more than needed nitrogen fertilizer also stimulates soil bacteria to degrade more organic matter and needs to be avoided. Incorporation of excessive amounts of fresh organic matter may also over stimulate the soil food web and decrease organic matter. It is also likely that growing the same crop in the same location year after year will lead to reductions in organic matter.

Conclusion

SOM contributes greatly to soil quality and plant health. SOM helps provide nutrients, helps soil absorb and retain moisture, and helps prevent soil erosion, and just plain makes the garden easier to cultivate and maintain. We have many options to increase SOM including addition of mulch materials, the use of green manures and cover crops, and the addition of compost. The addition of organic matter is a positive and worth while investment for any gardening project with very visible rewards. The worms will tell you how you are doing. Does your garden look like you want it to?

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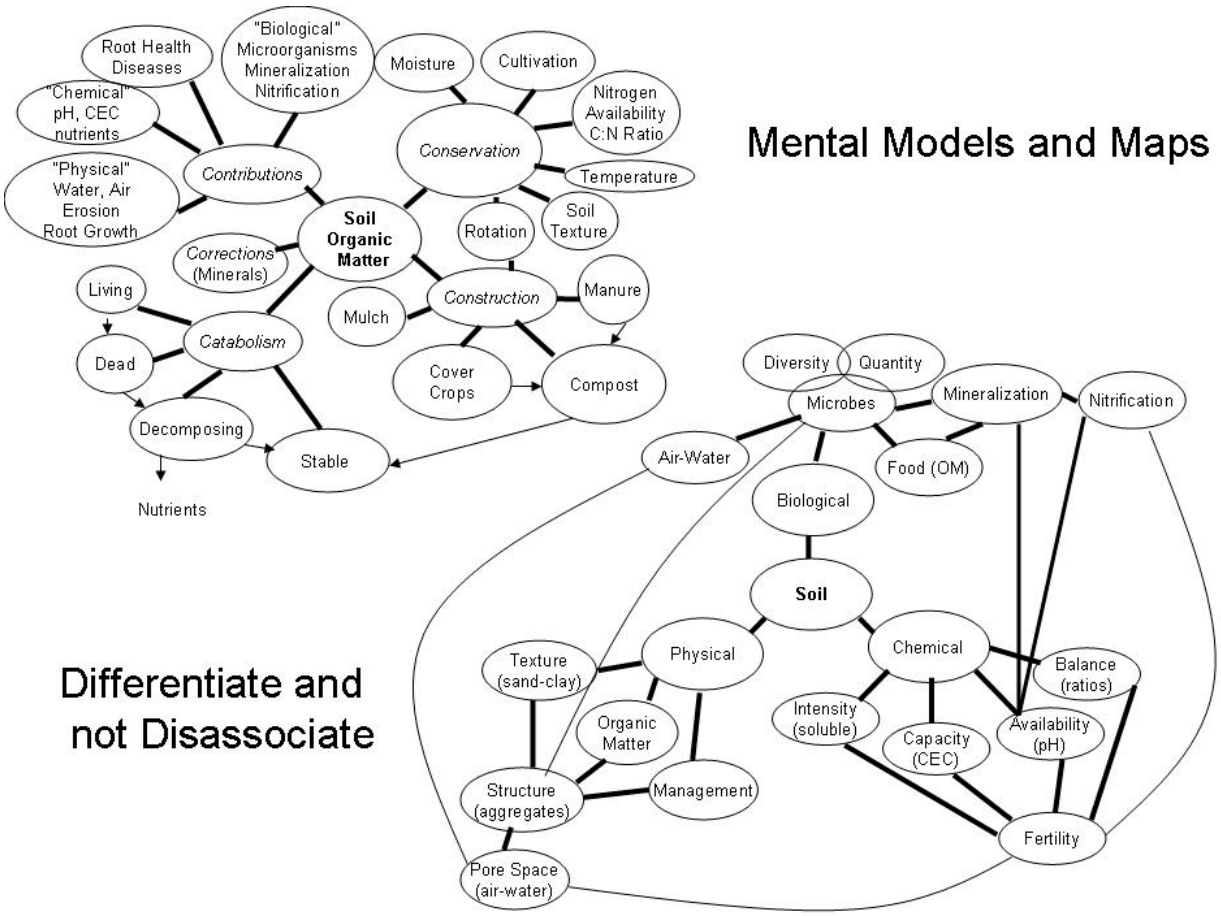
Web sites to consider for additional information:

http://www.safs.msu.edu/soilecology/index.htm Sustainable Agriculture – Soil Ecology
http://www.covercrops.msu.edu/ Sustainable Agriculture – Cover Crops
http://www.ncat.org/ National Center for Appropriate Technology
http://www.moffa.org/home.html Michigan Organic Food and Farm Alliance
http://www.mosesorganic.org/ Midwest Organic and Sustainable Education Services
http://www.hrt.msu.edu/john-biernbaum
http://www.msuorganicfarm.org
http://www.hoophouse.msu.edu


Mental Models and Maps
Root Health Diseases
"Biological" Microorganisms Mineralization Nitrification
Moisture
Cultivation
"Chemical" pH, CEC nutrients
Nitrogen Availability C:N Ratio
Conservation
Contributions
"Physical" Water, Air Erosion Root Growth
Temperature
Soil Texture
Rotation
Soil Organic Matter
Corrections (Minerals)
Living
Construction
Manure
Mulch
Catabolism
Dead
Cover Crops
Compost
Decomposing
Stable
Nutrients
Diversity
Quantity
Microbes
Mineralization
Nitrification
Air-Water
Food (OM)
Biological
Soil
Physical
Chemical
Texture (sand-clay)
Balance (ratios)
Organic Matter
Intensity (soluble)
Availability (pH)
Capacity (CEC)
Structure (aggregates)
Management
Fertility
Pore Space (air-water)
Differentiate and not Disassociate