GROWING HEALTHY SOIL IN THE GARDEN

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Just like location, location, location for real estate, it's soil organic carbon, soil organic carbon, soil organic carbon for soils.

Most farmers and gardeners understand the importance of having enough nitrogen, phosphorus, and potassium, but the value of soil carbon is often underappreciated.

Plants get carbon from the air through photosynthesis, but the carbon in the soil plays an important role in plant health by supporting soil microbial life, contributing to good soil structure and tilth, and increasing water holding capacity.

Soil is a living system, and increasing soil carbon levels is one of our best opportunities for increasing soil health.

Soil health is the capacity of soil to function in biological productivity (plant growth and decomposition); environmental quality (water filtration and erosion resistance); and plant, animal, and human health. Carbon is the most important unifying factor for all of these and also the primary ingredient of soil organic matter. Organic matter is what gives healthy soil its dark-brown color and rich, earthy smell.

When managing for soil health, it is actually the organic soil carbon that's of interest. Soil organic carbon was or is part of a living organism – microbes, earthworm castings, compost, decaying roots and leaves, manure, and humus. In contrast, soil inorganic carbon includes things like charcoal and calcium carbonate (ag lime).

Soil organic matter (SOM) and soil carbon are often used interchangeably, and while one is a component of the other, they are not the same.

SOM encompasses all organic components of the soil system. SOM consists of approximately half carbon while the rest is nitrogen, phosphorus, potassium, and other minerals. It includes living and dead plant and animal tissue as well as plant root excretions and soil microorganisms. SOM is typically a small percentage of the soil (less than 3 percent in most Wyoming soils) but plays a very important role in soil health, plant resistance to disease, water holding capacity, and soil tilth. SOM is a source of all essential plant nutrients in varying proportions (with the exception of carbon and oxygen, which

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come from air and water). Most fertilizers, on the other hand, provide only a few plant nutrients.

SOM sources include manures, compost, dead plants, and even living plant roots. All of these contain different forms of carbon-rich materials, including lignin, cellulose, sugars, lipids, and humic acids.

Soil Food Web

Plants do not absorb a significant amount of carbon from the soil, but SOM is the food and energy source for the soil food web. Larger soil organisms like worms and arthropods are the "shredders." They break down organic matter into smaller pieces and help aerate and mix the soil while they work.

Next come the soil microbes (bacteria, fungi, protozoa, and nematodes). There are billions of these little recyclers in a single shovel full of healthy soil, and they rely on organic matter for energy and nutrients. As they break down complex carbon-based molecules like lignin and cellulose in dead plants and manure into smaller components, many plant-available nutrients are released as byproducts. Plants would not be able to get the nutrients they need from the soil without soil microbes.

As all of these soil organisms, large and small, are eating and reproducing, they are also improving the tilth of the soil making it a more hospitable place for plants to grow.

There are many soil functions directly or indirectly affected by soil carbon.

1. **Soil microbial activity:** increases plant nutrient availability, enhances degradation of pollutants, and helps with plant disease suppression.
2. **Soil structure:** improves water infiltration, increases rooting depth, helps soil resist erosion and compaction, and improves oxygen availability for roots and microbes.
3. **Soil water holding capacity:** increases drought resistance and plant available water.

All of these soil functions help increase seed germination, root development, resistance to disease, and crop quality and yield.

Cost of Tillage

Many of the microbes involved in decomposition are aerobic, and create carbon dioxide as a byproduct (just like humans). Tillage introduces a large amount of oxygen into the soil very quickly. This stimulates microbial activity, which leads to rapid organic matter decomposition in the soil. As a result, valuable soil carbon is lost as carbon dioxide. This is why too much tillage is a primary factor in loss of SOM and declining soil health worldwide.

Tillage is also very damaging to soil structure, leads to long-term subsoil compaction, increases the risk of erosion, and discourages earthworms and beneficial soil fungi. Reducing tillage in a garden will improve the health of the soil over the long term. Consider using a shovel instead of a rototiller when you can and leaving the soil undisturbed as much as possible.

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Rototilling in the fall leaves the soil bare and unprotected all winter. Let undiseased plants stay on the surface as mulch to protect the soil and feed the underground food web.

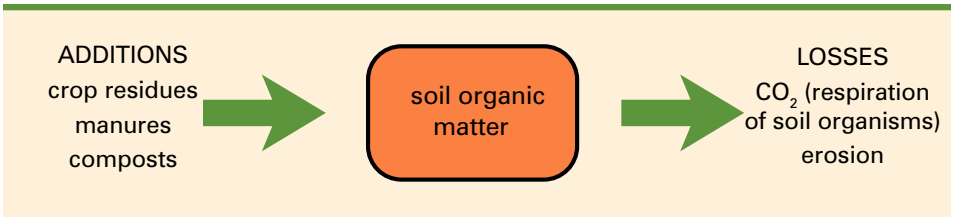
Some weeds like thistle and bindweed are spread by tillage as well.

Managing for Soil Carbon

Improving soil carbon status is a matter of increasing gains and decreasing losses (see chart page 13).

Using composts and manures is the simplest way to add carbon to soil. These can be added on top of the soil as mulch or incorporated before planting. Leaves and grass

Reduce Tillage	Add organic materials
Reduce losses	**Increase gains**
• Avoid excess tillage - use only when and where it's necessary • Dig garden beds by hand • Build "no-till" garden beds • Don't rototill the garden in the fall • Never leave soil bare - mulch with leaves, straw, grass clippings, etc.	• Mulch gardens and landscapes • Add compost or manure to the garden • Use sheet mulching to build no-till garden beds • Leave undiseased stalks and leaves in the garden as mulch to protect soil and feed the worms and microbes • Use annual weeds that have not yet gone to seed as mulch • Compost or bury vegetable kitchen scraps in the garden • Save your coffee grounds and add them to soil



Additions and losses of organic matter from soils.
From: Building soils for better crops: Sustainable soil management/by Fred Magdoff and Harold van Es. – 3rd ed.

clippings make great compost or mulch and don't have the same risk of high salt that manure does. Don't burn those leaves; use them to feed the soil!

Never leave the soil bare. Always use mulch to conserve water, protect the soil, and make a more hospitable habitat for soil organisms.

Alfalfa hay is also a good mulch or compost addition, as well as grass hay baled before it went to seed. Straw and wood chips make great mulch to help conserve water, protect the soil, reduce weed pressure, and provide food for the worms and soil microbes.

And don't forget coffee grounds and vegetable scraps; these can be added to the compost pile or buried directly in the garden.

Sheet mulching or lasagna gardening can be a great way to get rid of the rototiller in the garden, add carbon, prevent soil erosion, stop weeds, and use water more efficiently. Organic materials like leaves, grass, manure, coffee grounds, straw, and hay are added to the soil surface in alternating layers (with plenty of water). If kept reasonably moist,over time, these will decompose in place and create a lovely garden bed.

Keep in mind this process takes time and a lot of organic materials, so starting in summer or fall is best. For more information on this process, including photos and videos, visit bit.ly/notillgarden.

Living plant roots are another source of soil carbon. Plants secrete polysaccharides (complex sugars) into the soil that feed the microbes. Perennial plants shed dead roots and grow new ones as they go through cycles of growth and dormancy. These dead roots become food for soil microbes and are recycled, continually adding more carbon and nutrients to the soil. This is why soil under pastures, lawns, or prairie grasses can be so productive when converted to a garden or farm.

This process is also called carbon sequestration – taking the carbon out of the atmosphere (as carbon dioxide) and storing it in the soil as organic matter (note photo page 12).

Cover crops can be a great way to capture carbon and nitrogen from the atmosphere and store it in your soil. For more information about using cover crops in the garden, visit bit.ly/gardencovercrops

Reducing tillage, adding organic matter, and keeping living roots in the soil can keep more of the carbon in the soil where it is useful.

Soil specific

Humus is the highly decomposed portion of soil organic matter. Humus is made of humic and fulvic acids. These are very large, complex molecules that hold nutrients and water in the soil, making them more available to plants.

Soil tilth is a term used to describe the favorability of soil conditions for growing plants. A soil with good tilth has good structure, nutrients, and water holding capacity.

Tillage is the mechanical disturbance and mixing of soil. The degree and results of disturbance depend on the implement used. For example, a shovel causes much less disturbance and damage than a rototiller.

Measuring Change

Changes in soil carbon can be measured. The simplest method only requires a shovel, while more advanced methods involve laboratory analysis (more information bit.ly/soiltestgarden).

A lot can be learned by digging a small hole and taking note of the color, smell, and structure of the soil. Soil with more carbon will typically be darker in color, have a stronger earthy smell (humus), and better tilth.

You may also notice more earthworms and deeper roots. Observing changes in color, smell, and structure over time can tell a lot about the effects of the current management on soil health and carbon status. Compare your garden or pasture soil to the soil along a fence line or other undisturbed area. Which one looks and smells better?

As you manage nitrogen, phosphorus, and potassium for a healthy thriving garden, consider ways to manage carbon, too. The long-term benefits will be well worth the time and effort.

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