Grow YOUR SOIL

Soil Science Spotlight

If we understand a soil, we can improve it

Organic Matter

Soil organic matter is the remains of decomposed plant material which was grown in your garden and then returned to the soil, ideally as cured compost or if necessary, as mulch. Compost is local, free, and one of the best fertilizers available to improve overall soil health. Soil organic matter (SOM) is about 58% carbon. This carbon originally comes from the air in the form of carbon dioxide, which is absorbed through the stomata of plant leaves and then is transformed into sugars through photosynthesis, and later further transformed into various types of plant material. The carbon bonds in organic matter hold energy, which is released when soil organisms eat it, so it is the primary food source for soil bacteria, fungi and other soil life forms that support the entire soil food web. These soil organisms change the soil to support their own growth; luckily these changes cause a cascade of effects that are beneficial to agriculture: they help the soil capture and retain more water and more nutrients; make some soil nutrients more available to crops; makes the soil more resistant to wind and water erosion; and allows roots easier access to deeper soil nutrients and water. Without organic matter, soils die. Most agricultural soils, which experience organic matter depletion over time unless properly maintained by the addition of compost, can only support crop growth adequately when they receive increased applications of energy-intensive fertilizers and irrigation. Successful farming requires soil organic matter levels in the 4-6% range, where soils can reach optimal health and productivity with a minimum of additional inputs when managed well.

How much compost is needed to increase soil organic matter levels? An accurate answer depends on many factors affecting the metabolic activity of soil organisms: soil temperature, moisture level, and texture. But, in general, applying 2 to 3 cubic feet of compost per 100 square feet annually is necessary to maintain most agricultural soils' organic matter levels at a level that will support production. In situations where the SOM levels are extremely low, it may be necessary to apply as much as 4 to 6 cubic feet per 100 square feet annually, but applications levels above 6 cubic feet per 100 square feet are generally not *sustainable*. This is because 100 square feet of soil cannot produce enough crops to make more than 6 cubic feet of compost per year. Unsustainable levels of compost application require "robbing" one soil in order to feed another, creating a cycle of depleted soils

As farmers, we have two different goals for organic matter. On one hand, we want our soil's organic matter to be available to soil microbes to feed the soil food web and maintain nutrient accessibility to our crops. On the other hand, we want our soil organic matter to persist in the soil so that we can increase our soil's organic matter levels and reap the productivity and fertility benefits of a soil with relatively high organic matter. In addition, because soils can hold a lot of organic matter, and organic matter has a lot of carbon, improving soil organic matter levels can help reduce atmospheric carbon and thus mitigate climate change. Percentages of organic matter are in weight of organic matter per weight of soil, and generally represent the top 6 inches of soil. The average amount of organic matter currently in agricultural soils is about 1% (this average continues to decline over time, due to wind and water erosion, unsustainable farming practices, and other factors).

What if we want to estimate the amount of additional carbon an acre of soil could hold if we increased its organic matter level from 1% to 5%?

Let's first assume that the density of the soil (called its "bulk density") is 1.3 grams per cubic centimeter (cm^3). That means that a cubic centimeter of this soil weighs 1.3 grams (which is pretty average). If that cubic centimeter of soil contains 1% organic matter by weight, that is 0.013 grams of organic matter; since organic matter is 58% carbon, that means there is approximately 0.0075 grams of pure carbon in a cubic centimeter of this soil. Using conversion factors, we know that there are a whopping 616,741,000 cubic centimeters in the top 6 inches of an acre of land. Multiplying this by 0.0075 grams of carbon gives us 4.625 million grams or 4.625 metric tons of carbon. If we increase the organic matter level to 5%, the acre of soil will now be holding 23.1 metric tons of carbon, or an increase of 18.5 metric tons. There are 3.43 billion acres of arable land in the world. If we increased the organic matter by 4%, we could bring about 63.5 billion metric tons (gigatons) of carbon from the atmosphere to the soil. While this is not close to the 530 gigatons of carbon estimated to have been released by human activity since 1850, if we could not only increase the top 6 inches but instead the top 24 inches, using GROW BIOINTENSIVE® and other methods, we might enable soils to hold close to half the amount released – a huge contribution to CO_2 drawdown levels. Obviously, the challenges we face in improving our agricultural soils and drawing down our atmospheric carbon levels are immense but increasing soil organic matter levels is an important approach that farmers and gardeners can use.

Over the past few decades, surprising findings have been made – and repeatedly proven true by researchers –about organic matter in the soil, but popular writers, teachers and others have found them difficult to accept. These finding include the facts that:

1) Humic substances such as *humins*, *humic acids*, and *fulvic acids* – popularly thought to be components of organic matter distributed in terrestrial soil, natural water, and sediment, fundamental to soil fertility and used extensively as plant nutritional supplements - *have never been found in soil* using very high tech, sophisticated methods. Instead, these molecules are artifacts: substances created as a result of the alkaline extraction methods used for years by soil chemists when analyzing soil organic matter. Mistaking these substances for natural compounds necessary to soil fertility, researchers incorporated their "discoveries" into soil literature as being synonymous with soil organic matter.

2) Soil microbes degrade organic matter in the soil, but after that degradation process, *contrary to some schools of thought, they do not "glue" smaller organic molecules together to synthesize larger, more complex organic molecules*. Organic molecules in the soil are simply degraded plant materials, degraded microbes, microbial metabolites, and black carbon existing in the soil and interacting with the mineral components of the soil.

3) *The idea that some organic compounds are resistant to degradation and persist in the soil due to their chemical nature is not quite accurate*. In fact, organic *molecules* such as lignin (a complex oxygen-containing organic substance that, with cellulose, forms the chief constituent of wood) are degraded fairly easily, much more quickly than a *complete* organic substance (like a piece of wood. *It is not the chemical nature of the compounds that leads to stability* of organic matter in the soil: instead, physical interactions of organic substances with the environment leads to more (or less) stability: being physically inaccessible or hidden from soil microbes, interacting and binding with mineral/clay surfaces in the soil, and/or being within soil pores that are then filled are the proven causes of organic matter stability and long-term persistence of organic compounds in the soil.

Why is this important, or interesting? Because knowing how organic matter persists in soil allows us to choose which tools and techniques to use so we strike the right balance when making soil organic matter available to microbes so our crops can take up valuable nutrients, while keeping enough carbon in the soil to build fertility and keep our productivity sustainable over time.

- One of the most critical tools is growing compost material we grow and return to the soil each year. To achieve a harmonious and sustainable balance between productivity and fertility over time, we are guided by the rule that *60% of our crop-growing area and time should be devoted to producing large amounts of compost material rich in carbon* – tall crops like corn/maize, sorghum, rye, wheat and other “small” grains, which ideally produce food and calories as well – but their lignin content is not important.

- In addition, how we return the crop residues to the soil is another tool to consider. There is now strong evidence that *composting with a higher initial Carbon:Nitrogen ratio, with less “turning” of the compost during the decomposition process, allows a higher quality and quantity of organic matter to be returned to the soil.*

- Finally, we have the tool of cultivation to consider. Some cultivation is beneficial, particularly for soils that are compacted and lack the open soil structure that is necessary to provide air for soil microbes and pore spaces for roots to grow. However, *excessive* cultivation leads to increased rates of soil organic matter degradation. The goal with GROW BIOINTENSIVE is to grow soil, which includes growing soil structure, up to 2 feet deep. An initial cultivation using double-digging is generally very valuable and may continue to provide benefits for several years, but the goal over time is to *minimize* cultivation – while continuing using all other 7 principles of GROW BIOINTENSIVE – to allow soil organic matter levels to increase and an optimal soil structure to be reached and maintained.