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Organic Matter is an Essential Component of Soils

Soils are composed of mineral and organic matter. Weathered rocks provide soil minerals, while organic matter forms from decayed animal and plant residues. An important component of healthy soil, organic matter helps maintain and improve soil's physical condition. Some of these benefits include increased nutrient and water holding as well as stabilizing structure, which helps soil drainage.

Organic matter is in a constant state of transition, continually breaking down and releasing finer, more decomposed particles. This breakdown is caused by scavengers in the soil (insects, earthworms, bacteria and fungi) as they feed on organic matter. These scavengers also become part of the soil organic matter when they die. As long as there are fresh sources of tissue in the soil, the cycle can continue and organic matter levels will stay constant. However, if fresh material is not added to the soil, organic matter will slowly be lost.

Forests and Grasslands Recycle Organic Matter while Agriculture Must Add and Maintain It

In a forest, nutrients are cycled as trees pull them from the ground, and the falling leaves return them to the soil, completing the cycle. Over time, the soil will reach a natural maximum organic matter content.

In rangeland or pastures, plant roots provide constant replenishment of organic matter. When these forest and grassland ecosystems are used for

Figure 1. Forest soil receives organic matter from leaf fall, while the adjacent agricultural land must have applications of manure or high carbon amendments

agronomic production, the addition of organic matter is often severely reduced (Figure 1). To maintain a healthy level of organic matter in agricultural ecosystems, we can either add organic materials, or minimize how quickly they are lost.

Organic Matter is Lost as Bacteria and Fungi Transform Carbon into Carbon Dioxide (CO_2)

Since CO_2 is a gas, it moves from the soil to the atmosphere. This release of CO_2 from soils can be used to determine the activity of soil biology as a measurement of soil health.

Mineralization is a term used to describe the breakdown of organic matter into inorganic, mineral components. This includes CO_2 as well as nitrogen (N), phosphorus (P) and other nutrients that come from organic matter. Soil bacteria also need these available nutrients. If there are excess nutrients that aren't needed, they are released to the soil and can be used by grain and forage crops.

It is important to remember that plants need mineral forms of nitrogen (NO_3 or NH_4), while most N in plant tissues is tied up in molecules like amino acids. Soil bacteria play a beneficial role, as they can convert amino acids into plant-available forms.

One of the Most Obvious Methods of Adding Organic Matter to Soils is to Use Animal Manure, Biosolids or Compost

There are other carbon-rich amendments you can add like biochar or cover crops. Biochar is a charcoal-like material that is a byproduct of burning materials such as grasses or manure with no oxygen. The Terra Preta soils of South America are an example of the burning process. These soils have a high organic matter content due to burned residues that add a highly stable, high-carbon organic matter to the soils.

Green manure is another way to add organic matter to soil. Like cover crops, green manure protects against soil erosion, helps retain nutrients, and suppresses weeds. Rather than being harvested, a green manure crop is mowed, crimped or plowed into the soil to become organic matter. These crops can be chosen for their soil nitrogen-building abilities (legumes) or subsoiling and macropore production (cereal grasses).

Amount of Available Carbon and Nitrogen is Different among Manures and Other Organic Amendments

The ratio of carbon to nitrogen (C/N) in any organic material will impact decomposition and nutrient availability. When the C/N of organic materials goes above 20 (20 times more C than N), there isn't enough N in the tissue to satisfy soil bacteria. To continue feeding on the organic matter, bacteria pull N from the soil supply. In those situations, soil N will become immobilized by bacteria and unavailable for plant uptake.

Materials with high C/N include wood chips and sawdust. While these materials may add carbon to a soil, they could also cause N deficiencies if added to

a garden. Alternatively, the lower ratio found in manures (12:1) will provide enough N for bacteria so that any excess is released into the soil. That is why manures make good N fertilizers. Bedding can also have an effect, as sawdust or straw will add more carbon to animal manures.

When Water Quality Limits Manure Applications, Soil Maintenance is Key

Where there are limits to adding manure to soils, a farmer can build up organic matter using management practices that limit tillage and leave crop residues. Soils with minimal tillage develop aggregates, or clods, of mineral and organic materials. These aggregates protect organic matter from breakdown by soil biology. Aggregates are typically easier to form and maintain in soils with more clay.

When soils undergo tillage, and aggregates are broken up, organic matter is lost at a faster rate. If manure can't be added, farmers can use minimal tillage to maintain a higher organic matter content.

Some simple methods to recognize soils with high organic matter include dark, blacker soil colors as well as strong granular structure. These spherical soil shapes can form quickly (although very small) around plant roots (Figure 2). Granular structure can be seen around grass roots and pastures.

Water-logged soils, like those in swamps, bogs and coastal areas, also limit soil biology. Saturated soils limit oxygen, a necessary ingredient for microbial respiration. However, when coastal regions (e.g., the Everglades or North Carolina pocosins) are artificially drained, organic matter becomes exposed and easily lost to microbial respiration.

While Most Manure/Plant Decomposition Results in Losses as Carbon Dioxide (CO_2), What Remains is Mostly Stable Humic Materials

Humic materials are complex and difficult to separate and describe. However, a common fractionation is to split them up by how well soil organic matter remains dissolved in acids or bases. This method splits organic matter into fulvic acids (FA), humic acids (HA) and humin.

Fulvic acids remain dissolved in acid or base solutions, which is important when considering nutrient availability. Fulvic acids can bond to micronutrients and since FA stay dissolved, they keep micronutrients available to plants. Micronutrients such as Copper (Cu) and Zinc (Zn) become solids at higher pH, so FA can be important in soils with lower amounts of micronutrients.

Humic acids have a greater molecular weight than FA and are not soluble in acidic solutions. This means that HA will not remain dissolved in most Maryland soils. While this doesn't help with

Figure 2. The darker colored soil from this lawn is granular in shape because of high organic matter

micronutrients, it can be beneficial if soils are higher in toxic metals (e.g. aluminum (Al)). Metals like Al can bond to HA and have reduced toxicity.

The third type of organic matter, humin is the most complex product of decomposition and does not dissolve in either acid or base solutions. Still, humin has the ability to attract and hold nutrients and water, as well as increase the stability of soil aggregates.

There are commercially available products that can add FA or HA to the soil. Observations of their effectiveness are mixed, which is probably due to the variability in soil type as well as the interaction with the soil biological community.

Evaluating your soil texture, soil organic matter content and management practices should provide some insight into using soil conditioners to increase FA or HA. Of course, any soil that is no-till and receives manure or cover crop residues will get plenty of fresh FA or HA as the material decomposes.

Organic Matter Benefits Almost all Soils

While it may seem difficult to maintain, organic matter can be managed to improve soil health. Increasing organic matter in the soil surface, improves other soil properties by:

- Lowering bulk density;
- Increasing pore space for drainage;
- Increasing the ability to hold nutrients; and
- Improving aggregate stability

Aggregate stability is important because if soil clods break down at the first sign of rain, the surface can become an impenetrable crust. A hard soil surface is not good for seed emergence.

The benefits of organic matter aren't limited to physical properties. It also provides:

- Slow-release N;
- Macro/micro nutrients; and
- A diverse microbial population

An excellent source of organic matter provides good nutrient cycling and improves organic matter turnover. This is best accomplished through a diverse microbial pool. Older, stable organic matter, as well as fresh organic material (manure, cover crops and year-round plant), increase biota diversity and soil health.

Further Reading

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Terry E. Poole. Updated by Jarrod O. Miller.

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