Organic Matter: Fuel for Your Soil

What is soil organic matter?

Soils are composed of both abiotic (non-living) and biotic (living) components. Soil has four main components: mineral matter, organic matter, air, and water (Fig. 1). The mineral matter is composed of sand, silt and clay particles. The proportion of these mineral components is what forms the texture of your soil. The soil water contains dissolved minerals and is the main source of water and nutrients for plants. The air in the soil is needed for plant roots and soil microorganisms to obtain oxygen. The soil organic matter includes a variety of plant and animal debris in different stages of decomposition. The living plant roots and soil microorganisms are also often considered part of the soil organic matter.

Soil organic matter is the smallest component of the soil. Although it is a small percentage of the overall soil, it is the heart of a healthy productive soil. Most of the soil organic matter is present near the soil surface (top six inches), rather than deeper in the soil.

Fertility, water availability, susceptibility of erosion, soil compaction, and even resistance to disease all depend on soil organic matter! Crop cultivation, harvesting, erosion, and natural decomposition can play a role in the gradual reduction of organic matter in soils. However, you can maintain and even increase your soil's current organic matter level through proper management.

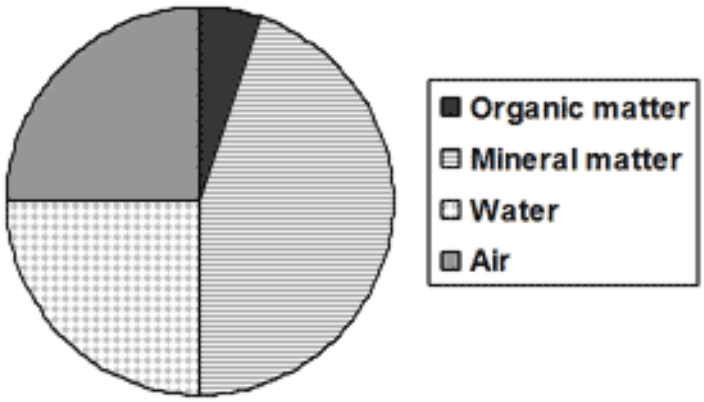

Figure 1. There are four main components of soil

Components of soil organic matter

Not all soil organic matter is created equal. Soil organic matter is divided into three pools based on their availability for microbial breakdown (Table 1).

Table 1. Pools of organic matter and the different roles they play in the soil

Pool	Size/Age (years)	Functions
Biologically Active	Small (1-5)	nutrient mineralization, macro-aggregation, disease suppression
Protected	Intermediate (5-30)	soil structure, porosity, water relations
Stable	Large (50-10,000)	micro-aggregation, CEC, fate of ionic and non -ionic compounds, colors

As soil organisms decompose plant and animal debris they transform the organic matter into new compounds. After years or even decades of these transformations, the organic matter is eventually transformed into complex compounds that very few microbes can further degrade. The hard to degrade compounds make up the largest percent of your soil's total organic matter (Fig. 2). Stable organic matter consists of three chemical groups: humic acids, fulvic acids and humins. Much of the stable organic matter in the soil originated from plants that grew one or more centuries ago.

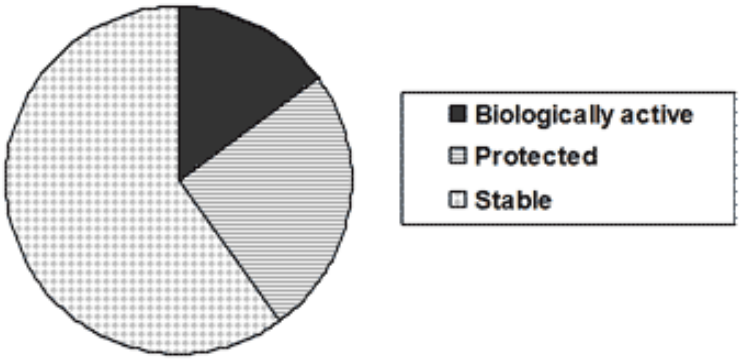

Figure 2. There are three pools of soil organic matter

Some of these compounds become bound with clay particles to form microaggregates. These microaggregates hold on to nutrients like a magnet holds onto 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 addition to nutrients, stabilized organic matter can absorb six times its weight in water. The water holding capacity of organic matter will make the difference between crop failure or success during a dry year. Lastly, stable organic matter binds to a pesticide which prevents them from moving into the water supply.

The biologically active pool is composed mainly of plant residues in different stages of decomposition. This is the smallest and youngest pool and has a high turnover rate of 1 to 2 years. A soil rich in active organic matter will support a diverse, active population of soil organisms. 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 materials and release plant-available nutrients such as ammonium.

Decomposition of active organic matter is especially important in providing nitrogen, phosphorous, sulfur, and iron. As the soil organisms feed and decompose on the active organic matter they play a role in forming soil macroaggregates. Soil aggregates are clumps of soil particles that are held together by moist clay, organic matter (like roots), gums (from bacteria and fungi) and by fungal hyphae. Organic matter that becomes trapped within an aggregate is thought to be the protected pool of organic matter. The protected pool is available for decomposition by soil organisms but physically protected within soil macroaggregates from microbial attack. This pool is intermediate in size and age and turns over in two to five years. Soil pores are the spaces between soil particles and between soil aggregates. They can be full of air or they can have water in them. Soils with lots of aggregates are called "well-aggregated" and this condition is thought to be very desirable. Well-aggregated soil allows good root penetration, improves water infiltration, makes tillage easier, and reduces erosion. A soil high in active organic matter is also less likely to support uncontrolled spread of plant pathogens. Complex interactions between an enhanced soil population and plant pathogens create situations in which the soil-borne pathogens are suppressed. For example, research studies show that applications (10 – 15 tons/acre) of organic amendments (both raw and composted) can reduce the severity of root rot diseases.

How do I build up soil organic matter?

To effectively manage your soil organic matter you will first need to determine your management goals (Fig. 3). Essentially to build organic matter in a soil you want to add organic material and reduce organic matter losses.

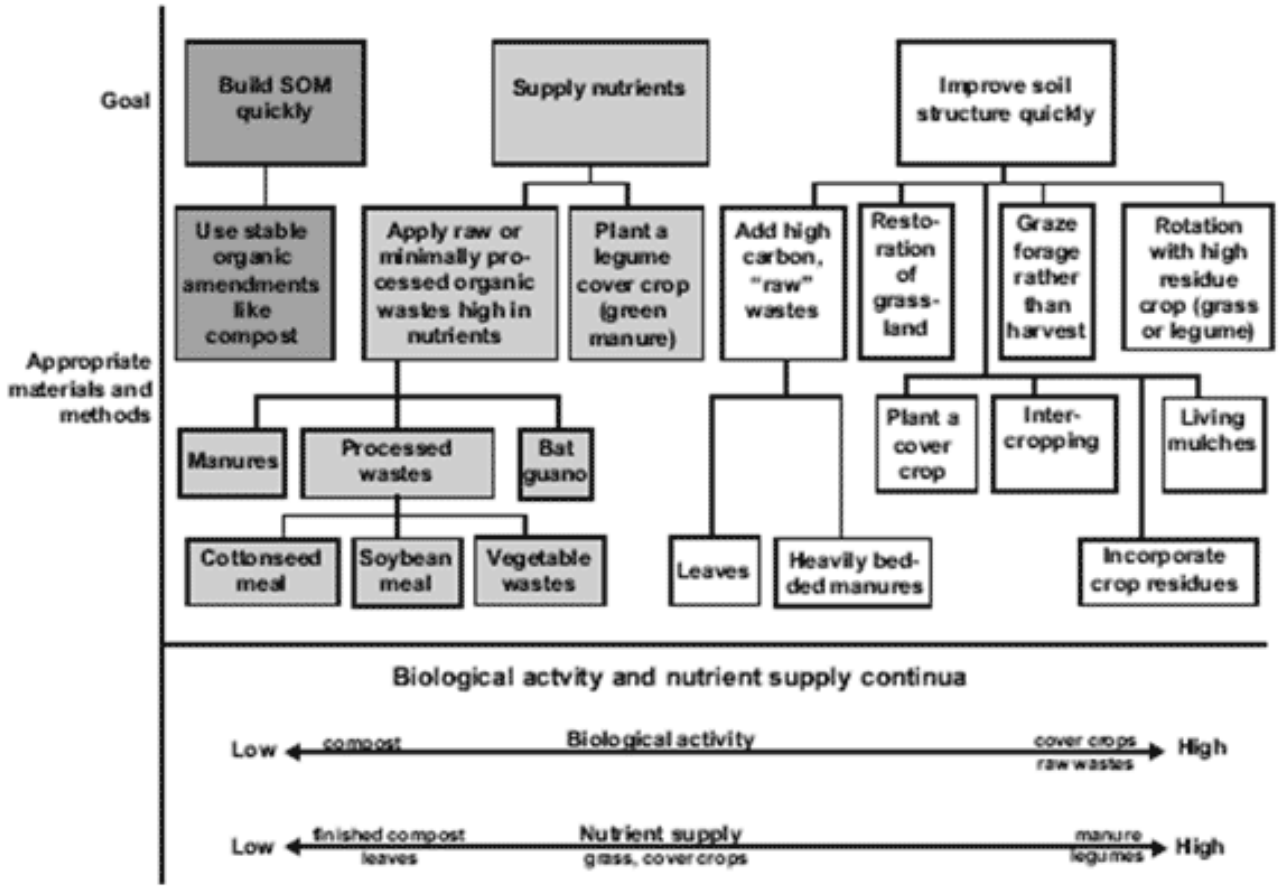

Figure 3. What is your management goal? (Dr. Leslie Cooperband, Univ. of WI)

Reducing organic matter losses is an important aspect of maintaining soil organic matter. Most organic matter losses in soil occur after land is cultivated. Native levels of organic matter may not be possible under row crop production, but many farmers can increase the amount of active organic matter by reducing tillage. Intensive tillage aerates the soil and increases decomposition of organic matter. Commonly decomposition of organic matter is faster than the rate at which organic matter is added back to the soil therefore soil organic matter levels decrease. Controlling erosion as reduces organic matter loss. The soil that erodes from the surface of your land is the soil with the highest concentration of organic matter. Erosion can be reduced by keeping the soil covered with residue or growing plants. Reducing organic matter loss 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.

To add organic matter you can simply grow healthy and productive crops and plan a high residue crop rotation that include sod crops that leave lots of roots in the soil, crops that leave lots of surface residue, and/or cover crops that supply both. Organic amendments can also be used to build soil organic matter. There is no end to the number of possible organic amendments available for your soil. Organic amendments can be applied raw or following some kind of processing like anaerobic digestion or composting. Common amendments in Vermont include

- On-farm wastes: manure, composted manure, crop residues, spoiled straw, hay and silage
- Municipal wastes: yard debris
- Post consumer food wastes (homes, restaurants, institutional cafeterias)
- Pre-consumer food wastes from grocery stores
- Composts

Fertilizers are a source of readily available nutrients and have a direct, short term effect on plant growth. Soil conditioners affect plant growth indirectly by improving the physical and biological properties of the soil, such as water retention, aeration, and microbial activity. Animal manure is an example of an organic amendment with fertilizer value. It supplies the N, P, and K needs of many crops because greater than 25% of their total nutrient contents are in forms readily available for the crop. Compost is an example of a soil conditioner. Compost has the unique ability to improve the chemical, physical, and biological characteristic of soils.

Always remember that building and maintaining organic matter takes a sustained effort. When you begin to add organic matter to the soil, the first pool to increase is the active organic matter. Gradually, the species and diversity of organisms in the soil will change, and the amount of stabilized organic matter will rise. It may take a decade or more for the total organic matter levels to significantly increase after a management change. However, don't get discourage, the beneficial effects of adding organic matter appear long before the total organic matter levels (values you see on your soil test) rise. Remember, that the improvements that are made can easily be reversed in a year or two by returning to previous practices.

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