

STRATEGIES TO INCREASE ORGANIC MATTER IN THE SOIL

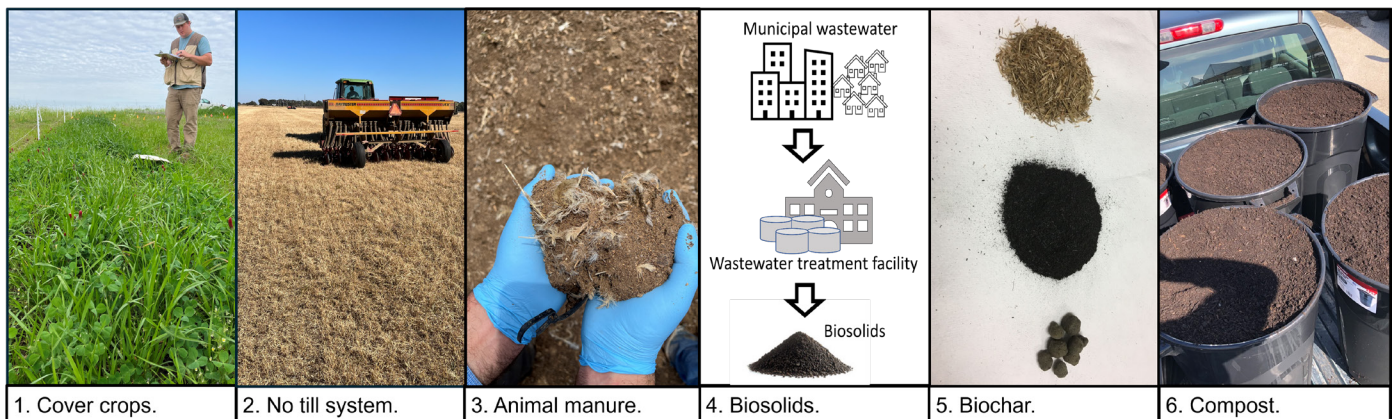
HIGHLIGHTS

- Increasing organic matter in the soil will lead to an improvement in soil chemical, physical and biological properties.
- Reactions that occur in the soil cause loss of organic matter to the atmosphere as carbon dioxide is released. Therefore, it is essential to continuously add organic matter to the soil.
- Organic matter persistence in the soil can only be achieved by reducing or eliminating tillage practices.
- The improvement of organic matter content in the soil can be done through the adoption of conservative agricultural practices, such as cover crops, no-till farming and the application of organic amendments (manure, biosolids, biochar and composting).

IMPORTANCE

Organic matter is the organic part of the soil and is the most important indicator of soil health. According to the United States Department of Agriculture (2024), soil health is the continued capacity of soil to function as a vital, living ecosystem that sustains plants, animals and humans. Soil organic matter is composed of fresh plant residue, animal manure, soil organisms, decomposing organic matter and stable organic matter (humus). Organic matter must be regularly added to the soil because its levels decrease over time due to soil reactions. Organic matter can be enhanced through the adoption of conservative agricultural practices, such as cover crops, no-till farming and the application of organic amendments (for example, manure, biosolids, biochar and composting).

Increasing organic matter in the soil will improve soil chemical properties, including greater nutrient concentration and availability due to nutrient release and protection in plant-available forms. It will also enhance cation and anion exchange capacity, ensure slow nutrient release and reduce nutrient leaching. Additionally, soil physical properties are also improved, including formation and stabilization of soil aggregates; improvement of soil aeration, water flow and water-holding capacity; reduction of erosion and runoff; and increase in soil temperature in the beginning of the growing season. Furthermore, the addition of organic matter in the soil will enhance soil biological properties, including an increase in microbial activity and diversity, macro and mesofauna population, and plant pathogen suppression.



Photos 1, 2, 3, 4, and 6 by Leandro O. Vieira. Photo 5 by Sérgio G.Q. de Castro

COVER CROPPING

Fresh plant residues are the main food source for organisms in the soil. Therefore, cover crops foster microbial activity and diversity in a way that nutrients are mineralized. Besides, some nutrients are mineralized during the fallow season. If a cover crop is being used, plants will uptake those available nutrients, reducing their losses. In other words, nutrients will be kept in the system. A cover crop is any crop grown with the primary purpose of protecting and improving the soil.

Cover crops can provide more than organic matter and prevent nutrients from leaving the system. Leguminous plants, for example, can fix nitrogen from the atmosphere. While most of the nitrogen fixed by legumes is used to their own metabolism and growth, when the crop is terminated, that fixed nitrogen will become available for the next crop. This fixed nitrogen not only improves soil fertility but also promotes microbial activity in the soil. Other cover crops, such as brassicas, can attenuate soil compaction. Their root system is more aggressive, aerating the soil and increasing macro pores for water flow when they are terminated.

NO-TILL SYSTEM

Tillage increases microbial activity by introducing more oxygen into the soil, resulting in rapid nutrient mineralization. However, this nutrient “flush” is unnecessary during the initial growth stages and can lead to nutrient losses. More nutrients are mainly required during mid to late vegetative and reproductive stages. When no-till is adopted, on the other hand, the breakdown of organic matter will be slower allowing a gradual release of nutrients that aligns with plant needs. In addition to that, no-till practices preserve soil structure and aeration created by soil organisms and the root system of previous crops, reducing soil erosion and runoff.

While adding organic matter to the soil is essential for long term soil fertility, not tilling the soil preserves the organic matter, improving it over time. This is particularly important in tropical and subtropical regions where the decomposition of organic matter is accelerated. The warm and humid weather leads to increased microbial activity and consequently higher rates of organic matter decomposition. When implementing no-till practices is challenging, reduced tillage can serve as an alternative to improve the persistence of organic matter in the soil.



*Corn being planted in a no-till system on an area where radish (*Raphanus sativus*) was grown as cover crop. Photo by Leonardo Z. Ghizzo*



*Sugarcane planted in a no-till system on an area previously cropped with sunn hemp (*Crotalaria spectabilis*). Photo by Sérgio G.Q. de Castro*

ANIMAL MANURE APPLICATION

Animal manure adds considerable amounts of organic matter and nutrients that can increase microbial activity, growth and diversity. For example, cattle and swine manure present considerable amounts of nitrogen, phosphorus and potassium. Chicken litter, on the other hand, presents considerable amounts of nitrogen, phosphorus, potassium, sulfur and magnesium. Since most of those nutrients are in organic forms and need to be mineralized, manures act as a slow-release fertilizer. Their use results in soil fertility improvement, leading to better plant growth and soil health.

The concentration and availability of nutrients in manure rely on several factors, including the type of animal, the animal's diet, if bedding was used and how much, and the moisture content (Table 1). Additionally, how the manure is handled and stored can significantly impact nutrient concentrations. Although there is a range of expected nutrient concentrations in manure, it is essential to collect a representative manure sample and send it to a laboratory for analysis before application.

BIOSOLIDS APPLICATION

The sewage sludge, after being properly treated to be land-applied, is called biosolids. This is a heterogeneous matrix containing a significant amount of organic matter and soluble plant nutrients, such as nitrogen, phosphorus, sulfur, calcium, magnesium, iron, copper, manganese and zinc (Table 1). Similarly to manure, biosolids can also act as a slow-release fertilizer, but nutrient solubility will vary depending on treatment process. While heavy metal accumulation in soils due to biosolids application is a concern, stringent regulations on waste treatment have significantly mitigated this issue. These stringent regulations also apply to pathogen levels, and biosolids that can be land-applied present very low levels of it and typically do not pose risks to human health.

Generally, biosolids from wastewater treatments that handle only household residues should contain very low levels of metals and other chemicals. However, if industrial waste is mixed into wastewater treatment from households, unwanted chemicals can be detected in the biosolids. Therefore, it is recommended to collect a representative sample and send it to a laboratory for analysis before application.

Table 1. Average range concentrations of nitrogen (N), phosphorus (P₂O₅), potassium (K₂O), sulfur (S) and magnesium (Mg) in animal manures and biosolids.

Source		N	P ₂ O ₅	K ₂ O	S	Mg
Manure	Poultry	1.5-3.0	1.0-3.0	0.5-2.0	0.2	0.4
	Cattle	1.5	1.5	1.2	–	–
	Swine	0.5-1.2	0.3-0.7	0.2-0.3	–	–
Biosolids		4.0-8.0	2.0-4.0	0.2-0.3	0.9	1.0

Source: Adapted from Havlin et al. (2014)

BIOCHAR APPLICATION

When biomass is burned at little or absent oxygen concentrations, which is a process called pyrolysis, it becomes biochar. The advantage of applying biochar is that its carbon is not easily degradable, which can contribute to organic matter accumulation in the soil. Biochar presents a relatively high pH, cation exchange capacity and carbon concentration. It also presents low particle density and is very porous, providing a suitable habitat for increased biological activity. The nutrient concentration and plant availability depends on the type of biomass used to produce the biochar. It can be produced from a variety of sources, such as plant residues, manure, wood chips and other agricultural byproducts.

COMPOSTING

Composting consists of producing a more decomposed organic material outside of the soil by mixing, piling or storing organic materials under circumstances that promote aerobic decomposition and conserve nutrients. Commonly used as mulching material and potting mix ingredient, compost can also serve as a soil amendment. It will provide organic matter for the soil while slowly releasing nutrients, fostering biological activity. Furthermore, applying compost can potentially reduce the incidence of plant root and leaf diseases, as the high temperatures during the composting process can eliminate disease-causing organisms.

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