Improving Soil Quality By Increasing Organic Matter Content

Fact Sheet FS1137

Cooperative Extension

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The US Department of Agriculture defines soil quality as 'the capacity of a soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation' (USDA-NRCS). Organic matter content is an important component of soil quality.

Organic Matter Effects

Agricultural production. In addition to its fertility and water-holding capacity benefits, adequate soil organic matter is essential for building and preserving good soil structure, which is often the key to obtaining and sustaining high crop yields. Maintaining optimal soil organic matter is difficult almost everywhere, and under continuous tillage is nearly impossible. It is commonly found that the more disturbed a soil is, the greater the reduction in soil organic matter. The limiting factor for good crop yields on New Jersey soils is often poor physical condition resulting from excessive tillage operations without adequate organic matter additions. In fact, losses of up to 50% of organic matter have been documented in New Jersey when soils under row crop agriculture are compared to soils under pasture. Losses are even greater (up to 75%) when soils are converted from forest to agriculture.

Restoring organic matter content necessitates the use of soil-management practices that tend to accumulate organic matter, such as minimal tillage, cropping rotations, summer and winter cover crops, and the use of animal manures whenever possible. The proper use of fertilizers will also help to increase the production of green manure crops as well as improving yields of cash crops, thereby in many cases leaving more crop residues to be returned to the soil. In most cases, rates of organic matter accumulation in soils are very low (considerably less than 1% per year), but improvements in soil quality through better aggregation and increases in water retention are realized before substantial increases in active organic matter are detectable.

Ornamental landscape and turf soils. Soils under well-managed residential, industrial, or recreational lawns have higher organic matter levels and better physical properties than similar soils under intensive agricultural management. However, during initial urban development, the quality of soils is usually compromised by stripping the topsoil, localized disturbance of soil layers, and compaction. As in agricultural situations, adding organic matter improves conditions by providing nutrients, retaining water, supporting soil structure, and promoting infiltration. In turn, this benefits the environment by preventing runoff and erosion, filtering water and recharging groundwater, and minimizing the need for fertilizer and irrigation.

Global environment. Despite depletion of soil organic matter by disturbance, more carbon is stored in soils globally than the total contained in vegetation and the atmosphere (Swift, 2001). Maintaining or restoring relatively high soil organic matter content sequesters carbon, utilizing plant photosynthesis as the intermediary process to "fix" carbon dioxide (CO_2, a greenhouse gas). Conversely, loss of organic matter from soils by microbial decomposition is recognized as a source of CO_2 to the atmosphere. The capacity of agricultural, suburban, and even urban soils to sequester carbon provides potential to mitigate rising atmospheric CO_2 levels.

How Much Plant Nutrition Does Organic Matter Provide?

Since most nitrogen in soil is stored in the form of organic matter, there is a relationship between a soil's organic matter level and its nitrogen content. The relationship will vary depending on the kind and stage

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of decomposition of the organic matter present. In humid-region soils with well-humified organic matter, the carbon to nitrogen (C:N) ratio is about 10:1 (or simply 10), and the ratio of organic matter to nitrogen is about 20:1. Thus, if a soil contains 3.0% organic matter, it contains about 0.15% nitrogen. Calculated in terms of pounds per acre (to 6" depth, roughly two million pounds of soil), the approximate weight of organic matter in this example is 60,000 pounds and that of total nitrogen is 3,000 pounds. Not all of that nitrogen is immediately available; only 1 to 3 percent (30 to 90 pounds per acre) of available nitrogen will be released through the season for use by growing crops, depending on weather conditions.

Considering its usefulness as a source of nitrogen for plants, the quality of organic matter is closely related to its degree of decomposition and its initial percentage of nitrogen. Fresh green organic matter is more valuable as a nitrogen source than that remaining as a more-or-less final decomposition product. Well-rotted animal manure, clover sods, and other young "green manures" are much more useful as sources of nitrogen than are straw, corn-stalks, timothy sods, woodchips, sawdust, etc. The smaller the percentage of nitrogen in organic materials, the less nitrogen released for plant use after the microorganisms of decomposition have had their nitrogen requirements satisfied. Unless organic materials contain over 1.5% nitrogen, on a dry-weight basis, little or none of this element will be released for plant use during the season immediately following their incorporation into the soil.

Therefore, if organic materials containing more than 1.5% nitrogen are added to the soils, that fraction of nitrogen exceeding 1.5% will be available in a relatively short period of time for a growing crop. However, when materials such as wheat straw, corn stalks, wood chips, sawdust, etc. that contain less than 1.5% nitrogen are incorporated into the soil, it is necessary either that considerable time be allowed to elapse before a crop is planted or that extra nitrogen be added to meet the further needs of the soil microorganisms and to feed the crop.

Current Recommendations For Organic Matter Additions To Soil

For soils having "low" organic matter content, it is recommended that organic matter amendments be added to increase organic matter content by 1/2 to 1%.

In agricultural situations, soil organic matter amend-ments include crop residue, cover crops plowed into the soil in the spring ("green manure"), animal manure, sewage sludge, municipal leaves, and composts of various sources, such as food industry waste. For any of these cases, it would be desirable to have a nutrient analysis of the organic amendment to determine the fertilizer "credits" that the application provides, reducing commercial fertilizer applications appropriately.

In suburban settings, backyard compost, sphagnum peat moss, or commercial "humus" products can be used to increase soil organic matter content. Prior to seeding or transplanting, spread 3 to 5 cubic feet of organic amendment per 100 square feet (equivalent to 1 to 1.5 cubic yard per 1000 sq. ft), creating an organic layer approximately 1/3 to 1/2" deep. Till or turn in and mix to a depth of about 6".

For established perennial plantings (including grasses), in which the organic matter amendment cannot be mechanically mixed into the soil, smaller applications left on the surface or raked lightly in will have to suffice. Repeated applications can be made to achieve significant increases of soil organic matter over time. To the extent that soil biota (earthworms, ants, etc.) thrive, organic matter will be re-distributed deeper into the soil. Furthermore, the turnover of fibrous roots of the perennial crop and lack of soil disturbance will contribute to building soil organic matter content as well. Soil fungi, including beneficial mycorrhizae, have the opportunity to establish in undisturbed soil but are hindered in annually cultivated soil.

Can Soils Have Too Much Organic Matter?

Soil organic matter in natural soils accumulates in cold climates and/or under wet conditions. While organic matter is a very valuable component of good quality soil, addition of organic matter may not improve soil quality in some specific situations. Excessive organic matter might cause too much water retention, particularly in poorly drained soils, leading to aeration problems in certain sites for unadapted plants. Soil that is continually wet will also promote root disease in susceptible plants. On the other side of the spectrum, organic matter can also cause problems in hot, dry sites. Dry organic matter becomes hydrophobic and will actually repel water rather than absorb it.

Another problem with excessively high contents of organic matter is related to its binding to pesticides, reducing their effectiveness. With a greater percentage of pesticides bound to soil organic matter, the potential accumulation of pesticides in the soil increases and with that the risks of environmental pollution and exposure. Certain nutrient deficiencies are associated with organic soils (for example, copper), which require

careful fertilizer management. Also, soils having large proportions of organic matter will decrease in volume over time as the organic matter oxidizes, needing continual replenishment, a potential difficulty for perennial plantings/crops. For all these reasons, very high soil organic matter content is not encouraged; 10% organic matter content of soil is suggested as a maximum for general agronomic/horticultural use. Organic-matter based "soilless" mixes are best utilized for greenhouse, container, and rooftop gardening use with high levels of management.

Conclusion

Suggested best soil management practices always include maintaining an optimal range of organic matter content to favor crop/vegetation growth and enhance the health of the environment.

References

USDA-NRCS Soil Quality website, soils.usda.gov/sqi/concepts/concepts.html

Swift, Roger S. (2001) Sequestration of carbon by soil. Soil Science 166:858-871, Lippincott Williams & Wilkins, Inc.

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Modified & updated from an unofficial fact sheet (#4S) by Dr. Roy Flannery, former extension specialist/professor, Rutgers University.

Additional Resources

Rutgers Cooperative Extension Fact Sheet FS1135 Soil Organic Matter.

Rutgers Cooperative Extension Fact Sheet FS1136 Soil Organic Matter Level and Interpretation

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