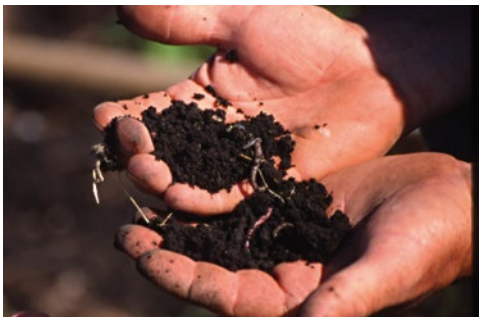


Turfgrass Biological Soil Health

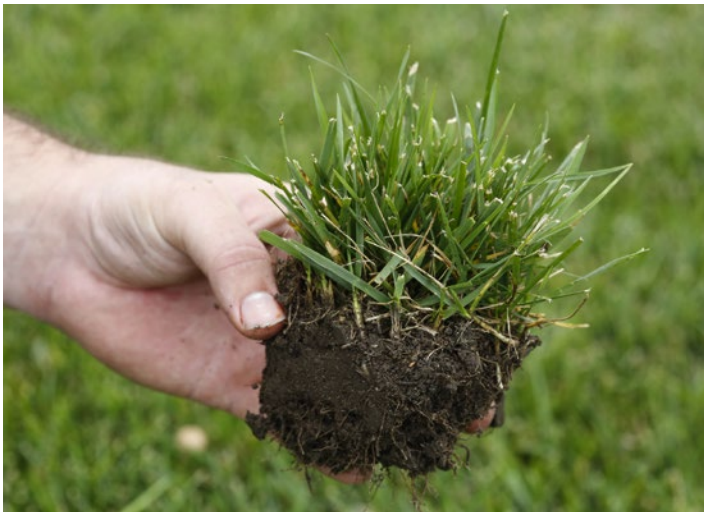
Overview

Soil health or soil quality refers to the ability of soil to function and sustain productivity, enhance and maintain water and air quality, and support plant health. Soils provide many essential functions, such as regulating water, sustaining plant and animal life, reducing potential pollutants, cycling nutrients, and physical stability. Soil health involves physical, chemical, and biological processes and properties. Common physical soil health indicators include soil texture, compaction, moisture, aggregation, and porosity. Common chemical soil health indicators consist of soil nutrient analysis, including carbon and nitrogen, organic matter, pH, and cation exchange capacity. However, soil physical and chemical properties generally have a slow response to management changes. Additionally, soil biological properties often are more sensitive to management practices, making these easier to influence.

Biological Soil Health

Soil biology includes macroorganisms, bacteria, actinomycetes, protozoa, algae, nematodes, and fungi. Macroorganisms are comprised of earthworm and arthropods, and their main functions are breaking down organic matter and enhancing soil structure. Bacteria have several functions in the soil, but the most important is decomposing residues, which release nutrients to the plants. Actinomycetes are similar to bacteria, but grow like fungi, and their primary benefit is breaking down more resistant plant and animal materials. The main benefits of protozoa in the soil is reducing bacterial diseases since these feed on bacteria, which also releases nitrogen for plant growth. Algae can be problematic and compete with turfgrass if it is mowed at a short height of cut or is thinned out. Once algae is established it can result in a surface crust layer, which limits nutrient and water movement, and control measures may be necessary. Nematodes can be beneficial or detrimental to turfgrass health. For instance, turfgrass health improves as nematodes release nutrients to the soil by consuming other organisms. On the flip side, nematodes can be detrimental when they feed on plant roots and promote plant disease. Lastly, fungi has several benefits such as the decomposition of organic matter and facilitating the plant uptake of moisture and nutrients.

Common biological soil health indicators include soil microbial biomass, enzymes, mineralization, and respiration. Management practices that influence biological soil health include fertilizers, soil amendments, biostimulants, pesticides, and cultural practices. Improving biological soil health can result in enhanced nutrient cycling and availability, improved soil aggregation and structure, increased decomposition of organic matter, and improved water infiltration and holding capacity.



IOWA STATE UNIVERSITY
Extension and Outreach

HORT 3111 July 2021

Depending on the type of fertilizer, it can have either positive or negative effects on biological soil health. For example, many inorganic fertilizers have higher salt levels and can change the soil pH, both of which can reduce microbial populations and activity. On the other hand, organic fertilizers (biosolids, composted poultry manure, organic meals, etc.) increase microbial populations, stimulate microbial activity, and enhance nitrogen mineralization, which is most likely due to the addition of carbon with the fertilizer application. Microbes utilize carbon for energy, thus carbon often is the limiting factor for microbial growth and activity in the soil. Maintaining balanced and consistent fertility, along with maintaining a balanced pH, can enhance microbial activity. See below for additional material on Natural (Organic) Fertilizers and Lawn Fertilization.

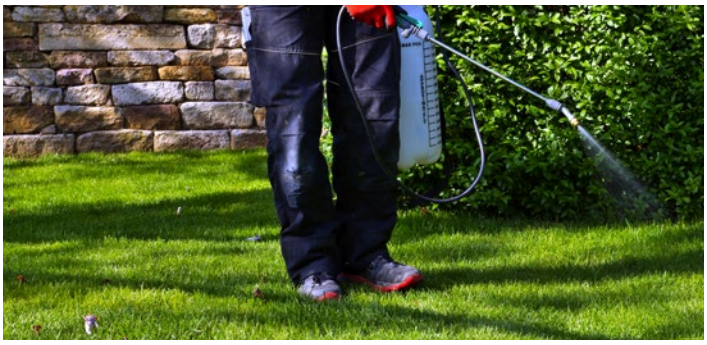
Soil Amendments

Compost/manure can improve soil biological health in a similar way to organic fertilizers. Compost/manure provides nutrients and carbon to the soil, both of which can be utilized by microbes. Thus, compost/manure has the potential to increase microbial populations and activity. However, there are a few concerns using compost as a soil amendment, such as inconsistent compost quality and high salt levels, which can lead to declines in biological soil health.

Humic substances are another soil amendment that can have positive effects on biological soil health. Humic substances (fulvic acid, humic acid, and humin) are carbon-rich, complex, heterogeneous mixtures that are formed by reactions during the decay of plant and microbial substances. Humic substances can lead to increases in microbial populations and activity, improved nitrogen mineralization, and increases in soil respiration. However, benefits from the additions of humic substances can vary depending on rates, soil type, and geographic location.

Biostimulants

Seaweed extracts, humic substances, protein hydrolysates, amino acids, and microbial inoculants have been used as biostimulants on turfgrass. Biostimulants are materials that stimulate plant and microbial growth when applied at small quantities. Seaweed extracts and humic substances increase microbial growth and development by providing carbon, and for seaweed extracts, additional nutrients and trace minerals. Fish and squid hydrolysates, along with amino acids, can provide nutrition to the turfgrass and microbes when applied at higher rates. At lower rates, these act as biostimulants that increase microbial populations and activity. Amino acids and aquatic hydrolysates provide nitrogen and carbon to



microbial populations. In general, microbial inoculants have had minimal success at improving biological soil health. This is due to several reasons including shelf life and long-term storage, and establishment and survival after being applied to the soil. The poor colonization after application is due to abiotic stresses of the soil environment and from competition with the native microbe populations. Similar to soil amendments, benefits from applications of biostimulants are variable and inconsistent, and can depend on climatic conditions, soil type, and geographic location.

Pesticides

Fungicides, insecticides, nematicides, and herbicides all are considered pesticides. Pesticides target pathogens, insects, and weeds, and are applied to turfgrass to maintain a healthy turfgrass stand. However, applying pesticides may have an adverse effect on beneficial soil microbes, and thus, reducing biological soil health. In contrast, some pesticides stimulate microbial growth and activity. In conclusion, the result of pesticide applications is not easily predicted, and may impact positively or negatively soil microbial communities, soil biochemical reactions, and soil enzymes.

Cultural Practices

Soil moisture management, aeration, and returning clippings can improve biological soil health. Maximum microbial activity generally occurs when the soil is around 50% of the soil's water holding capacity or field capacity, so timely irrigation may have to be applied during drought conditions. If the soil is allowed to dry or becomes saturated with water, microbial activity decreases. Aeration techniques (especially hollow tine aeration) can lead to improved biological soil health. Many of the beneficial turfgrass microbes require oxygen to survive and grow, so aerification should be considered if the soil becomes compacted or does not drain water effectively. An additional cultural practice to improve biological soil health is to return clippings when possible. Returning clippings increases microbial populations and activity compared to removing the clippings.

More Information

The following publications are available at county extension offices and the **Iowa State University Extension Store** (store.extension.iastate.edu):

- HORT 3031: **Natural (Organic) Fertilization for Turf**
  store.extension.iastate.edu/product/14460
- PM 1057: **Lawn Fertilization**
  store.extension.iastate.edu/product/4378
- HORT 3093: **Turfgrass Management Calendar: Kentucky Bluegrass Lawns**
  store.extension.iastate.edu/product/4383

References

Datta, R., Baraniya, D., Wang, Y.F., Kelkar, A., Meena, R.S., Yadav, G.S., ... and Formanek, P. (2017). Amino acid: its dual role as nutrient and scavenger of free radicals in soil. Sustainability, 9(8), 1402.

Doran, J. W. (2002). Soil health and global sustainability: translating science into practice. Agriculture, ecosystems & environment, 88(2), 119-127.

Fetter, J.C., Brown, R.N., and Amador, J.A. (2013). Effectiveness of squid hydrolysate as a home lawn fertilizer. HortScience, 48(3), 380-385.

Hussain, S., Siddique, T., Saleem, M., Arshad, M., and Khalid, A. (2009). Impact of pesticides on soil microbial diversity, enzymes, and biochemical reactions. Advances in agronomy, 102, 159-200.

Khare, E., and Arora, N. K. (2015). Effects of soil environment on field efficacy of microbial inoculants. In Plant microbes symbiosis: applied facets (pp. 353-381). Springer, New Delhi.

Shi, W., Bowman, D., and Rufty, T. (2007). Soil microbial community composition and function in turfgrass ecosystems. Biodivers. Bioavailability, 1, 72-77.

Shi, W., Muruganandam, S., and Bowman, D. (2006). Soil microbial biomass and nitrogen dynamics in a turfgrass chronosequence: a short-term response to turfgrass clipping addition. Soil Biology and Biochemistry, 38(8), 2032-2042.

Tian, G., Granato, T.C., Dinelli, F.D., and Cox, A.E. (2008). Effectiveness of biosolids in enhancing soil microbial populations and N mineralization in golf course putting greens. Applied Soil Ecology, 40(2), 381-386.

Torello, W.A. (2008). Microbiology of turfgrass soil. Hole Notes. August. 40(7), 22-23.

Written by Alex J. Lindsey, postdoc research associate, horticulture; Adam Thoms, assistant professor, horticulture; and Nick Christians, university professor, horticulture, Iowa State University.