Virginia Cooperative Extension
Virginia Tech • Virginia State University
EXPERT REVIEWED
SPES-408P

Building Healthy Soil with Best Management Practices

Authored by Sapana Pokhrel, Graduate Student, School of Plant and Environmental Sciences, Virginia Tech; Rory O. Maguire, Professor and Extension Specialist, School of Plant and Environmental Sciences, Virginia Tech; Wade E. Thomason, Professor and Extension Specialist, School of Plant and Environmental Sciences, Virginia Tech; and Ryan D. Stewart, Associate Professor, School of Plant and Environmental Sciences, Virginia Tech

Soil Health

Soil health is a phrase that has become popular among soil scientists, farmers, policymakers, and others. The concept of soil health dates back over 100 years (Brevik, 2018 and has become much more widely used in recent decades. Hundreds of scientific articles focused on soil health are published each year (Janzen, Janzen, and Gregorich 2021). These studies often report on changes or attributes of various soil physical, chemical, and biological properties that relate to soil health and their responses to different management conditions. Still, the term *soil health* continues to mean different things to different people.

By examining the words *soil* and *health,* we can piece together a useful and practical definition. *Health* refers to a state of well-being, while *soil* consists of mineral particles and soil organic matter near the Earth's surface and supports plant growth as well as human and animal life. Putting these concepts together, soil can be thought of as a living ecosystem that varies in its state of well-being. Along these same lines, the U.S. Department of Agriculture's Natural Resources Conservation Service defines *soil health* as "the continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans" (USDA NRCS, n.d.). This way of looking at soil's function and role has shifted over time.

The term *soil health* is distinct from *soil fertility* and *soil quality.* Soil fertility pertains to nutrients for optimum crop yield, quality and profit, while *soil quality* is analogous to air and water quality and relates to soil chemical and physical properties.

Soil health combines and extends these concepts, considering how soil management practices can be used to prevent soil erosion, develop soil structure, increase soil carbon and water-holding capacity, and enhance biodiversity. More important, the concept of soil health can be used as a guiding framework to address larger socioeconomic and environmental concerns.

Core Principles and Agricultural Best Management Practices for Building Soil Health

Every farmer knows that maintaining the soil is crucial to sustaining their operations over the long term because soil provides plants with nutrients and water. But not everyone is aware of steps they can take to enhance and promote soil health. While this publication focuses on agriculture, people managing urban and suburban land can improve soil health by following similar principles.

People can adopt best management practices, or BMPs, to protect natural resources and the environment. Four core principles are widely accepted for building or maintaining good soil health (4thesoil 2021; USDA NRCS, n.d.):

- Minimize soil disturbance.
- Keep soil covered.
- Maximize living roots.
- Energize through diversity.

These core principles are associated with these main BMPs:

- Reduced tillage.
- Residue cover.
- Cover cropping.
- Crop and livestock diversity and integration.

Reduced Tillage

Reduced tillage, also called *conservation tillage*, refers to a range of tillage practices that cause less disturbance to the soil than conventional tillage, which uses moldboard plows. Reduced tillage includes no-till (see fig. 1), strip-till, mulch-till, shallow-till, and ridge-till. Continuous no-till is a type of reduced tillage that protects soil by minimizing the disturbance, reducing erosion, preventing mineralization of soil organic matter, and increasing crop residue remaining on the soil surface.

Applying these reduced tillage practices varies, depending on crop type, but all increase the soil water-holding capacity and aggregate stability.

Figure 1. A mixed cover crop of cereal rye and vetch in a continuous no-till field at Blacksburg, VA, 2021 (Photograph by Sapana Pokhrel, Virginia Tech).

Residue Cover

Leaving plant residue on the soil surface has benefits such as preventing soil erosion. Crop residue prevents the impact of raindrops, which can disperse the soil particles at the surface, disturb soil structure or create a crust that prevents water infiltration.

Residue must be managed properly so that ground is continually covered throughout the year and no soil is left bare. Improperly managed residue can create problems with seed sowing, pests, and diseases. However, managed residue adds carbon back into the soil with time and aids rainfall infiltration. It can also moderate extreme soil temperatures and slow runoff.

Cover Crops

Cover crops are non-cash crops planted to protect the soil, scavenge soil nitrogen (N) and phosphorus, and suppress pests and weeds. Cover crops are intended to provide living plant material between cash crops during periods that would otherwise be fallow. Besides reducing soil erosion, cover crops increase water infiltration, add organic matter, and improve other soil properties. Different cover crops can be used to achieve different soil health goals. For example, grass cover crops, like cereal rye and barley, produce large amounts of biomass for soil organic matter and scavenge the residual N in soil. Brassica cover crops — such as mustard, radish, and turnip — are popular for scavenging nutrients and suppressing soilborne pathogens and pests. Cover crops also affect the N cycle in two ways:

- Legume cover crops — such as vetch, clover, alfalfa, and winter pea — fix atmospheric N.
- Non-legume cover crops — such as cereal rye, wheat, and forage radish — scavenge residual N from the soil.

These processes can increase the amount of N available in soil for subsequent crops and can improve N use efficiency (NUE), which represents the amount of N taken up by a crop compared to the amount of N applied as fertilizer. Improved NUE with cover crops may reduce the amount of additional fertilizer application needed and prevent N loss to surrounding water bodies.

Energize Through Diversity

In the overall soil health building system, diversity means both integrating livestock and related manure where possible and growing more than one crop on the same land by either rotating crops or adding cover crops.

Diversity benefits soil by enhancing the nutrient cycle, root mass and depth, and sunlight capture; improving soil structure; and increasing soil biological activities. By supporting the function of soil microbes, diversity can increase crop yield. For example, compared to a monoculture grass cover crop system, a mixture of legume and grass cover crops in a corn system reduces the carbon-to-nitrogen ratio of residue, which increases the decomposition rate and N cycling. Using crop rotations increases crop diversity and can help control pests and weeds.

Conclusions

Nutrient management has long been the basis for good crop production, but more focus on sustainability and resiliency of farming systems and the overall soil ecosystem has led to interest in soil health. While measurement of soil health can be difficult due to natural disparities among different soil series and other factors, there is a clear consensus on principles and practices that can build and maintain soil health. Reduced tillage, cover crops, residue cover, and crop and livestock diversification and rotation are practices that show promising benefits in keeping the soil healthy. Farmers following these four core soil health principles are increasing carbon sequestration, improving soil structure, reducing runoff, preventing soil erosion, and providing food and habitat to beneficial soil microbes.

Practicing soil health-building BMPs helps with adaptation to a changing climate and adds resilience to these farming systems. We must keep our soil healthy and productive, not only for today's generations but also for tomorrow's.

References

Brevik, E. C. 2018. "A Brief History of the Soil Health Concept." *Soil Science Society of America Journal.* 1906: 9. https://profile.soils.org/posts/field-and-historical-notes/a-brief-history-of-the-soil-health-concept/

Janzen, H. H., D. W. Janzen, and E. G. Gregorich. 2021. The 'Soil Health' Metaphor: Illuminating or Illusory? *Soil Biology and Biochemistry,* 159: 108-67.

4thesoil. 2021. https://www.4thesoil.org/.

U.S. Department of Agriculture Natural Resources Conservation Service. n.d. "Soil Health." Accessed Sept. 25, 2022. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/.

Visit our website: www.ext.vt.edu

Produced by Virginia Cooperative Extension, Virginia Tech, 2022

VT/1022/SPES-408P