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Authors
Jennifer Woodyard and
Eileen Kladivko

Purdue Agronomy
ag.purdue.edu/AGRY

Four Strategies to Improve Your Field's Soil Health

What Is Soil Health?

The definition of soil health is changing. For many decades, the study of soil health emphasized soil's physical and chemical properties. Today, soil scientists strive to include biological aspects as well, since many of the processes that influence soil occur because of living organisms.

This shift reflects the desire of farmers, researchers, and agricultural professionals to protect the long-term sustainability of soils, water, and cropping systems. This publication provides four basic strategies to help improve the health of your soil.

These four strategies are based on four basic soil health principles outlined by the USDA-Natural Resources Conservation Service (NRCS):

1. Minimize soil disturbance
2. Keep soil covered
3. Maximize plant diversity
4. Maximize the period of living root growth

When you consider how to improve your soil's health, keep in mind the natural characteristics of your soil, including its texture, natural drainage class, and slope.

Because these factors are often unique to your location, soil health can mean different things. In other words, healthy soil in northern Indiana is going to be different from healthy soil in southern Indiana due to the inherent nature of the soil. Characteristics like these can influence the timing and degree of your soil's response to the strategies we describe in more detail below.

Key Soil Health Components

What does a healthy soil encompass? Here are some of the important players in soil health.

Soil aggregates are a fundamental concept in soil structure. Aggregates are groups of soil particles that bind to each other more strongly than to other particles. They form pores that help soils retain water and air. Soil aggregates can change quickly. Within a few years of starting conservation practices (such as implementing no-till systems and planting cover crops), aggregates can change in size and stability.

Well-structured soils allow for adequate aeration, water infiltration, and root penetration and growth. Well-structured soils also resist erosion and compaction. We often think of aggregates just as one of soil's physical properties, but biological organisms influence this structure. Earthworms, mycorrhizal fungi, plant roots, and organic matter all influence the ways soils form aggregates.

When earthworms are present in a system, they create tunnels. Later, plants can use these tunnels as root channels, allowing roots and water to penetrate deeper into the soil profile. Earthworms also leave behind casts, which are rich in nutrients. Mycorrhizal fungi form beneficial relationships with plants by bringing water and nutrients, particularly phosphorus, to a plant in exchange for energy in the form of carbon. There are many different "good" soil microorganisms that help break down residue, recycle nutrients, and combat the "bad" pathogenic microorganisms that might negatively influence your cash crop growth.

What you plant can also influence biological activity in your soil. Introducing plant diversity into your system is a natural way to control weeds and pests, including pathogenic microorganisms. Diversity can increase nutrient and water use efficiency, introduce different root types and residue, and reduce stress on the cropping system.

Diverse root types and residue may reduce your soil's risk of erosion. Some plants decompose faster than others, so where erosion is a concern, you may want to consider introducing a plant that decomposes more slowly and keeps the soil covered longer. Soil microbial communities thrive on diverse residue produced by various plants. As you add diverse plants, healthier soil for agronomic purposes develops. That's because different plants are able to target a broader range of soil resources than a monoculture system can target. Monoculture systems may exhaust certain soil resources more quickly and require additional inputs to maintain.

Organic matter plays a big role in soil health. Changes in organic matter content do not occur quickly, and it may take several years to see an appreciable difference, but increasing your soil's organic matter will improve its overall health. Organic matter largely contributes to a soil's cation exchange capacity (CEC), and organic matter helps soil hold nutrients and water for plant use. Soil microbes decompose residue into organic matter and eventually transform it into mineralizable nutrients for plant uptake.

The Four Strategies

The four strategies for improving your soil's health are not an all-inclusive list. Rather, these strategies provide a good base to improve overall soil health. Many of the strategies we discuss are connected and act together to improve soil health.

1. Practice No-Tillage/Strip-Tillage

Reducing tillage to either no-till or strip-till minimizes disruptions to soil aggregates by not breaking them up continuously and forcing the system to restart (Figure 1). Minimal tillage maintains natural aggregates, one of the key components of soil health, and helps prevent loose soil particles from washing or blowing away easily.

Residue decomposes more slowly under a reduced tillage system for several reasons. One reason is that fewer aggregates are broken up with less intensive tillage, so less organic matter is exposed to decomposition. Second, reduced tillage can make soil temperatures slightly cooler. Lower temperatures help organic matter accumulate, because the residue is not broken down as quickly. Reducing tillage can increase soil organism diversity and activity, another one of the key components of soil health. Reduced tillage does not disrupt earthworm burrowing and helps protect the network created by mycorrhizal fungi that connects them to their host plant. Leaving residue on the soil surface also acts as a barrier against raindrops and wind that could cause erosion.

Figure 1. Planting corn into no-till cover crop residue. Photo provided by Edwin Remsberg and USDA-SARE.

2. Add More Crops to Your Rotation

Corn-soybean or continuous corn rotations dominate the Midwest landscape. In the short-term, these systems yield in abundance and provide good economic returns. However, a strong strategy for long-term resiliency includes increasing plant diversity in your system.

Adding winter wheat in your rotation after soybeans is a fairly simple way to increase plant diversity, a key component of soil health. Wheat's early harvest also offers a longer window of opportunity to establish cover crops and add another layer to the crop rotation (Figures 2 and 4).

Another potential option in some areas is double-cropping soybeans after wheat harvest. Whether you use cover crops or another cash crop, keeping the soil covered as long as possible benefits overall soil health. Pick what fits best in your operation and budget.

Figure 2. A 14-species cover crop mix planted after wheat harvest. Photo by Jennifer Woodyard.

3. Include Cover Crops

Cover crops are becoming more widely adopted, but many farmers still have questions about their usefulness. There is no one-size-fits-all solution to cover crops, but a good place to start finding more information is *Managing Cover Crops: An Introduction to Integrating Cover Crops into a Corn-Soybean Rotation* (Purdue Extension publication AY-353-W), available from the Education Store, edustore.purdue.edu.

Cover crop roots improve soil aggregation and reduce erosion. Cover crop residue also reduces the impact of raindrops on the soil surface and serves as a habitat and food source for soil microbes. As organisms decompose the residue, nutrients are released back into the soil.

Organic matter, a key soil health component, can increase over a longer period as residue is added back into the system. Combining no-till and cover crops is a great way to keep your soil covered, minimize disturbance, maximize living root growth, and maximize plant diversity.

Cover crops can also help manage nutrients in the field by scavenging nitrogen from the soil during typically fallow months (Figure 3). In the winter (after you remove the cash crop) and in the early spring (before planting) are periods when you usually see the most loss of soil nitrogen. Cover crops can prevent some of this loss and recycle nitrogen in the system, eventually releasing the nitrogen from the dead residue as soil organisms begin the decomposition process.

Choosing species that die in the winter ("winter kill" species such as oats and radish) rather than species that overwinter (such as cereal rye and annual ryegrass) will make a difference in the amount of soil nitrogen scavenged and the timing of its release.

Figure 3. Cereal rye cover crop growth in the spring before planting at Southeast Purdue Agricultural Center. Photo by Jennifer Woodyard.

4. Manage Nutrients

Nutrient management goes hand-in-hand with the first three strategies we discussed. You may need to adjust your fertilizer applications after switching to a reduced tillage system, adding a cash crop, or implementing cover crops in your rotation.

As organic matter increases, you may see an increase in your soil's ability to hold nutrients longer. Keep your local fertilizer dealer in the loop as you make changes to your system, so they can give you recommendations to fit your specific needs.

Growing cereal rye before planting corn is not recommended for novice cover crop growers, because you may need to apply more of your nitrogen with the planter to get the corn off to a good start. Over-applying fertilizers can reduce mycorrhizal fungi's natural ability to scavenge nutrients for plants and can harm some species' abilities to colonize in the future.

Figure 4. This photo shows several plants in a 14-species cover crop mix in October 2016. This mix (which was planted August 10) produced an average of 4,600 pounds of biomass per acre at the Purdue Diagnostic Research and Training Center. Photo by Jennifer Woodyard.

Whenever you apply nutrients, regardless of whether you use any of the other strategies discussed here, it is important to keep the 4R principles of nutrient stewardship in mind:

1. Right source
2. Right rate
3. Right time
4. Right place

More information about these principles is available from the Nutrient Stewardship website, www.nutrientstewardship.com/4rs.

A common practice is to test soil fertility once every two years. Regularly testing your soil is an easy way to take preventative measurements against over- or under-applying the nutrients necessary for a successful cash crop. Poor chemical health in your soil could indicate poor overall soil health.

Conclusion

Any of the strategies listed in this publication can help improve soil health over time. Because these strategies overlap so much, you may be able to maximize the benefits by using several of them together. However, when trying something new, it is usually best to start small and learn how to properly manage the new techniques before you expand the practices. Considering the health of your soil is a great step toward building a sustainable cropping systems future.

Additional Resources

No-Tillage Impacts on Soil Carbon, Nitrogen, and Water

Available from the Iowa State University Extension Store, store.extension.iastate.edu

This fact sheet (CSCAP 114 2012) describes the benefits of no-tillage in a corn-soybean system and can be used with a companion video. This publication is part of the Climate and Corn-based Cropping Systems Coordinated Agricultural Project (CSCAP).

Managing Cover Crops: An Introduction to Integrating Cover Crops into a Corn-Soybean Rotation

Available from the Purdue Extension Education Store, edustore.purdue.edu

This publication (AY-353-W) outlines an introductory approach to integrating cover crops into a corn-soybean cropping system.

Agronomy Technical Note: Recommended Cover Crop Seeding Methods and Tools

Available from the USDA-Natural Resources Conservation Service, www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_030986.pdf

This excellent publication describes cover crop seeding methods that can be used in Indiana and the Midwest.

Midwest Cover Crops Council (MCCC)

www.mccc.msu.edu

This website includes cover crops selector tools that allow you to choose your county and get seeding dates for each cover crop. There is a tool for agronomic crops for many states, plus for a tool for vegetable crops for Michigan. You can also get seeding rates by reading the information sheet about your cover crop of choice. The website includes a wealth of other information about cover crops from around the Midwest.

Midwest Cover Crops Field Guide, second edition

Available from the Purdue Extension Education Store, edustore.purdue.edu

This pocket guide (ID-433) was produced by the MCCC and the Purdue Crop Diagnostic Training and Research Center. The guide contains more detailed information about selecting and managing cover crops and describes common cover crops for our region. The descriptions also include ranges of cover crop seeding rates.

Terminating Cover Crops: Successful Cover Crop Termination with Herbicides

Available from the Purdue Extension Education Store, edustore.purdue.edu

As the title suggests, this publication (WS-50-W) describes how producers can effectively terminate cover crops with herbicides to prevent them from becoming weeds in the cash crop.

Soil Nitrogen Cycle

Available from the Iowa State University Extension Store, store.extension.iastate.edu

This one-page publication is a great teaching resource about the nitrogen cycle and can be used with a companion video. This publication is part of CSCAP.

Indiana Soil and Water: Tips for Environmentally Friendly Phosphorus Applications in Indiana
Available from the Purdue Extension Education Store, edustore.purdue.edu

There is no single and universal answer to the question of how and when to apply phosphorus (P) fertilizers. However, this publication (AY-386-W) does propose four basic P application management tips.

Purdue Manure Management Planner
www.purdue.edu/agsoftware/mmp

This website has a free downloadable software that helps you create a manure management plan for crop and animal feeding operations.

Find Out More

Find other publications in the *Indiana Soil and Water* series in the Purdue Extension Education Store: edustore.purdue.edu

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