Agronomic Spotlight

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Soil Health Management

What is Soil Health?

The term soil health is defined as "the capacity of soil to function as a vital living system, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health."[1] The concept of soil health relates to the dynamic properties of soil, meaning those properties that change with soil use and management over time.[2] These properties include soil organic matter quality and content, microbial community structure, bulk density, water infiltration rate, compaction, and nutrient holding capacity.[3]

Factors associated with soil health can be categorized as physical, chemical, and biological (Figure 1). The various factors influence each other, such as a change in soil pH will result in a change in the microbial community structure.

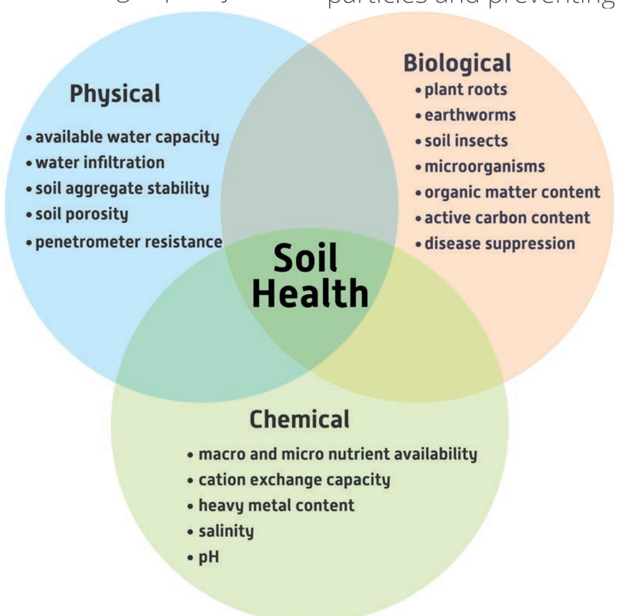

Figure 1. Soil health is influenced by the interaction of physical, chemical, and biological properties of the soil.

Nutrient Availability and Storage

Macro- and micro-nutrients are present in the soil in both mineral and organic forms (nutrients in living or once-living tissues). Organic nutrients become available for use by plants when the organic matter is decomposed by soil microorganisms. Healthy soils foster the presence of a complex food web, made up of a diversity of soil fungi, bacteria, nematodes, arthropods, plant roots, and forms of organic matter. The goal of soil health promotion is to supply appropriate amounts of nutrients to plants while minimizing the loss of nutrients from the system.[4]

A soil's ability to hold onto nutrients is usually measured as the cation exchange capacity (CEC) of the soil. The CEC level is the soil's capacity to hold onto positively charged nutrients on negatively charged clay particles and organic matter pieces. The weathered, acidic soils in tropical and sub-tropical regions tend to be positively charged, and the anion exchange capacity is used to measure the soil's ability to hold negatively charged anions. Anion and cation forms of nutrients are loosely attached to soil particles and can be easily made available for uptake by plant roots. Increasing the level of organic matter is one way to increase the CEC of the soil and thus the capacity to hold positively charged nutrients.

Organic matter and microorganisms also play an essential role in binding soil particles together into soil aggregates. Arbuscular mycorrhizal fungi that interact with plant roots produce a glue-like substance call glomalin that helps hold soil aggregates together.[5] Soil aggregates help soils resist erosion, improve soil tilth, and promote the formation of soil pores, which allow for better water infiltration and gas exchange. Soil aggregates also sequester carbon by encasing organic matter particles and preventing their decomposition.

Suppression of Disease and Pests

Healthy soils tend to suppress pest and pathogen populations and activities. Increased plant diversity and organic matter content usually result in more diverse microbial and arthropod communities. Increased numbers of spiders, harvestmen, and ground beetles help reduce populations of ground-dwelling insect pests.[4] Increased activity of beneficial fungi, nematodes, and bacteria help to suppress soilborne plant pathogens, reducing root disease incidence and severity. Reduced soil compaction, increased drainage, and better aeration result in conditions that are less favorable for root disease development. Crop rotations can also reduce the population levels of some soilborne pests and pathogens.[6]

Soil Organic Matter

Soil organic matter has substantial effects on the physical, chemical, and biological attributes of the soil. Organic matter increases the cation exchange capacity of the soil and provides material for nutrient cycling. It also increases the water-holding capacity of the soil and improves soil tilth.[6] Soil organic matter drives the soil food web, providing energy for soilborne organisms integral in the nutrient cycling process, pest suppression, and interactions with plant roots.[2] Organic matter increases populations of earthworms and other soil fauna that create macropores and channels in the soil, improving water infiltration, drainage, and root colonization of the soil profile.

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Managing Soil Health

Some common goals of soil health management include decreasing soil disturbance, increasing soil cover, increasing species diversity, increasing the proportion of time that living roots are present in the soil, minimizing soil erosion, and conserving soil organic matter.[1,2,7]

Tillage: Tillage can be destructive to the physical and biological properties relating to soil health. Tillage can lead to soil compaction and plow pan layers that inhibit water infiltration and drainage. Tillage can also contribute to the destruction of bio-pores, such as root channels and earthworm tunnels, and break the continuity of macropores affecting drainage and gas exchange. Tillage can increase the rate of organic matter decomposition by increasing oxygenation and breaking up soil aggregates, resulting in increased soil erosion.[3,4,6]

Tillage can also be used as a soil health management tool. Chisel plowing loosens surface soils without completely burying crop residues, leaving residue cover on the soil surface. Subsoiling can break up hardpans to increase drainage and root penetrationof the soil. Ridge till can be used to create drier and warmer soil conditions that result in lower severities of root rot diseases. No-till, ridge-till, strip-till, and zone-till systems can all be used to help minimize soil disturbance and maximize residue cover while allowing for good seed germination and seedling establishment.[2,6]

Organic Matter: Managing organic matter can be very important for maintaining soil health in vegetable cropping systems. Vegetable systems often have minimal amounts of crop residue returned to the soil and rely on more intensive forms of tillage. Organic matter amendments can be used to maintain or increase the levels of organic matter in the soil.[2] Animal manure can be added in liquid or solid forms as a source of both carbon and nitrogen. However, a nutrient analysis of the manure before application will help ensure the proper application rate and avoid the over-application of some nutrients. With vegetable crops, the application of manure must be timed to prevent the introduction of foodborne pathogens on the harvested crop.[2,3]

Green manure is another name for fresh plant tissue, such as cover crop residue. Green manures can improve soil aggregation, protect against erosion, and reduce soil crusting. Depending on the type of crop used, green manure left on the soil surface can be a source of inoculum for plant diseases or harbor insect pests.[2]

Compost can be another important source of organic matter, including plant residue, animal manure, and brewery waste. Compost has been partially decomposed by microorganisms, so the organic matter is more stable and decomposes more slowly. It is not a good source of nitrogen, but it can be a source of phosphorus, depending on the nature of the parent material. Compost is not as effective as some other sources of organic matter for increasing soil aggregation.[2,6]

Increasing the diversity of plants in the agroecosystem helps to increase soil aggregation and stability, improves nutrient cycling, and increases the biological diversity of the system (microorganisms, beneficial insects, and others). Plant diversity can be increased through crop rotation, cover cropping, the use of trap crops, and inter-cropping.[3]

Soil Health Assessment

Developing a soil health management plan starts with documenting the farm background and management history. Then a soil health assessment can be performed to determine the current state of the soil, and this information can be used to identify issues and set goals. After prioritizing the issues and goals, short- and long-term management plans can be developed and implemented.[2]

Several states/regions have developed soil health assessment programs, which may include both laboratory and field assessment methods. Laboratory methods include assessment of soil pH, nutrients, and organic matter levels, as well as biological components, such as microorganisms and microbial biomass. Field assessment methods may include analysis of water infiltration, compaction, and other soil characteristics, as well as evaluations of plant stress and biological data, such as earthworm counts.[3] The Natural Resource Conservation Service (NRCS) provides a list of state and regional soil health scorecards that growers can use to do their own field assessments.[8]

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Websites verified 10/27/2020.

For additional agronomic information, please contact your local seed representative.

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