Building Soil Health

Managing Soil Health—To sustain plant, animal, and human life and maintain or enhance ecosystems services

CROP 3090B July 2016

IOWA STATE UNIVERSITY
Extension and Outreach

Soil Health

Soil health is the continued capacity of the soil to function within natural or managed ecosystem boundaries to

1. Sustain plant and animal productivity.
2. Maintain or enhance water and air quality.
3. Promote plant and animal health.

Soil Health Indicators

Soil health indicators are the physical, chemical and biological properties of the soil (Fig.1) that are affected by management practices such as tillage and crop rotation and they are used to determine the status of soil health. Soil health indicators that are affected by management practices are considered as dynamic indicators, compared to properties such as soil texture, drainage class, depth to bed rock and cation exchange capacity (CEC), which are inherent properties and depend on the parent material and factors that affect the soil formation process.

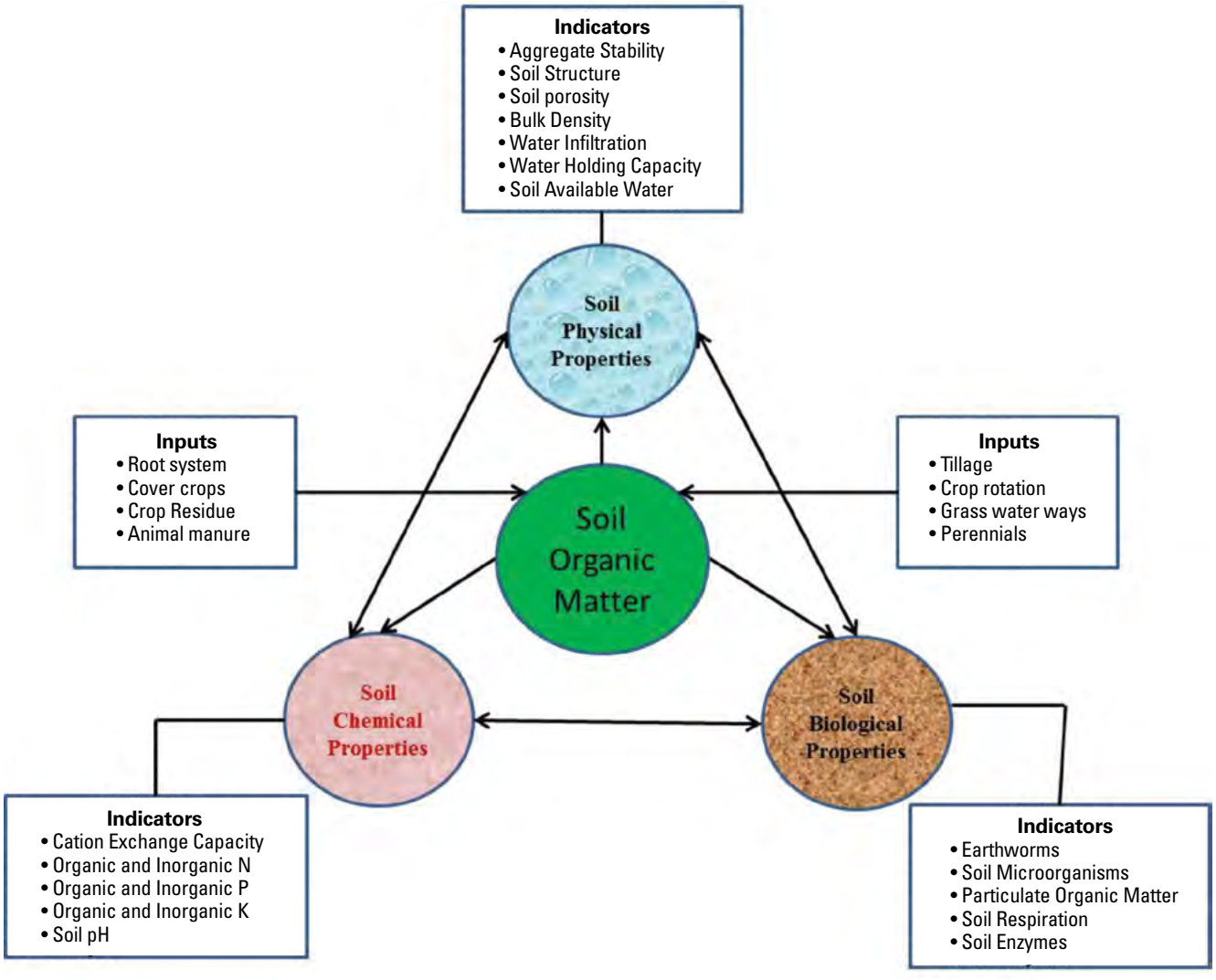


Figure 1. Relationships between soil health indicators as affected by organic matter and management inputs (Al-Kaisi, 2015).

Physical indicators – include soil structure (Fig. 2), bulk density, water infiltration, and aggregate stability. These indicators influence soil water and air availability that are essential for plant and organisms growth.

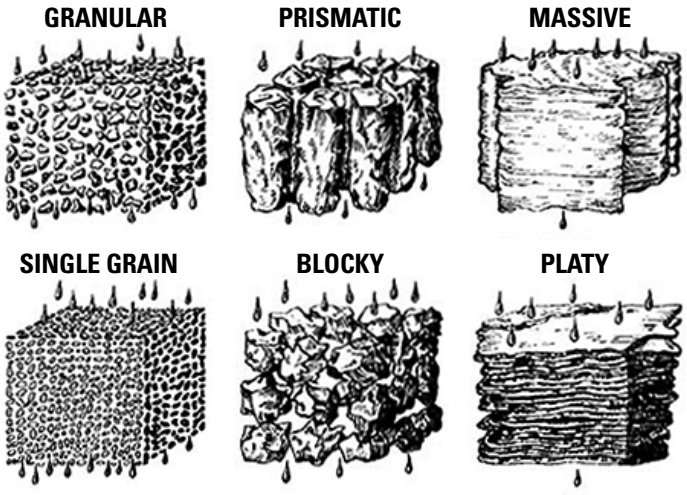


Figure 2. Examples of different types of soil structure. Source: Managing soil tilth (Whiting et al., 2014)

Chemical indicators – include soil pH, cations exchange capacity, and macro and micro nutrients that are needed for plant growth and soil organisms.

Biological indicators – include soil organic matter and soil macro- and microorganisms and microbial activities and their byproducts.

What is the Main Contributor to Soil Health?

Soil organic matter (SOM) is only 1 to 6 percent of the total soil mass (Fig. 3) and the single most important contributor to soil health.

Depending on the soil forming conditions, SOM has the following composition:

- 7 to 21 percent of readily decomposable organic matter.
- 3 to 9 percent of soil microbial biomass, which includes 30% bacteria, 10% fauna, 10% yeast, algae, protozoa, nematodes, and 50% fungi.
- 70 to 90 percent of stable soil organic carbon (humus).

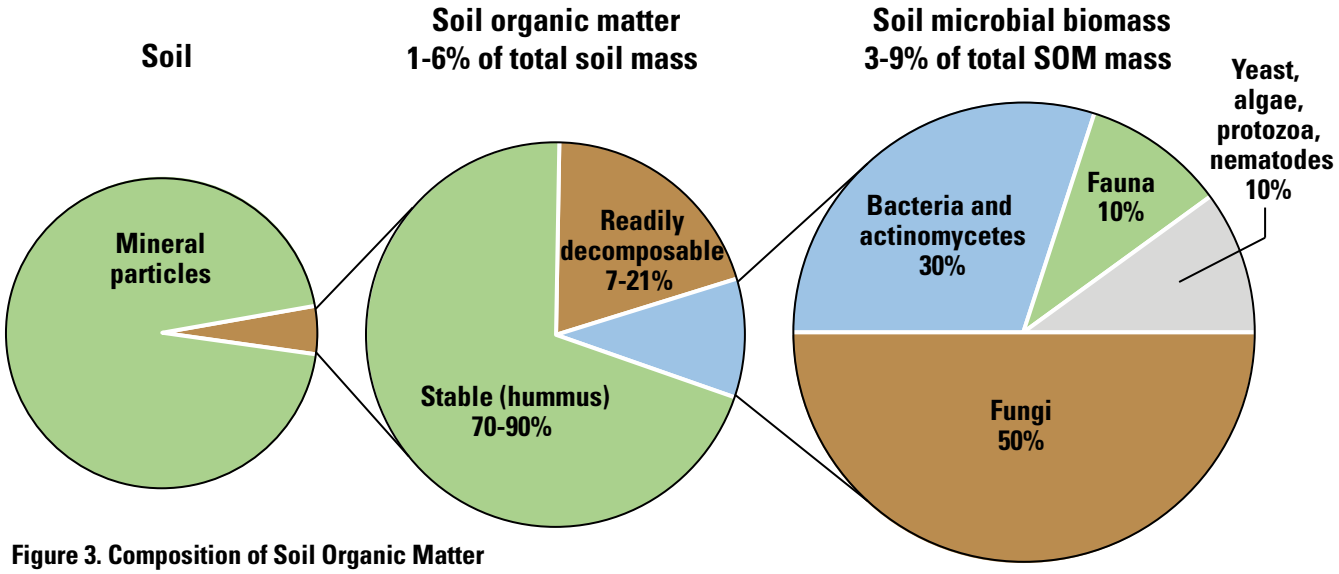


Figure 3. Composition of Soil Organic Matter

Importance of Organic Matter

Soil organic matter plays a major role in defining soil health because of its effects on all the physical, chemical, and biological properties of soils and their links to each other.

Soil organic matter

- Provides nutrients that are essential for plant and soil organisms' growth.
- Conserves soil nutrients in their organic forms to be released slowly in the soil as conditions become optimum (moisture and temperature).
- Produces hormones that help plants to grow.
- Provides food for soil microorganisms.
- Binds soil particles together into aggregates that improve soil structure, water infiltration, soil water and air movement.
- Improves soil water holding capacity for plant use.
- Enhance cation exchange capacity.

Demonstrating water infiltration in the field using a PVC ring

Soil Aggregates Formation

One important role of soil organic matter and microbial community is in the formation of soil aggregates. A group of fungi in the soil called ***arbuscular mycorrhizal fungi*** (AMF) lives on the root system to produce organic compound called ***glomalin***. Glomalin is the glue-like substance secreted by the hyphae (Fig. 4) of AMF, which plays a significant role in soil aggregation and is capable of storing carbon in the inner recesses of soil particles.

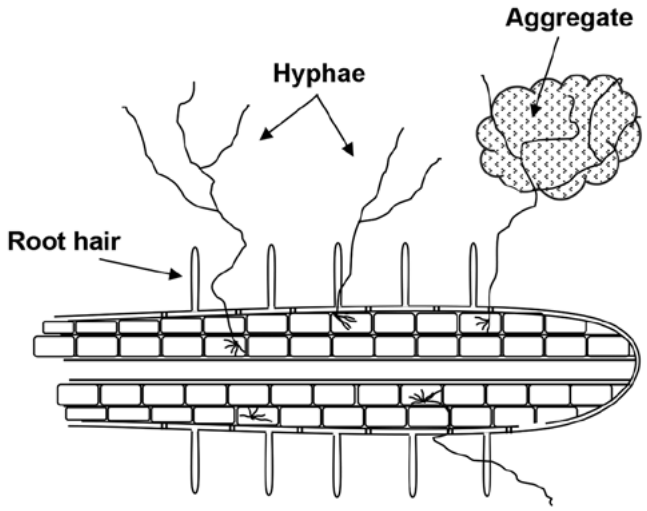
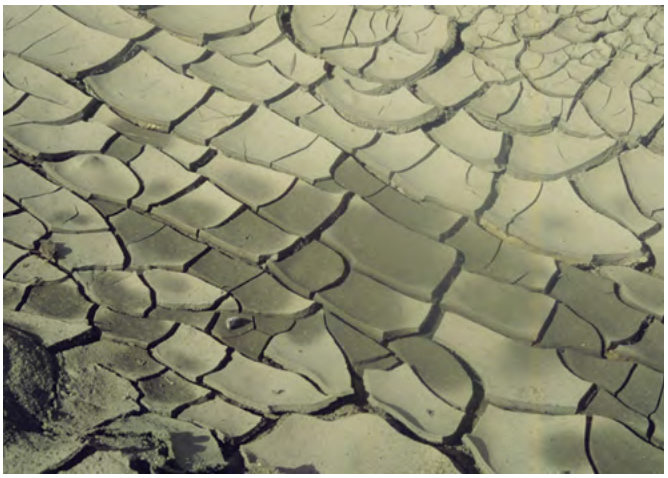


Figure 4. Hyphae of arbuscular mycorrhizal fungi on roots and root hairs and its role in building soil aggregates. Source: Nichols, www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1144429.pdf

Management Practices that Improve Soil Health



Soil surface crusting due to tillage and lack of residue cover

Mixed cover crops can build soil health

Soybean growing in no-tillage corn residue

Traffic Management/Control

Traffic control and management is to minimize random travel on the field to reduce soil compaction, surface crusting and runoff, and soil erosion to improve soil structure and soil health. Excessive tillage and uncontrolled traffic leads to soil compaction, which results in soil surface structure destruction and crusting under heavy rain events.

Cover Crops

The inclusion of cover crops such as mixed cover crops, legumes, small grains, radishes, and others in the crop rotation improves soil health. Cover crops enhance soil organic matter, soil structure, biological functions, and reduce soil erosion and soil crusting. Cover crops protect the soil surface to increase water infiltration and reduce surface runoff and soil erosion.

Use of Animal Manure

Animal manure contributes to soil health improvement. As a plant nutrient source, animal manure is comparable to commercial fertilizer if applied according to a sound nutrient management plan. Nitrogen and other nutrients from animal manure are slowly released to plants through mineralization process. Also, animal manure contributes to soil organic matter, improving soil aggregation, water infiltration and soil water-holding capacity, and increases the diversity of soil microorganisms.

Crop Rotation and Residue Management

Crop rotation is important for improving soil health. Crop rotation and residue protect the soil from rain and wind erosion by improving water infiltration to recharge the subsoil profile. Also, this practice contributes to soil nutrient pool and carbon during the breakdown of crop residue.

No-Tillage and Reduced Tillage

The adoption of no-tillage and strip tillage along with other conservation practices improves soil health. A no-tillage cropping system retains crop residue at the soil surface, decreases soil disturbance, improves water infiltration, conserves soil moisture and reduces the rate of oxidation of organic matter during decomposition to increase soil organic carbon in the top layers of the soil.

Terraces for Soil Erosion Control

The adoption of terraces on sloppy landscapes, grass waterways, and other perennial strips are essential to soil health improvement. Terraces reduce the lengths of slopes across the landscape to control the flow of water on the slopes to reduce soil erosion and nutrient loss, which affect productivity and water quality.

Integration of Perennials within Row Crops

Annual row crop production with soil tillage impacts soil health by increasing organic matter loss and soil erosion. Integrating perennials in targeted areas in the field has the potential to reduce and reverse the environmental impacts associated with annual row cropping. The integration of perennials with row crops increases soil organic matter, soil biodiversity, and improves the hydrologic properties of the soil.

Conservation Agricultural Systems Benefit Soil Health

Conservation agricultural systems are defined as an integrated approach that includes many conservation practices as shown in Fig. 5. This system can include no-tillage, perennials/cover crops, and crop rotation.

The benefits of this system to soil health can include increase in soil organic matter, enhancing soil biodiversity and nutrient cycling, storage and availability of soil nutrients, macro-pores, water infiltration and storage, and improving aggregate stability. These benefits influence many other ecosystem services.

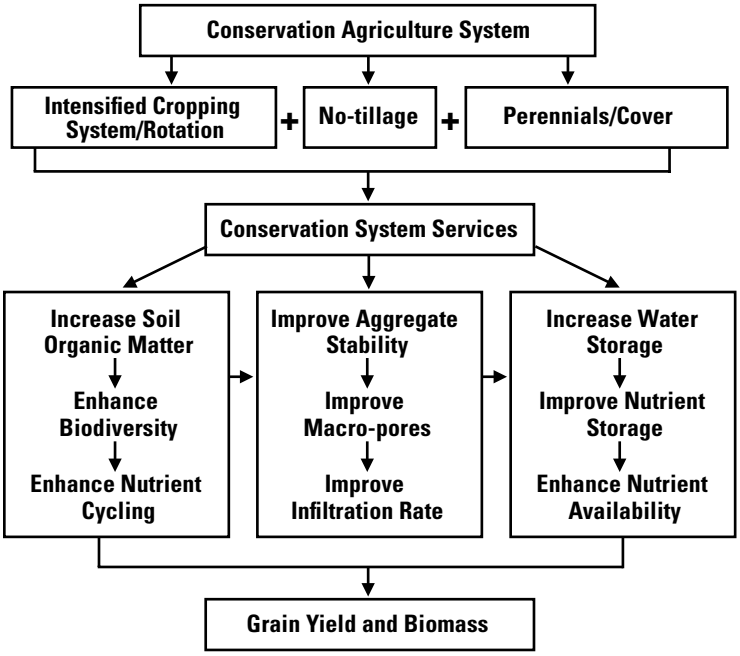


Figure 5. Systems approach for building soil health and productivity (Al-Kaisi, 2015).

Strip-tillage field before planting corn or soybean

Terraces breaking slopes to control erosion

Visit http://crops.extension.iastate.edu to learn more

AUTHORS

Mahdi Al-Kaisi and David Kwaw-Mensah, Department of Agronomy, Iowa State University. Photos by Mahdi Al-Kaisi.

Funding for this management manual was provided by

USDA United States Department of Agriculture

Natural Resources Conservation Service