Understanding soil health

A Cornell University scientist advocates a more proactive and holistic approach to soil health.

by Geraldine Warner

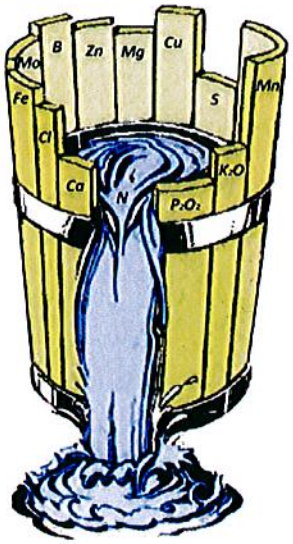
In the past, growers considered soil health in terms of the limiting factor.

For example, nitrogen is the most limiting factor when it comes to yield potential. Once there's sufficient nitrogen in the soil, the next most limiting factor is phosphorus. And the next one is calcium, and so on *(see Figure 1)*.

FIGURE 1

Limiting factor concept

In the past, nutrient management was based on the chemical aspects of the soil, which soil scientists nowadays believe may be too simplistic.



SOURCE: Harold van Es, Cornell University

"The idea was that these different chemical components more or less function independently," Dr. Harold van Es, soil scientist at Cornell University, New York, explained during a Washington State University soil workshop last winter.

In the past, growers have relied on reactive management—using short-term responses to immediate problems and relying mostly on external interventions. For example, if the nitrogen was low, fertilizer would be applied. The solution to compacted soil was to use a subsoiler. Van Es said this is somewhat like a person taking a pill for an illness.

"The question is, are these symptoms of more fundamental problems and a poorly managed ecosystem? We want to move towards long-term, proactive management," he said.

A proactive approach involves creating the conditions over time that promote healthy growth of crops with enhanced defenses—just as a person would promote their own health through a good diet, exercise, reduced work stress, and good social interactions, he said.

In the long run, fewer external interventions are needed and the soil system functions in a more natural way, becoming more self-regulating, efficient, diverse, self-sufficient, and resilient.

Soil processes

Soil health or soil quality can be defined as the capacity of the soil to function chemically, biologically, and physically *(Figure 2)*. All these processes are important because they support healthy soil and healthy crops, van Es said.

Growers typically focus on the chemical aspects of soil health. They take soil samples so they can be analyzed for pH level, and the amounts of phosphorus, potassium, and minor elements.

But the physical and biological aspects are equally important for soil health, and also need to be measured, van Es said. "If you don't measure it, you can't manage it very well," he said, advising growers to identify soil constraints beyond just nutrients and to monitor the ongoing improvement or degradation of soil.

The physical, biological, and chemical properties of soil interact. For example, a compacted soil (a physical property) suppresses beneficial biological processes, and increases root diseases.

It works the other way around, too. Decomposition of organic matter (a biological function) increases aggregation of the soil (a physical property). And, high sodium content (a chemical property) reduces aggregation, stability, drainage, and aeration (physical properties), as well as impairing beneficial biological processes and rooting.

FIGURE 2

Functional processes in soil

PHYSICAL
- Good tilth (structure)
- Plant support
- Aeration
- Soil water storage and movement
- Erosion resistance
- Root proliferation and organism movement

CHEMICAL
- Nutrient storage and release
- Energy carbon storage
- Salinity/toxicity prevention

BIOLOGICAL
- Organic matter decomposition
- Nutrient access and transformations
- Pest suppression, low pest population
- Support of microbial community, beneficials, producing plant growth promoting compounds
- Immobilization of toxins

SOURCE: Harold van Es, Cornell University

Whole system approach

This is why van Es recommends adopting a whole-system approach to soil and crop management and shifting as much as possible from a reactive to a preventive style. "The overall goal is to have good crops and yields."

A holistic soil management approach is knowledge intensive, van Es said. "You need to have an understanding of the soil process and the soil constraints and how you figure that into your management. It's the opposite of the basic recipe approach that we've been used to."

There are three ways to assess soil health:

—**Your observations:** How do yields compare to previous years or to your neighbor's? Are there symptoms of nutrient deficiency or diseases? Look at the color, compaction, and tilth of the soil, along with root health and development.

—**Soil testing kits:** Soil tests can be done in the field, but the results are only for educational purposes. They're not suitable for monitoring because the results are variable, depending on when the tests are done and other factors, van Es said.

—**Laboratory testing:** Labs offer comprehensive soil health tests as well as targeted tests looking at specifics such as heavy metal content or disease potential. Labs provide standardized quantitative information.

For more information, go to *http://soilhealth.cals.cornell.edu*. ●

10 CHARACTERISTICS *of a healthy soil*

1. Good soil tilth. *This refers to the overall physical character of the soil and its suitability for crop production.*
2. Sufficient depth. *The soil should be deep enough to allow the roots to grow and function properly.*
3. Sufficient but not excess supply of nutrients. *Enough nutrients are needed for optimal plant growth and maintaining balanced cycling of nutrients, but an excess can lead to leaching and potential groundwater pollution as well as toxicity to plants and microbes.*
4. Few disease pathogens and insect pests.
5. Good soil drainage. *Excess water will drain more rapidly from a soil with good structure and a distribution of different size pores.*
6. Large populations of beneficial organisms. *Soil microbes help in nutrient cycling, decomposition of organic matter, maintenance of soil structure, and suppression of pests.*
7. Low weed pressure. *Weeds compete with crops for water and nutrients and can harbor pathogens and pests.*
8. Free of chemicals and toxins that may harm the crop.
9. Resistant to degradation. *A healthy, well-aggregated soil is more resistant to erosion, drought, and vehicle compaction.*
10. Resilient in unfavorable conditions.

SOURCE: Cornell Soil Health Manual