An overview of soil health

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Health:
• 1. a: the condition of being sound in body, mind, or spirit; especially: freedom from physical disease or pain;
  
  b: the general condition of the body <in poor health> <enjoys good health>

• 2. a: flourishing condition: well-being <defending the health of the beloved oceans — Peter Wilkinson>
  
  b: general condition or state <poor economic health>

• 3. : a toast to someone’s health or prosperity — (Merriam Webster)

Origin: Old English hǣlth, of Germanic origin; related to whole.

(Oxford dictionary, with a nod to Wendell Berry and Dr. Guy Jodarski)

Healthy Soil

Fertility + Good Soil Physical Characteristics + Fresh Organic Matter + Abundant Soil Life =

HEALTHY SOIL

Soil Physical Characteristics
• Texture (% sand, silt, clay)
• Structure (aggregation and aggregate stability)
• Porosity
• Color (humus, drainage)
• Organic matter content (macro and decomposing)
• Infiltration/ aeration
• Compaction/bulk density
• Water holding capacity
• Bearing strength
**Aggregation/ good soil tilth is a biological process**

- Luxuriant plant growth
- Healthy and abundant supporting biology:
  - Earthworms, arthropods, bacteria, fungi, nematodes, actinomycetes, protozoa, etc.
  - Almost all other organisms in the soil depend on fresh organic matter produced by plants:
    - Living plants or recently dead
    - Must be replaced continuously!

**Practices that harm soil tilth:**

- Excessive tillage—any sort.
- Heavy traffic—mechanical or animal
- Too little fresh OM going into the soil.
- Bare ground or too little residual (no mulch or crop on top of soil).
- No living crops or low sward density (few roots in the soil).
- Soluble fertilizers without concurrent addition of carbon rich vegetation, mulches, or composts.

**Soil fertility: an essential element of soil health. What nutrients do plants need?**

(Source: UW-Madison Dept. of Soil Science Extension)

**What about other nutrients?**

- Plant-essential nutrients (17)
- Beneficial plant nutrients (selenium, sodium, silicon, ???)
- Other nutrients needed by organisms other than plants—too many to mention. For:
  - Microbes
  - Earthworms, arthropods
  - Livestock
  - People!
A new soil analysis: The Haney Test

Working with soil biology:
We can’t do this alone.

For healthy soils, we need to provide a continual supply of fresh organic matter to soils.
Some biological tools and concepts:
- Fostering interactions between physical, chemical and biological realms in the soil
- Increasing species abundance and diversity
- Enhancing biological nitrogen fixation
- Legume-hosted and free living
- Enhancing rooting density, depth, pattern
- Promoting and protecting mycorrhizae
- Managing soil fertility and plant nutrition

Soil biology and organic matter
- Three main categories of soil organic matter:
  - living
  - recently dead
  - long dead
- Living and recently dead: Fuel for the soil foodweb
- Long dead: humus (water and nutrient holding)
- It’s all good, but for different reasons—get as much as you can.
  - (your soil type will automatically limit this, but very few agricultural soils are at their practical upper end)

Some practical benefits of soil organic matter
- Living plants:
  - Protection from wind and water erosion; soil shading
  - Bioprotection from some insects and diseases
  - Protect/rebuild soil structure (aggregation): mycorrhizae
- Fresh (recently dead):
  - Food for much of the soil foodweb
  - Plant nutrient source
- Stable (long dead: humus)
  - Helps stabilize soil aggregates
  - Water and nutrient holding capacity (better than clay!)

Soil organic matter and water holding capacity
- Increasing soil organic matter by 1% will give you an about ¾ inch of additional water holding capacity in the first six inches of soil.
One basic goal for improving soil health: 
Improving soil biology

• If you feed them, they will come:
  – Accomplished by continuously adding substantial amounts of

  fresh organic matter:
  Cover crops
  Compost

One goal for improving soil health: 
Develop a Disease-suppressive soil

❖ Suppressive soil: Pathogen fails to persist or cause infection despite presence of susceptible host and favorable environment
❖ 1st documented in late 1880’s
❖ Since been observed in multiple pathosystems worldwide

Mechanisms of suppression:

• Competition:
  – Beneficial microbes occupy niches on plant root surfaces to fight pathogens and help acquire nutrients

• Antibiosis:
  – Production of antimicrobial metabolites that are detrimental to pathogens and that trigger defensive capacity in plants

• Predation & Parasitism

• Induced systemic resistance (pathogens and insect herbivores)

• Improved resource acquisition (example: mycorrhizae)
  • (Source: Dr. Lori Hoagland, Purdue University)

What about nitrogen?

• Do pastures need nitrogen?
  • YES!

• ......But from where?
The new craze: Cocktail cover crops

- Cover crops: expanding on the benefits of crop rotation/diversity
- Principle: use dense plantings of multiple species of cover crops to stimulate biomass (fresh organic matter) production and a full suite of soil biological agents
- Objective: grow as much fresh organic matter from a wide variety of plants to foster a variety of soil biological associations.
- Advantages: improve soil organic matter content, nutrient retention and cycling, and natural (crop) plant protection mechanisms

A few suggestions

- Favor multi-species cover cropping systems
- Use mixes of species from at least three plant families:
  - Legumes
  - Grasses
  - Brassicas
  - One more is even better
- Try to find species with a mix of upright growth and rooting patterns (tall and short, upright and prostrate, taproot and fibrous root)
- Keep it practical and affordable...
- Consider using low-growing cover crops for interplanting
More is better, but let’s be real...
(Slide courtesy Sandy Syburg, Purple Cow Organics)

A word of caution about fertility:
Cover crops alone can’t overcome poor fertility in many soils

Wabasso loamy sand:
High fertility

Wabasso loamy sand:
Low fertility

Wrapping it up--

• The crops we grow for cash don’t provide the amount and variety of organic matter it takes to sustain a vibrant soil ecology. Cover crops can be a practical way to help.

• Aim for having a dense, vigorous, and diverse cover crop system.

• Consider intercropping as an option.

• Anything you do will help—don’t worry about having a perfect system. Try a few experiments and see what’s possible.

References

• Hoagland, Lori A., Department of Horticulture and Landscape Architecture, Purdue University (personal communication)


• Michigan State University Extension: Field Crop Ecology (Publication E2646) and Michigan Field Crop Pest Ecology and Management (E2704)

• Midwest Cover Crops Council: www.mccc.msu.edu

• Soil and Water Conservation Society: Soil Biology Primer. 2000 (also available online from NRCS)


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