Welcome to the webinar!

- The webinar will start the top of the hour.
- To type in a question, use the q and a box on your control panel. We'll read the questions aloud after the presentation.
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Building Organic Matter for Healthy Soils: An Overview

Mark Schonbeck and Diana Jerkins
Organic Farming Research Foundation

May 9, 2018

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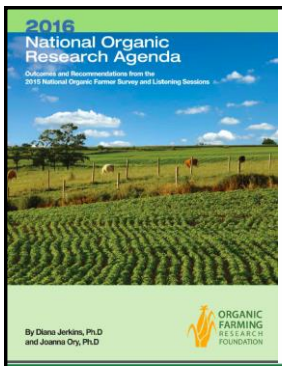
Mark Schonbeck

Diana Jerkins

Building Soil Organic Matter for Soil Heath and Fertility

Research-based Practical Guidance for Organic and Transitioning Farmers

Presented by OFRF
Diana Jerkins, PhD & Mark Schonbeck, PhD
Production of the Soil Health Guides & Webinars is made possible by a grant from the Clarence E. Heller Charitable Foundation.



In a survey of more than 1,000 organic farmers conducted by OFRF in 2015:

- 74% cited soil health and quality as a high research priority.
- 66% cited fertility and nutrient management.

Download full report at http://ofrf.org/.

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Research questions include:

- Best rotations, cover crops, and organic amendments for building soil organic matter (SOM) and soil health.
- Best practices for different regions, soils, climates, and farming systems.
- Practical field measurement methods for SOM and soil health.
- Restoring depleted soils, rebuilding soil health during organic transition.
- Minimizing negative impacts of tillage.
- Enhancing resilience to weather extremes and climate change.

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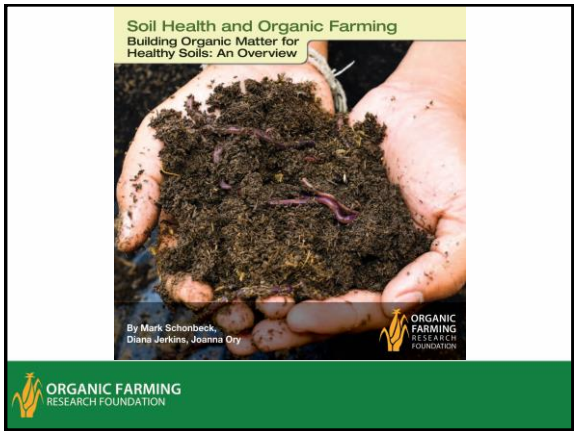
Soil Health and Organic Farming
Building Organic Matter for Healthy Soils: An Overview
By Mark Schonbeck, Diana Jerkins, Joanna Ory
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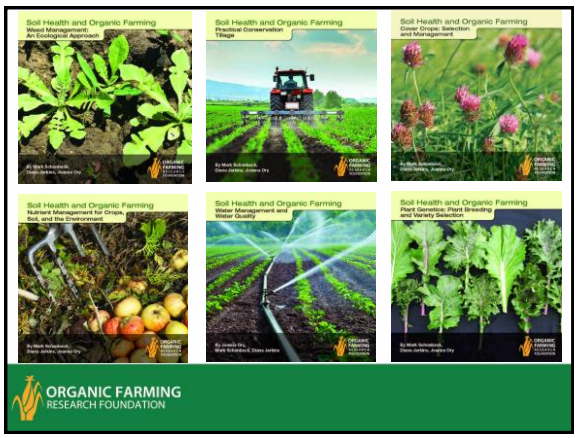
Soil Health and Organic Farming
Weed Management: An Ecological Approach
Soil Health and Organic Farming
Practical Conservation Tillage
Soil Health and Organic Farming
Cover Crops: Selection and Management
Soil Health and Organic Farming
Nutrient Management for Crops, Soil, and the Environment
Soil Health and Organic Farming
Water Management and Water Quality
Soil Health and Organic Farming
Plant Genetics: Plant Breeding and Variety Selection
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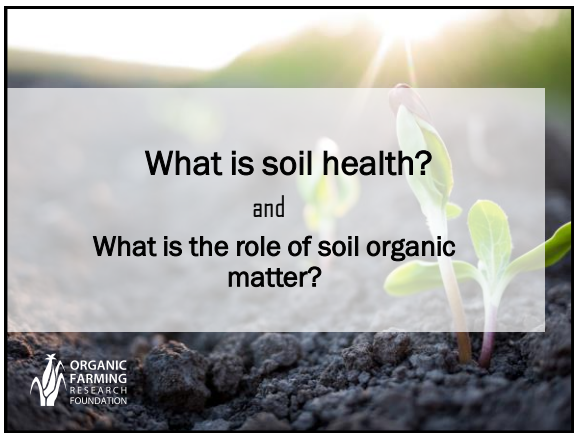
What is soil health?
and
What is the role of soil organic matter?
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Healthy soil

- Provides sufficient but not excessive plant nutrients.
- Retains and cycles nutrients, protects water quality.
- Hosts abundant, diverse beneficial soil organisms, few pests and pathogens.
- Enhances crop resistance and resilience to pests, diseases, and weather extremes.
- Requires less inputs to sustain yields.

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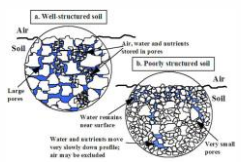
Healthy soil

- Has good tilth (crumb structure or aggregation).
- Has network of large and small pores that promote drainage and aeration.
- Absorbs, retains and provides plant available moisture.
- Fosters deep, extensive root system development.
- Resists compaction and erosion, and recovers from effects of disturbance.



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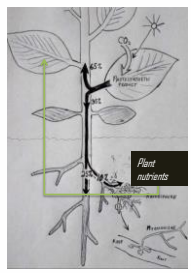
Plants and soil depend on each other

- Plant root exudates and fine root sloughing provide the primary source of "food" for the soil life in nature and in sustainable farming.
- Beneficial microbes thrive in the plant root zone, enhance nutrient and water uptake, and comprise the foundation of plant nutrition.
- In healthy soils, this relationship is optimized through:
  - Sufficient soil organic matter.
  - Enhanced microbial diversity.
  - Deep, extensive root systems.



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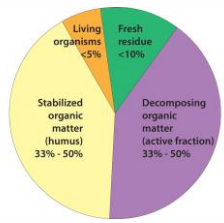
The soil organic matter (SOM) is comprised of multiple components, including:

- Plant and animal residues
- The soil life itself
- Active organic matter
  - Recently-dead soil organisms and their metabolites, available to further processing by soil life.
- Several forms of stable organic matter:
  - Protected in soil aggregates
  - Adsorbed to soil minerals (clays)
  - Deeper in soil profile
  - Chemically resistant



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The role of soil organic matter in the functions of healthy soil

- Retain, cycle, and deliver plant-available nutrients
- Absorb, retain, and deliver plant-available moisture
- Maintain tilth, aeration, and easy root penetration
- Prevent runoff, erosion, and compaction
- Provide food and habitat for diverse soil organisms, which in turn transform fresh residues into SOM
- Enhance crop resilience and resistance to stresses

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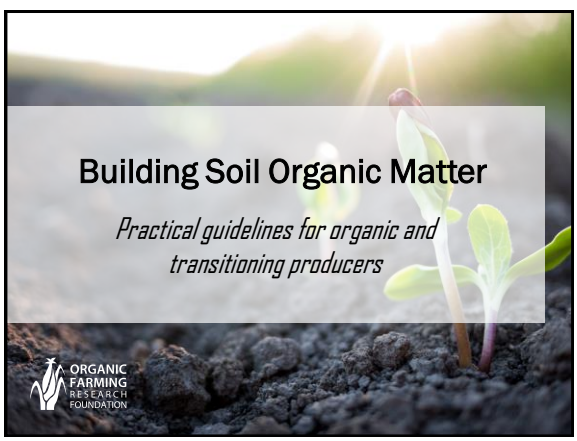

NRCS four principles of soil health

- Keep the soil covered as much as possible.
- Grow living roots throughout the year.
- Diversify crops to enhance soil microbial diversity.
- Minimize soil disturbance:
  - Physical (tillage, traffic)
  - Chemical (pesticides, fumigants, fertilizers)
  - Biological (overgrazing, invasive species)

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The living plant is the farmer's #1 tool for building soil organic matter

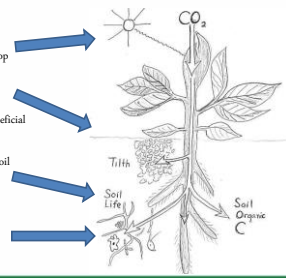
Keeps carbon flowing from atmosphere to soil.

Protects the soil surface from sun, wind and raindrop impact.

Builds SOM and enhances soil structure.

Feeds the soil life with root exudates, promotes beneficial organisms.

Opens the subsoil, builds stable SOM throughout soil profile.



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Plant roots play a vital role in building SOM

Root system of a mature Italian ryegrass plant

- Plants deliver 10 – 30% of their photosynthetic product to the soil life via the root system.
- Root residues are converted to SOM more efficiently (30-40%) than aboveground residues (15-20%).
- Mycorrhizal fungi and other root symbionts facilitate the process.[1]
- Roots build SOM surface to subsoil.[2]
- Recent findings: most of the stable SOM is derived from plant roots.[3]
- Organic systems grow larger roots.[4]

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A diverse plant community builds soil diversity

Each species in a "cover crop cocktail" offers a different root architecture and "recipe" of root exudates, and thereby supports a particular suite of soil microbes.

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Primary SOM building practices for organic crops: sustainable intensification

A cover crop of triticale and Austrian winter pea

- Maximize year round plant cover, living roots, and total plant biomass.
  - Avoid or minimize bare fallow.
  - Keep orchard floor in living cover.
- Diversify the crop rotation.
  - Grow high-biomass, multispecies cover crops.
  - Add a perennial sod phase if practical.
- Reduce tillage when practical.
- Encourage mycorrhizal fungi and other beneficial organisms.
  - Avoid excess nutrient levels.

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Primary SOM building practices for livestock: management-intensive rotational grazing (MIG)

MIG systems, such as mob grazing, holistic resource management, and adaptive multi-paddock grazing:

- Maximize forage biomass & quality.
- Promote deep roots.
- Distribute manure nutrients.
- Enhance soil health, moisture infiltration, and pasture resilience.
- Accrue several tons SOM/ ac-year.
- In upstate NY, SOM initially 2.8% increased to 4.0% after three years in MIG.

MIG keeps soil, pasture, and cattle healthy at Meadowcreek Dairy in Grayson Co., VA

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Complementary SOM building practices: organic and mineral amendments

- Use finished compost to build stable SOM.
- Return on-farm manure and other organic residues to the soil.
- Use organic mulches to protect soil surface (e.g., vegetable crops).
- Use off-farm organic or natural mineral inputs as needed to restore soil balance or replenish nutrients removed in harvest.
- Use commercial soil inoculants if needed to restore soil life.

Straw mulch adds organic residue and protects soil surface from hot sun and drying winds, thereby slowing SOM oxidation.

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Organic amendments: benefits and pitfalls

Compost (top) and tree leaf mulch (bottom) can build stable SOM.

Finished compost:

- Works with in-situ plant biomass in complementary and synergistic ways to build stable SOM.
- Provides slow-release nutrients.
- Adds diverse beneficial organisms.

Research findings:

- Compost + cover crop add more SOM than either alone.
- A little compost goes a long way .
- Effects on SOM: finished compost > raw solid manure > plant residues > manure slurry ~ inorganic NPK.

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What are your biggest challenges?

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Tillage and cultivation required for weed control can accelerate SOM oxidation or degrade soil aggregates (tilth).

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Soil-friendly Tillage

- Reduce tillage frequency and intensity when practical.
- Implement an integrated weed management strategy.
- Run rototiller at slower rotary speed and faster forward speed to avoid pulverizing soil aggregates.
- Consider alternative tillage tools:
  - Spading machine (deep, gentle, non-inverting, good seedbed)
  - Rotary harrow (shallow)
  - Sweep plow undercutter to terminate cover crops

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Some crops require N more quickly than soil life can mineralize it. Concentrated organic N sources (e.g., poultry litter) enhance yield but can leach N or accelerate SOM losses.

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Frequent compost applications sustain yields in intensive production, but can accumulate excessive soil phosphorus (P) or (in high tunnels) soluble salts.

Food waste + yard waste (left) becomes finished compost with an analysis of ~1-1-1(right). At 10 tons / ac-year, this adds 80 lb P/ac-year, or five to ten time annual P removal in harvests.

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Modern crop cultivars, bred for input-intensive conventional production, may not perform optimally in organic systems designed to optimize soil health.

Today's broccoli and cauliflower cultivars require unsustainably heavy N applications, and may become unmarketable in organic production due to nutrient limitation or other stresses.

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Soil health challenges during transition to organic

- Newly organic producers must learn organic soil, nutrient, weed, and pest management techniques.
- Land with history of conventional management may have soil health problems:
  - Compacted and/or eroded soils
  - Low SOM levels
  - Depleted, dormant, or unbalanced soil life that cannot readily process organic inputs into SOM and plant-available nutrients
- The transitioning grower must build SOM and soil health and stay in business without the help of price premiums for certified organic products.

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SOM dynamics – a tough tradeoff?

"Soil organic matter levels are the balance of C inputs to soil (through crop residues and amendments) and losses via mineralization (i.e., CO_2 respiration). These dynamics (stabilization vs. mineralization) are mediated through the soil food web, which plays a large role in SOM decomposition and supports crop nutrition. Growers have a vested interest in both processes because they rely on mineralization for short-term crop productivity but also strive for stabilization to build soil resilience, tilth, and quality."

Hurisso et al., 2016. Soil Sci. Soc. Am. J. 80 (5): 1352-1364.

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Research findings: SOM dynamics in organic systems are usually a win-win

- Soil microbial respiration and SOM generally increase together with adoption of integrated organic farming systems with balanced and diverse organic inputs to the soil; there is rarely a tradeoff.[1]
- Compared to poultry litter, applying finished compost enhanced soil microbial respiration 30% and total SOM 43% in organic vegetable production.[2]
- Organic fields had 74% higher microbial metabolic activity and 19% higher total SOM than conventional.[3]

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Exception: when soil life is starved or stressed by overtillage, bare fallow, or excessive soluble N …

Increased respiration burns off SOM, and microbial biomass diminishes.

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Tips on managing SOM dynamics

- Tilling-in a succulent legume cover crop favors SOM mineralization and nutrient release.
- Cover crop + compost may build more SOM than either alone.
- Diverse inputs with varied C:N build more SOM and lasting fertility than low C:N materials like manure slurry.
- Ridge tillage or strip tillage promotes nutrient release in crop row and allows SOM to build between rows.[1]

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Total soil organic matter

Total % SOM on soil test reports reflect overall soil health and SOM-related functions. However:

- It is difficult to measure % SOM precisely enough to detect short term changes.
- Total SOM responds slowly to management changes:
  - Best integrated organic systems add ~ 1,000 lb SOM/ac-yr
  - Management intensive grazing adds ≥ 2 tons SOM/ac-yr
  - 10 tons compost typically adds 1 – 2 tons stable SOM.
  - The top 8" of soil must accrue 10 tons SOM/ac to show a 1 point increase in SOM (e.g., from 2% to 3% on a soil test).
- Standard soil tests sample surface to 6 inches, yet more than half of total SOM occurs below 12 inches.[1]
  - Benefits of deep rooted crops are difficult to monitor.

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Other measures of SOM and soil function

- Indices of active SOM and microbial activity respond more sensitively than total SOM. These include:
  - Microbial biomass
  - Microbial enzyme activities
  - Microbial respiration (potentially mineralizable carbon, or PMC)
  - Permanganate-oxidizable soil carbon (POX-C).
  - Several other measures of active SOM
- POX-C reflects SOM stabilization, while PMC reflects SOM mineralization and crop nutrition.
  - Both are measured by relatively simple lab procedures.
  - Both are highly correlated with crop yields.

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Early indicators of improving SOM

Organic *vs* conventional (56 studies around world)[1]
- Microbial biomass: +41%
- Microbial enzyme activities: +32% to +84%
- Total SOM + 19%

Organic *vs* conventional (659 org & 729 conv fields, US)[2]
- Fulvic acid (an active SOM fraction) : +150%
- Total SOM: +13%

Organic vs conventional (20 year trial in IA)[3]
- Microbial biomass +16 to + 20%
- Total SOM + 10%

Crop rotation (2 or more) *vs* monoculture (122 studies)[4]
- Microbial biomass +21%
- Total SOM +4 to +8%

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Soil Health Assessments and Scorecards

- Soil health assessments integrate evaluate several physical, chemical, and biological soil properties, such as aggregation, POX-C, and PMC. Examples include:
  - Cornell comprehensive assessment of soil health (CASH).
  - Haney soil health test (HSHT).
  - NRCS soil test kits and score cards.
- Recent findings that these assessments do not work well outside the regions in which they were developed:
  - Northeastern region (CASH) and Texas (HSHT).
- Protocols are labor intensive and may not be practical for busy farmers.

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A simple and direct approach to assessing soil health trends in your fields

- Get to know your soil, its inherent properties, strengths, and weaknesses, as well as past management history.
- Make your own field observations each year to track changes in soil tilth, soil color, earthworm abundance, crop vigor, and other indicators of soil health.
- Conduct standard soil tests periodically, track pH, P, K, and other nutrient levels, and long term SOM trends.
- Conduct quantitative in-field measurements if you have the time and find that they help fine tune your SOM management system.

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Step One: get to know your soil

Use the NRCS Web Soil Survey

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Tips for field observation

- Is the topsoil soft and crumbly, with visible aggregates, or is it hard, cloddy, or crusted?
- Is the topsoil a dark, rich brown (high SOM), or a lighter tan or reddish (lower SOM)?
- Dig a few holes with shovel or soil probe. Is there a subsurface hardpan that could restrict root penetration?
- Does rainfall or irrigation water soak in quickly, or tend to pond or run off?
- Do you see an abundance of:
  - Earthworms?
  - Other macroscopic organisms?

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Tips for field observation

- Are crops thriving and resilient, or prone to drought, pests, diseases, and other stresses?
- Dig up some plants – are the roots deep, abundantly branched, and a healthy white color, or is root growth restricted or affected by disease (dark, discolored)?

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