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 for 30 minutes.
- A recording will be available in our archive (see below) and on the eOrganic YouTube channel within 2 weeks at most.
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Water Management, Water Quality, and Soil Health

Research-based Practical Guidance for Organic and Transitioning Farmers

Presented by OFRF

Diana Jerkins, PhD & Mark Schonbeck, PhD

Produced with funding from the Clarence E. Heller Charitable Foundation

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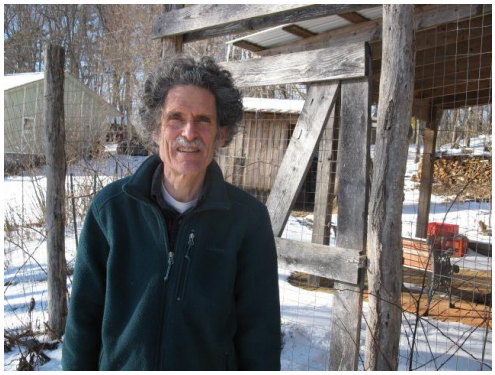

Mark Schonbeck, Organic Farming Research Foundation

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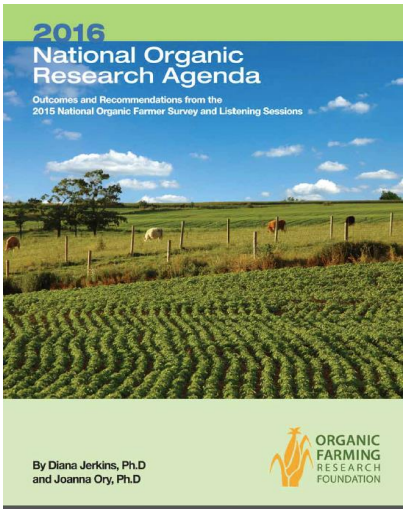

Available at *http://ofrf.org/*.

74% of farmers cited soil health as a high research priority.

34% cited climate change impacts on production:

- *Drought* – Western region.
- *Excessive rainfall* – Northeast, North Central, and Southern regions.

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Water quantity and organic production

- Leading causes of crop losses include:
  - Drought
  - Excessive rain
- Irrigation is essential:
  - In drier regions.
  - For specialty crops.
- *Climate change will intensify droughts and floods.*

Organic farmers depend on healthy soil to sustain crops through dry and wet spells.

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Water quality and organic production

- Production affects water quality:
  - Nitrate leaching
  - Nutrients in runoff
  - Pathogens (manure)
  - Sediment (eroded soil)
- Water quality affects crops:
  - Salinity, alkalinity, sodium
  - Pathogens

Organic farmers depend on healthy soil to protect water quality.

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Water quality concerns in humid and arid regions

Floyd County, VA, 45"/year
rainfall > evaporation

Nitrate-N leaches to groundwater

Hill County, MT: 11"/year
rainfall < evaporation

Doug Crabtree

Soluble salts move toward soil surface

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Soil Moisture 101

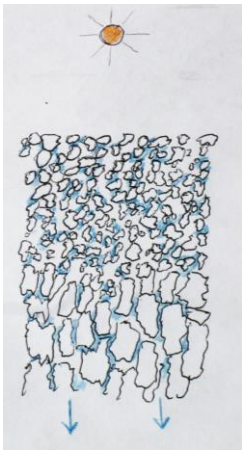
Effects of inherent soil properties on plant-available water

What happens in soil when it rains

During rain event, water fills soil pore space from surface downward (left).

Excess water drains from larger pores (gravitational water).

Plant-available capillary water remains in smaller pores (right).



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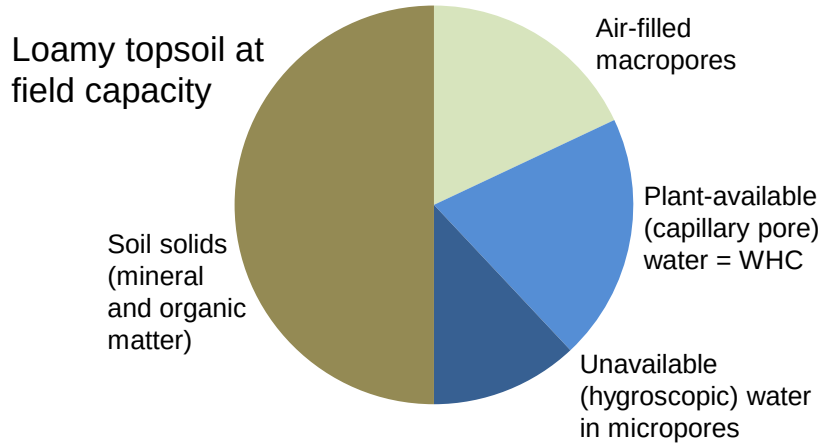
Soil pore space and plant-available water



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Inherent soil properties and plant-available water holding capacity (WHC)

- Soil texture
- Soil depth and profile
- Drainage, permeability
- Depth to restrictive layer
- NRCS Web Soil Survey:
- https://websoilsurvey.nrcs.usda.gov/

Soil profile in North Carolina coastal plain, showing A (top) and B (subsurface) horizons.

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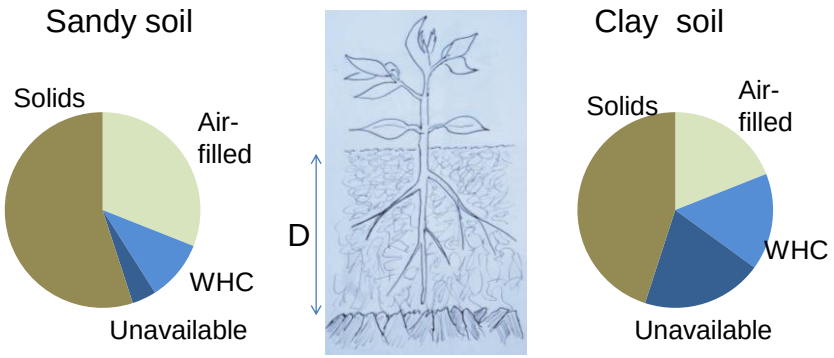
How soil properties affect plant-available water in the soil profile



Plant available water = % WHC X depth (D)

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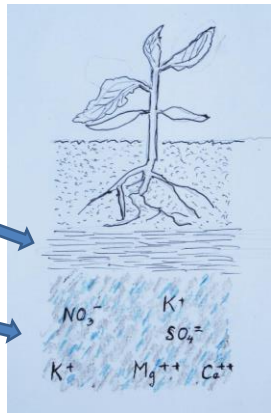
Soil profile and plant available water

Example: Southeastern U.S. coastal plain soils.

- Ultisols (highly weathered)
- Compaction-prone "E" horizon below "A" (topsoil).
- Root access to moisture and nutrients in "B" horizon is restricted.
- Annual subsoiling needed to sustain crop yields.



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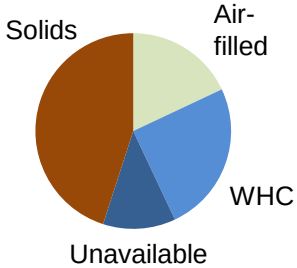
How soil health influences water availability and water quality

Dynamic (management-responsive) soil properties, WHC, and water quality

Plant available water in healthy soil

Healthy soil at field capacity



Rapid infiltration →

Moisture retained; unrestricted root growth.

Excess drains out →

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How healthy soils keep crops watered

- Ample soil organic matter (SOM).
  - *Each ton SOM adds 6 tons WHC.*
- Network of pores open to surface.
  - *Rainfall and irrigation infiltrate easily.*
- Well aggregated, low bulk density.
  - *High WHC, yet drains well.*
- High biological activity and biodiversity.
  - *Maintains SOM, structure, pore space.*
- Entire soil profile open to root growth.
  - *Crops access deep moisture reserves.*

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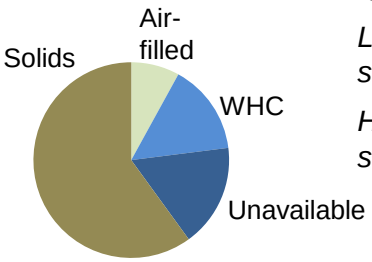
Plant-available water in compacted soil

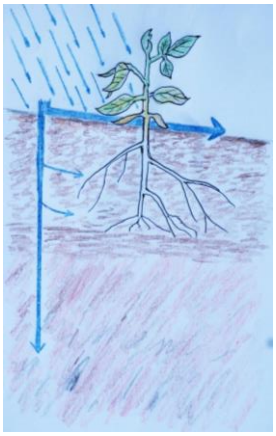
Compacted soil at field capacity



Surface crust, rain runs off.

Less water stored.

Hardpan stops roots.



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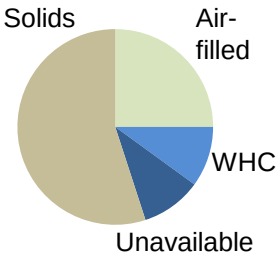
Plant available water in depleted soil

Depleted soil
at field capacity



Rain enters soil, but less is retained in because of low SOM.

Moisture and nutrients leach below root zone.

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Effects of excessive moisture on soil health

Heavy rain on exposed soil:

- Clogs pores, seals surface.
- Runs off
- May erode soil.

Ponding or waterlogging:

- Damages plant roots.
- Kills aerobic soil microbes.
- Increases risk of crop disease.
- Promotes certain weeds

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Effects of prolonged drought on soil health

During prolonged drought:

- Soil life goes dormant.
- Plant growth slows or stops.
- Organic inputs diminish.
- Risks of wind erosion and fire increase.

If drought follows wet spell:

- Compaction may be severe
- Crops may be less resilient

Leaving plant residues in place during dry seasons can prevent wind erosion and protect soil health.

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Co-managing soil and water resources in organic production

Research outcomes and practical applications

NRCS soil health principles and water management

- Keep soil covered
  - ➢ Prevents crusting, enhances infiltration
- Maintain living roots
  - ➢ Builds SOM and WHC, creates pore space
- Diversify crops
  - ➢ Builds SOM, uses water and nutrients efficiently
- Minimize disturbance
  - ➢ Prevents compaction, crusting, erosion

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Organic soil health practices and water management

Crop rotation, cover crops
- *Builds SOM and thus WHC, improves drainage.*

Compost
- *Adds stable SOM and WHC.*

Mulch
- *Conserves moisture, prevents crusting.*

Reduced tillage
- *Protects soil pore structure and SOM.*

Roll-crimped cover crop mulch conserves moisture. Rotational no-till conserves SOM, tilth, and WHC.

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Organic soil health practices and water management

Nutrient management
- *Protects water quality.*

Non-use of synthetics
- *Protects soil life.*

Management-intensive rotational grazing
- *Builds SOM throughout soil profile.*

Rotational grazing with sufficient rest periods can dramatically enhance pasture quality and drought resilience.

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Healthy soil enhances drought resilience in organic corn production

In the Farming Systems Trials at Rodale Institute, organically managed soil sustained corn through drought (left), while conventional corn showed severe water stress (right) and 31% lower yields. Organic management improved rain infiltration and soil moisture reserves.

Climate change, water, and soil health

- More frequent droughts and torrential rains
- Crop insurance claims in Northeast, 2013-16:
  38% drought, 34% excess rain, 28% all other.
- Response of NY farmers to 2016 drought:
  32% – build SOM, soil health
  26% – install irrigation.
- Response of NY farmers to 2017 floods:
  10% – build SOM to reduce erosion
  70% noted flood resilience from soil health practices.

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Cover crop confers flood resilience

Sorghum-sudangrass planted in July after potato harvest reached 4 feet by late September (A). Seven inches of rain on Sept. 29 sent the river raging three feet deep through the field (B), pushing the fence over (C), and flattening the cover crop (D). However, not one shovelful of soil was lost, and soil quality soon recovered.

How cover crops enhance water availability and water quality

- Prevent runoff and erosion.
- Build SOM and thus WHC.
- Maintain open pore structure.
- Enhance water infiltration and drainage.
- Absorb excess nutrients.
- Penetrate subsurface hardpan
- Enhance future crop access to deep moisture reserves.

A mature cover crop of triticale + field pea

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Rye breaks hardpan for cotton in South Carolina coastal plain soils

Sandy soils with compacted E horizon, usually require annual subsoiling.

Winter rye cover crops (top right):

- Increased SOM by 0.5% and water content by 1 – 1.5 in top 18 inches.
- Relieved compaction, allowing cotton to access subsoil moisture.
- Increased no-till cotton yields 38%.

Marshall et al., 2016. Open Journal of Soil Science 6: 149-158. http://dx.doi.org/10.4236/ojss.2016.610015

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Tillage radish: master subsoiler and nutrient scavenger

- Scavenges NPK.
- Penetrates hardpan more readily than rye.
- Large taproot holes speed infiltration, reduce runoff.
- Following crops root deeper, access subsurface moisture, become drought-resilient.
- Decomposes and releases nutrients rapidly.

Radish covers the ground rapidly (left), while its roots easily penetrate subsurface hardpan (right).

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Pearl millet and sorghum-sudangrass

- High biomass builds SOM.
- Drought-tolerant.
- Deep, fibrous root systems:
  - Break through hardpan
  - Scavenge subsoil N
  - Proliferate during regrowth after mowing.

Pearl millet (left) and sorghum-sudangrass showing root system (right)

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Soil moisture use by cover crops

- Facilitates timely planting in wet years.
- Can leave insufficient water for the next crop in drought years or low-rainfall regions.
- Wheat-fallow rotation:
  - Conserves moisture for the next crop.
  - Degrades SOM and WHC in the long run.

Organic dryland spelt grown at Vilicus Farms in northern Montana.
Photo by Doug Crabtree,
https://www.vilicusfarms.com/.

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Choosing cover crops for semiarid regions

Drought-tolerant crops vary in water consumption.

- Low: barley, pearl millet, pea, medic, lentil *(upper right*)
- Medium: wheat, sorghum-sudan, quinoa
- High: radish, alfalfa, sainfoin, sunflower *(lower right),* safflower.

Photos by Doug and Anna Crabtree, https://www.vilicusfarms.com/.

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Diversified crop rotations for organic dryland production

Doug and Anna Crabtree of Vilicus Farms grow 15 grain, pulse, and oilseed crops, and 10 cover crops in diversified rotations designed for their semiarid (11 in/yr) climate in Havre, MT. Cover crops are terminated with a blade plow that minimizes soil disturbance and leaves water-saving residues on the surface.

Compost, manure, and other organic amendments

- Compost and manure work with cover crops to build SOM and WHC.
- Organic nutrients can enhance crop growth and yield.
- More is not always better:
  - P surpluses inhibit mycorrhizae may run off to surface water.
  - N may leach to groundwater.

220 lb N/ac on CA organic broccoli:

- Optimized yield and profits.
- Leached up to 180 lb N/ac

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Weeds steal soil moisture

The cucumber crop (left) is bearing fruit, but weed competition for moisture may reduce yields. Invasive weeds like Canada thistle (right) displace native plants and degrade rangeland by by depleting moisture throughout the soil profile.

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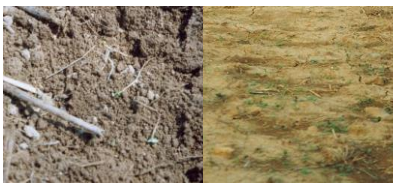
Cultivation and soil

Shallow cultivation:
- Gets weeds “in the white.”
- Can lead to crusting.

Organic weed IPM:
- Crop rotation
- Cover crops
- Preventing seed set
- Mulching
- Mowing
- Grazing
- Flame weeding, etc.



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Mulching saves water



Organic mulches such as straw (left) conserve soil moisture by slowing evaporation and weed emergence. Plastic film (center) blocks weeds and evaporation but requires drip tape to deliver water to crops. Weed mat (right) blocks weeds, admits rainfall.

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Reducing tillage to conserve soil water-holding capacity

- Mulch-till leaves >30% residue cover.
- Ridge till or strip till leaves alleys undisturbed.
- Rotary spader reduces compaction.
- Rototiller can be geared down to conserve aggregates.
- Sweep plow undercutter terminates cover crop, leaving residues on surface and conserving moisture.

Strip tillage thru wheat residues.

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Co-managing soil and water resources in organic production

Irrigated systems and high tunnels

Irrigation management and soil health

- Saline or alkaline irrigation water hurt crops and soil life.
- High sodium water can degrade soil aggregation.
- Over-irrigation can waterlog soil, leach nutrients, or release nitrous oxide.
- Include nitrate in irrigation water in nutrient budgeting.

Poorly drained, saline-sodic soils are especially prone to soil and water quality problems related to irrigation.
Photo: USDA ARS

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Irrigation management and soil health

Overhead irrigation (left) loses water to evaporation, leaching, or runoff, and can cause surface crusting from water impact. In-row drip (right) applies water more efficiently and gently in crop rows, and reduces between-row weed growth.

Healthy soil improves irrigation efficiency in UC Davis on-farm trial

Study goals:

- Save irrigation costs
- Prevent N leaching losses
- Build soil health
- Suppress weeds & diseases

Outcomes:

- Nearly 100% of rainfall retained in healthy soil.
- Irrigation cut off two weeks earlier with no yield loss.

Organic farmer Scott Park cut water use by 6 ac-inches, yet maintained top tomato through integrated soil health practices.

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Irrigation management in organic berry crops

- In-row drip can optimize moisture for organic blueberries.
- Organic mulch may reduce irrigation needs.
- Omitting post-harvest irrigation in blackberry saves water, improves hardiness.

Dr. Bernadine Strik of Oregon State evaluates organic blueberry cultivars, mulching, and irrigation practices.

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Managing for healthy soil in irrigated organic orchard in Utah

- Tillage in tree rows reduced SOM and microbial activity.
- *Alyssum* living mulch in rows did not increase water use.
- Legume (trefoil) alleys with mowings blown into rows:
  - Improved tree root growth.
  - Enhanced soil health
  - Did not affect water needs.

Covering orchard floor with living plants can enhances crop and soil health without adding to irrigation cost.

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Water, salt, and nutrient management in the high tunnel

- Limit salt and P inputs:
  - Poultry litter products
  - Potassium sulfate, etc.
- Use compost in moderation.
- Test irrigation water for salts.
  - Irrigate with roof water.
- Leach out salts as needed:
  - Sprinkler irrigate 6", or
  - Admit natural rainfall

By excluding rainfall, the high tunnel environment can generate a net upward movement of soil moisture and soluble salts.

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Thank you to the following organizations and foundations for their long term support of OFRF

California Department of Food & Agriculture | Clarence E. Heller Charitable Foundation | United States Department of Agriculture's Risk Management Agency | Western SARE | Forrest C. & Frances H. Lattner Foundation | Marisla Foundation | Agua Fund | The Ida and Robert Gordon Family Foundation, Inc.

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- Thank you for coming!

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