Preparing for Drought: The Role of Soil Health in Water Management in Organic Production

Research-based Practical Guidance for Organic and Transitioning Farmers in the Western Region

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Organic Farming Research Foundation

Joined by:
Scott Park, *Park Farming Organics*

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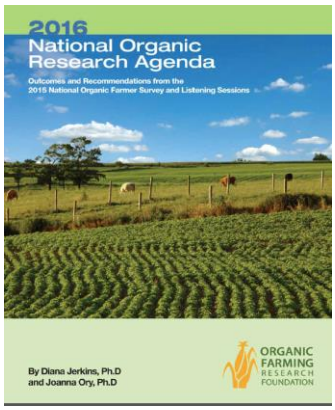
Research Priorities for Western Region Organic Farmers



- Soil health – **71%**
- Irrigation and drought – **56%**
  - Managing water and nutrients by building healthy soil
  - Designing drought resilient systems
  - Cover cropping with limited water
  - Soil life and nutrient cycling in dry climates

Report available at *http://ofrf.org/*

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Water Quality and Organic Production

- Production affects water quality:
  - Nitrate leaching
  - Nutrient 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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Nutrient Concerns in:

Irrigated vegetables
Mediterranean climate
winter rainfall > evaporation

Eric Brennan, USDA

Zahinger Kabir, NRCS

Nitrate-N leaches to groundwater

Dryland grains
Interior semiarid climate
rainfall < evaporation

Doug Crabtree, Havre, MT

Soluble salts move toward soil surface

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Soil Moisture 101

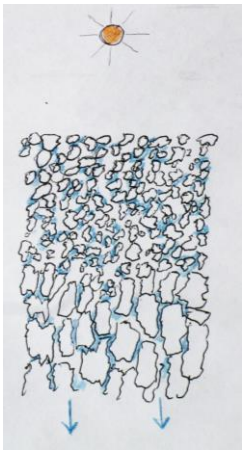
Effects of Inherent Soil Properties
on Plant-available Water

What Happens in Soil During Rainfall

Rain or irrigation water fills soil pore space from surface downward (left).

Excess water drains from larger pores.

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



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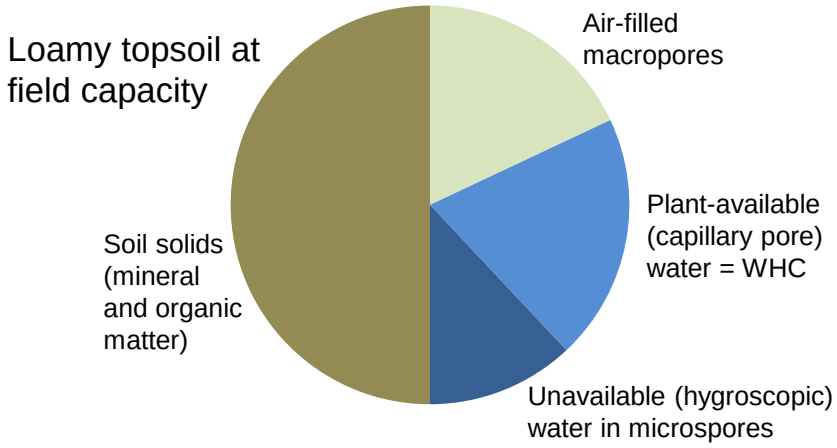
Soil Pore Space and Plant-available Water



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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/

Ray R. Weil

Woodburn silt loam near Corvallis, OR

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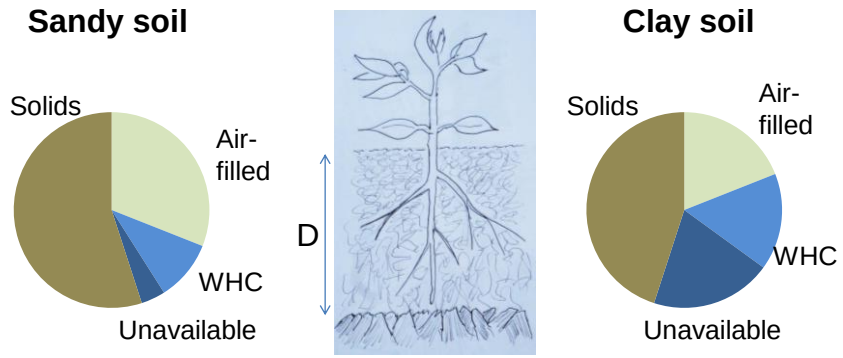
How Soil Properties Affect Plant-available Water in the Soil Profile



Plant available water = % WHC X depth (D)

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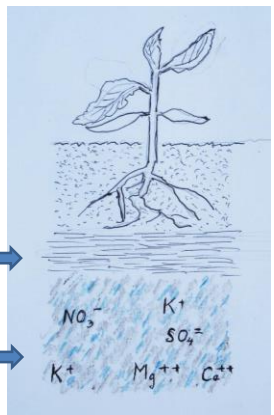
Soil Profile and Plant-available Water

Example: Chualar loamy sand at USDA Salinas, CA Organic Research Farm

- Argixeroll – clay-enriched subsoil (B horizon)
- Compacted layer at 30" impermeable to roots
- Deep reserves of moisture and nutrients not plant-accessible



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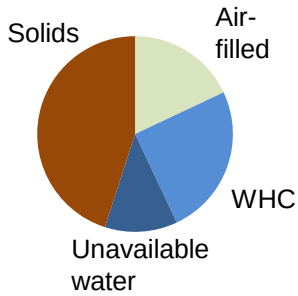
Soil Health, Plant-available Water, and Weather Extremes

Dynamic (Management-responsive)
Soil Properties and
Soil Moisture Relations

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 1% SOM adds ~4% WHC
- Network of pores open to surface
  - Rainfall and irrigation infiltrate easily
- Well aggregated, low bulk density
  - Drains well, facilitates root growth
- High biological activity and biodiversity
  - Maintains SOM, structure, and pore space
- Entire soil profile open to root growth
  - Crops access deep moisture reserves

Helen Atthowe

Cabbage and clover in healthy soil in Montana

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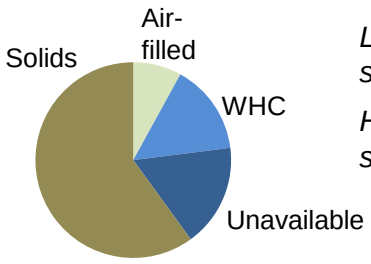
Plant-available Water in Compacted Soil

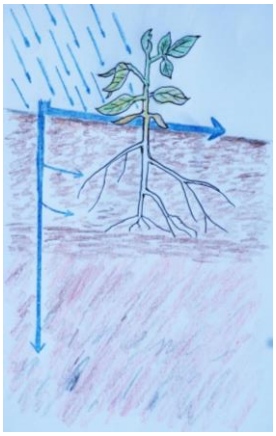
Compacted soil at field capacity



Surface crust, rain runs off

Less water stored

Hardpan stops roots



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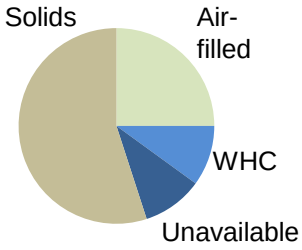
Plant-available Water in Depleted Soil

Depleted soil
at field capacity



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

Moisture and nutrients leach below root zone

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Effects of Excessive Moisture on Soil Health

Heavy rain or irrigation on exposed soil:

- Clogs pores and seals the surface.
- Runs off and erodes soil.

Ponding or waterlogging:

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

Z. Kabir, NRCS, Davis, CA

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Effects of Prolonged Drought on Soil Health

During a prolonged drought:

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

If a drought follows a wet spell:

- Compaction may be severe.
- Crops may be less resilient.

Helen Attowe

Leaving residues in place during dry seasons prevents wind erosion and protects soil health.

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Co-managing Soil and Water Resources in Organic Production

Benefits and Limitations of Organic Soil Management Practices

NRCS Soil Health Principles and Water Management

Keep soil covered

Prevents crusting, enhances infiltration

Diversify crops

Builds SOM, uses water and nutrients efficiently

Maintain living roots

Builds SOM and WHC, creates pore space

Minimize soil disturbance

Prevents compaction, crusting, erosion

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Organic Soil Health Practices and Water Management

Crop rotations and cover crops:

- Build SOM and thus WHC, which improves drainage.

Compost:

- Adds stable SOM and WHC.

Mulching:

- Conserves moisture and 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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Nutrient Management and Compost

Compost and manure:

- Work with cover crops to build SOM and WHC.
- Provide slow-release nutrients.

More is not always better:

- Excess P inhibits mycorrhizal fungi, which may reduce crop drought resilience.
- Nutrient surpluses may run off to surface water.
- N may leach to groundwater.

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Mulching can Save Water

Organic mulches, such as straw (left), prevent crusting, improve infiltration, feed soil life, and save soil moisture by slowing evaporation and weed emergence. Weed mat (right) does not feed soil life, but it blocks weeds, protects the soil surface, and allows rainfall and overhead irrigation to enter the soil.

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Plastic Film Mulch and Runoff

Carol Shennan, UC Santa Cruz

Eric Brennan, USDA Salinas, CA

Organic strawberry in black plastic (left) requires drip tape under the film for irrigation. Alley soil saturation, water and nutrient runoff, and erosion follow 0.4 inch rainfall on plastic-mulched strawberry beds in Salinas, CA (right).

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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 leaves residues on surface and conserves moisture.

Strip tillage through wheat residues

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Livestock Grazing and Soil Moisture

Management-intensive rotational grazing:

- Maintains extensive, deep roots.
- Builds SOM and WHC.
- Yields drought resilient, high quality forage.
- Distributes manure and protects water quality.

Rotational grazing systems that move herds to fresh grass daily help livestock operations withstand drought.

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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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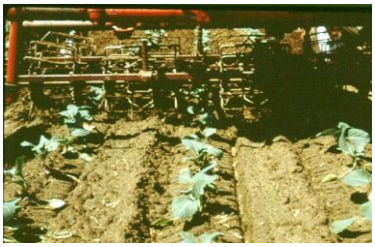
Cultivation and Organic Weed IPM

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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Co-managing Soil and Water Resources in Organic Production in the Western Region

Irrigated Crops

Irrigation Methods and Soil Health

Overhead irrigation (left) loses water to evaporation and can cause surface crusting. In-row drip (right) delivers water more efficiently and gently to crops, and reduces between-row weeds, but can also limit soil biological activity between rows.

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Irrigation Challenges in Arid Regions

- Soils are low in SOM, but can be productive if irrigated.
- Using groundwater for irrigation can:
  - Build salts in soil, hurt soil life, and degrade tilth.
  - Reduce crop yields.
  - Deplete aquifers.
- Soil health can be difficult to restore.

USDA Agricultural Research Service

A saline-sodic soil in a dry climate is prone to further degradation if irrigated for production.

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Managing for Healthy Soil in Irrigated Organic Orchard in Utah

- Bare orchard floor soils lose SOM and WHC.
- Legume (trefoil) alleys with mowings blown into rows:
  - Improved tree root growth.
  - Enhanced soil health.
  - Did not affect water needs.
- Organic living mulch (*Alyssum*) improves within-row soil health.

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

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Drought Puts Squeeze on California Tomato Growers

- 2014-17 drought sharply reduced irrigation allotments.
- OFRF study: can farmers grow tomatoes with less water?
- Trials in organic and conventional fields
- Standard irrigation (until 30 days before harvest) *vs.* deficit irrigation (stop 2 weeks early)

Scott Park &Amelie Gaudin

Recently irrigated tomato crop in central California

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Healthy Soil Improves Irrigation Efficiency

Park Farm Organics soil health practices:

- Diverse crop rotation
- Winter cover crops
- Compost, microbial inoculant
- Reduced till, controlled traffic

Outcomes:

- Nearly 100% of winter rainfall is retained in healthy soil.
- Deficit irrigation reduced water consumption 0.2 – 0.5 acre-ft.

Organic farmer Scott Park cut water use by 6 ac-inches in 2017, yet maintained tomato yield through integrated soil health practices.

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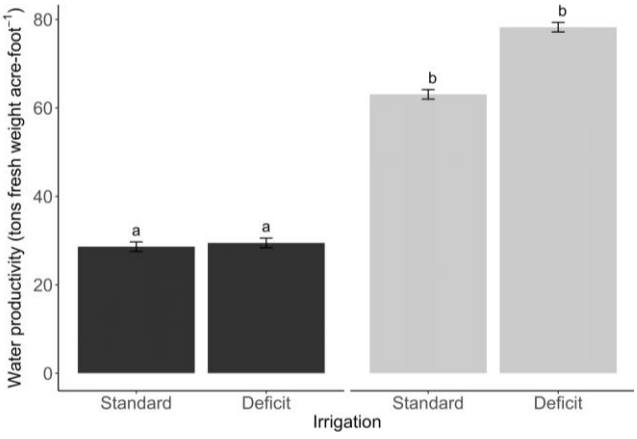
Irrigation Water Productivity



Organic:

- Much less water used
- Fewer rotten fruit (5% vs 10%)
- Fruit slightly higher in phenols

Based on slides by Dr. Amelie Gaudin

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Irrigation Management in Organic Berry Crops

- In-row drip optimizes moisture for organic blueberries.
- Organic mulch reduces irrigation needs.
- Omitting post-harvest irrigation in blackberry saves water and improves winter hardiness.

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

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Co-managing Soil and Water Resources in Organic Production in the Western Region

Some Research Findings in Irrigated Crops in Maritime Mediterranean Climates

The Problem of Winter Fallow in Mediterranean Climates

- Most rain falls in winter.
- Ponding degrades soil health.
- Runoff reduces moisture storage for next season.
- Soil erodes from sloping fields.
- N leaches to groundwater.
- Late fall harvest complicates cover crop planting.

Zahangir Kabir

Fallow field after 2” winter rainfall in Woodland, CA

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Comparing Winter Cover Crop vs Fallow at Grower-Collaborator Field Site

Zahangir Kabir

Winter Fallow (NCC) **Winter Cover Crop (CC)**

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Winter Runoff, Russell Ranch, UC Davis

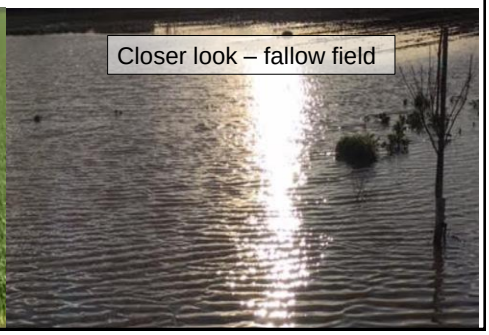
After a Storm Event in Solano Walnut Orchard

Poor Soil Structure & Soil Health

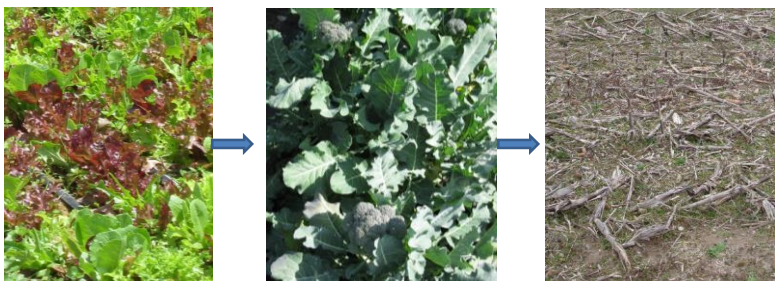
Healthy Soil with Good Structure

Photo: Kabir, Feb 07, 2017

Kabir, Feb 10, 2017



Organic Vegetables with Winter Fallow



Spring lettuce | Fall broccoli | Winter fallow

Leaching, denitrification, compaction

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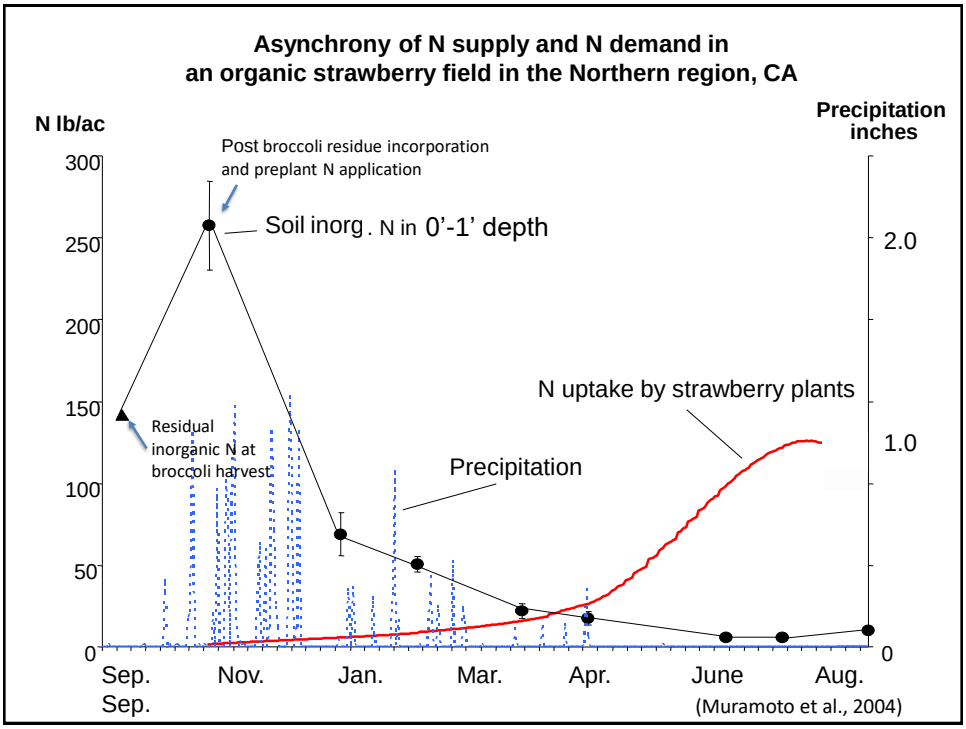

Organic Vegetables + Cover Crop

Sarah Brown, Oregon Tilth

Spring lettuce

Fall broccoli

Winter cover: rye + legume mix

N recovery, SOM, higher lettuce yield

Eric Brennan, USDA ARS, https://www.youtube.com/watch?v=JurC4pJ7Lb4

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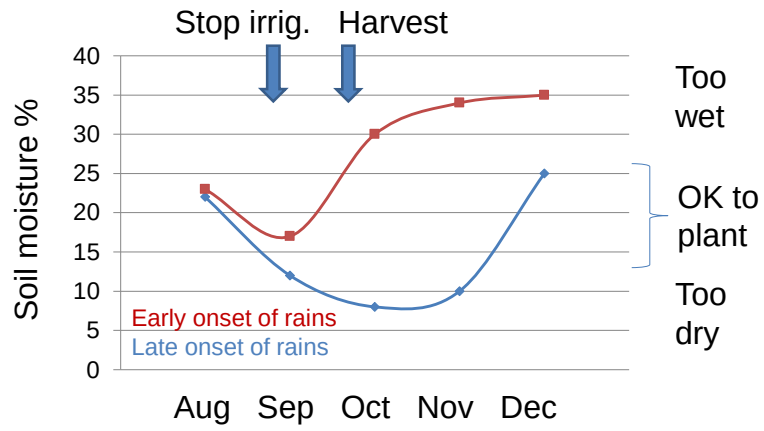
The Challenge of Getting the Cover Crop Planted



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Interseeding Cover Crops

Washington State University

Eric Brennan USDA-ARS

Nick Andrews, Oregon State U, provided by NCAT/ATTRA

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Co-managing Soil and Water Resources in Organic Production in the Western Region

Some Research Findings from the Semiarid Interior

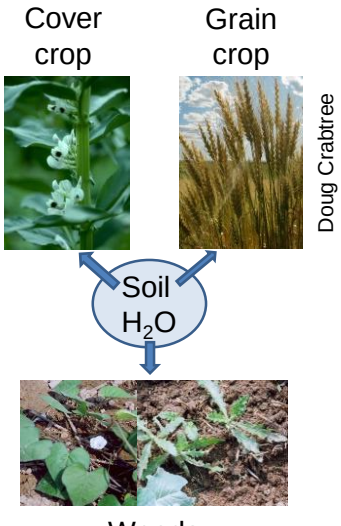
Dryland Challenges

In dry regions, cover crops build SOM and WHC in the long term, but may also:

- Produce less biomass.
- Suffer from weed pressure.
- Take moisture from cash crops.

During fallow years:

- Soils lose SOM, WHC, fertility.
- Wind erosion increases.



Doug Crabtree

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Cover Crops for Semiarid Climates

- Drought hardy
- Good biomass
- Low moisture demand
- Residue cover in dry season

New Mexico Stat U

Pearl millet (left) combines high biomass and moisture efficiency. Winter field pea (right) shows promise as a winter cover crop in dryland rotations.

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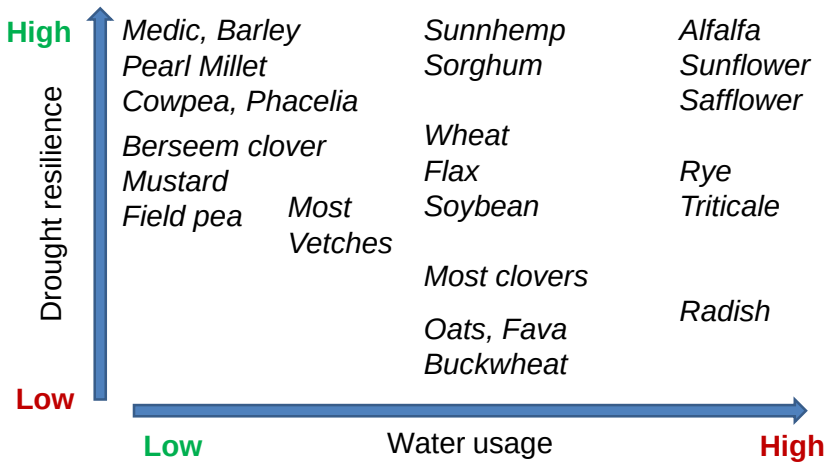
Drought Resilience and Water Use



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Cover Crops for Moisture-Limited Regions: CA Central Valley

- Limited winter rainfall, amount and timing variable
- Vetch, field pea, bell bean require sufficient fall rain
- Trials 2013 – pre-irrigate 2", dry fall, 5.65" rain in Feb-Mar
- Cucamonga California brome, Bracco white mustard > 5 t/ac
- Triticale 4 t/ac, saved moisture

USDA NRCS

Cucamonga brome and Bracco white mustard cover ground in April - on just 8" moisture

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Cover Crops for Moisture-Limited Regions: Northern Great Plains

- 30% of farmers in Western SARE survey use cover crops for soil health and grazing.
- Water and N use by cover crops can reduce wheat yields.
- Recommended practices:
  - Plant in fall or early spring.
  - Terminate at first flower.
  - Winter pea is best.
  - Avoid water hogs like alfalfa.

Doug Crabtree, Vilicus Farm in Montana

Black lentil: an excellent rotation cash crop in organic dryland grains.

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Cover Crops for Moisture-Limited Regions: Northeast Washington

- 20 farms – NRCS Conservation Innovation Grant
- 11” / yr, mostly winter snow; shallow, stony soils.
- Best results with field pea, spring planting
  - Terminate cover at 10% bloom.
- Fall-planting limited by dry soil and weeds.
- Wheat yields after cover were 34% to 122% of control.
- Yields dropped if soil dried to >3 inches at time of grain planting.
  - Terminate cover before this happens.

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Blade Plow

Undercuts cover crops and weeds just below surface:

- Leaves residue on surface.
- Leaves soil profile undisturbed.
- Saves moisture.
- Reduces wind erosion.
- Improves crop yields over other tillage methods.

Photos by Drew Lyon, U. Nebraska.

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Questions?

Download the Soil Health and Organic Farming Guides at www.ofrf.org.

This webinar was made possible by a grant from USDA Western SARE.