

# Selecting and Managing Cover Crops for Rotations in the Western Region

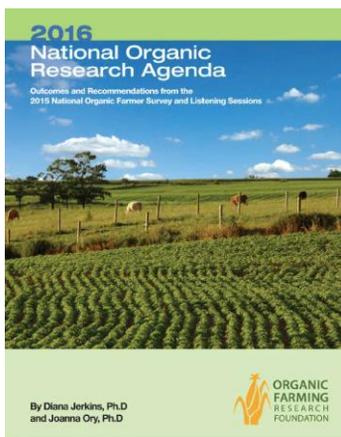
## *Research-based Practical Guidance for Organic and Transitioning Farmers*

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## Cover Crop Research Priorities for Western Region Organic Farmers



Soil health – **71%**

- Cover cropping with limited moisture

Fertility management – **66%**

- Cover crops for fertility in perennial crops
- N-fixing cover crops for arid regions



# How Cover Crops Protect and Build Soil Health

## Basic Concepts and Research Findings

### Soil Health Benefits of Cover Crops

- Stop erosion
- Relieve compaction
- Build soil organic matter (SOM)
- Feed soil life
- Recover and recycle nutrients
- Fix nitrogen (*legumes*)
- Improve tilth, drainage, and aeration
- Enhance moisture holding capacity



Six-foot tall fava bean cover crop at Fong Farm, Woodland, CA. Photo provided by NCAT / ATTRA.

## NRCS Soil Health Principle #1: *Keep Soil Covered*

Shield soil surface from wind, sun, and raindrop impact with:

- Winter cover crops.
- Frost-killed cover crop residues.
- Warm-season cover crops.
- Residues for dry summer fallow.
- Inter-planted cover in cash crop.
- Perennial orchard floor cover.



Buckwheat covers the soil within 14 days after planting.



## NRCS Soil Health Principle #2: *Maximize Living Roots*



Sorghum-sudan (left) and pearl millet (right) roots grow 5-7 feet deep.

Living cover crop roots:

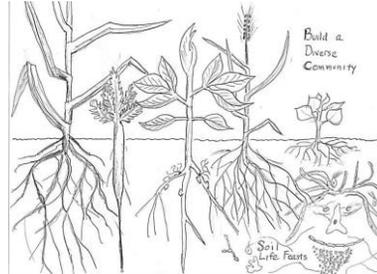
- Feed soil life.
- Penetrate hardpan.
- Maintain soil structure.
- Build long term soil fertility.
- Recover leached nutrients.
- Protect water quality.
- Reduce fertilizer bills.



## NRCS Soil Health Principle #3: *Increase Crop Diversity*

Diversified rotations with cover crops support soil organisms that:

- Fix N.
- Retain and cycle nutrients.
- Partner with plant roots (e.g., mycorrhizal fungi).
- Suppress plant disease.
- Build SOM.
- Maintain tilth.



Each plant species contributes its own root zone microbiome to the soil food web.



## NRCS Soil Health Principle #4: *Minimize Soil Disturbance*

Cover crops limit soil disturbance by:

- Maintaining continuity of food supply for soil life.
- Reducing fertilizer needs.
- Suppressing weeds and reducing need for cultivation.

Cover crops may require:

- Tillage for planting or termination.



After protecting the soil all winter, the cover crop is mowed, then tilled in. Rototiller can be set to work shallowly, 1 - 3".



## Cover Crops and Soil Health in the National Organic Standards

### Soil fertility practice standard:

*“[M]anage crop nutrients and soil fertility through rotations, **cover crops**, and the application of plant and animal materials.”*

### Crop rotation practice standard:

*“[I]mplement a crop rotation including **sod, cover crops, green manure crops, and catch crops** that build SOM, control erosion, manage nutrients, and provide pest management.*



## Living Plant Cover:

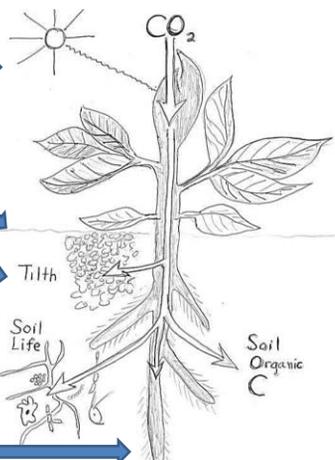
Provides carbon through photosynthesis.

Protects the soil surface.

Builds SOM and enhances soil structure.

Feeds beneficial soil life with root exudates.

Opens and deepens the soil profile.



## Sustainable Crop Intensification



SOM and soil life increase with:

- Total plant biomass production.
- The extent and duration of living roots.
- Soil coverage (days per year).



*Sustainable crop intensification practices:*

- High-biomass cover crops
- Perennial sod phase in rotation
- Living cover for orchard floor and alleys in perennial crops



## Cover Crops Work with Organic Amendments and Careful Tillage to Build Healthy Soil



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# Adding Cover Crops to Organic Production Systems

Some Research-Based Examples from the Western Region

## Organic Vegetables with Winter Fallow in Salinas Valley, CA



Spring lettuce



Fall broccoli



Fallow

*Leaching, denitrification, compaction*

## Organic Vegetables + Cover Crop



Spring lettuce



Fall broccoli



Winter cover: rye + legume mix

Sarah Brown,  
Oregon Tilth

*N recovery, SOM, higher lettuce yield*

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



## Alternate Year Fallow in Organic Dryland Grain Production



Year 1  
Wheat



Year 2  
Fallow



Year 3  
Wheat



Year 4  
Fallow

Susan Tallman, NCAT

*Erosion, loss of SOM and water capacity*



## Adding Cover Crops to Organic Dryland Grain Production



## Soil Health Problems in Plastic-mulched Organic Strawberry



Organic strawberry in black plastic (left). Alley soil saturation, nutrient runoff, and erosion follow 0.4 inch rainfall on plastic-mulched strawberry beds in Salinas, CA (right).



## Cover Cropping Furrows to Save Soil and Nutrients



Eric Brennan, USDAARS



'Ida Gold' mustard planted in November between plastic-mulched beds of organic strawberry (left) reduced ponding, retrieved about 22 lb N/ac, and was easy to kill with a weed whacker (right). See video at <https://www.youtube.com/watch?v=fesxbH03diY>.



## Orchard Floor Management



Utah State University



Keeping the orchard floor covered (left) optimizes soil health, but young trees establish better in vegetation-free strips. However, long term bare fallow orchard floor management severely undermines soil health.



## Grazing Orchard Cover Crop



As trees mature, they can tolerate full orchard floor coverage. In-row grasses and alley legume cover crop before (left) and after sheep grazing (right). Example from *Cover Crop (340)* in *Organic Systems*, ATTRA, 2013, <https://attra.ncat.org>.



## Managing for Healthy Soil in Irrigated Organic Orchard in Utah

Legume (trefoil) alleys with mowings blown into rows:

- Built SOM and organic N.
- Enhanced microbial biomass and activity.
- Enhanced tree root growth and nutrient uptake.
- Did not affect irrigation water needs.



Living orchard floor cover enhances crop and soil health without adding to irrigation costs.



## SARE Cover Crop Surveys: 2012 - 2016

- Corn, soy yields up 10% in 2012 (drought); up 1 - 4% in 2013 - 16
- Wheat yields up 2.8% in 2016
- Farmer adoption is increasing
- Farmers report better soil health, weed control, and yield stability.
- In 2016:
  - 65% planted mixes
  - 27% interseeded covers into standing cash crops



Rye, crimson clover, and radish were most widely used by farmers in the survey.

<https://www.sare.org/Learning-Center/Topic-Rooms/Cover-Crops/Cover-Crop-Surveys>



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## Does Cover Cropping Pay?

### Direct costs:

- Seed + planting ~\$30 – \$70/ac.
- Termination – fuel, labor, and new equipment

### Indirect costs:

- Cash crops not planted
- Planting delays and yield tradeoffs

### Cost offsets:

- Reduced fertilizer costs: 50 lb plant-available N can save \$230.
- Savings on irrigation and weed control

### Plant cover during fallow:

- Does not forgo income
- Prevents soil losses



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# Cover Cropping for Soil Health in the Western Region

Challenges and Resources to Help you Meet Them

## Challenge #1: Selecting the Cover Crop

### Site considerations:

- Goals and priorities
- Rotation niche
- Climate, season, and rainfall patterns
- Soil moisture
- Soil conditions
- Production system
- Tools on hand



### Cover crop traits:

- Plant family
- Growth habit
- Root mass and depth
- Seasonal life cycle
- N fixation, C:N ratio
- Nutrient recovery
- Resilience to drought, cold, etc.

## Cover Cropping for Soil Health

### Goal: Build SOM and improve tilth

- *Characteristics:* high biomass, fibrous roots
- *Examples:* cereal grains, millets, sorghum-sudan, and other grasses
- For best results include companion legumes or succulent broadleaf.



Italian ryegrass foliage and root mass



## Cover Cropping for Soil Health

### Goal: Feed soil life and build functional biodiversity

- *Characteristics:* diverse mix, including mycorrhizal hosts
- *Examples:* grasses + legumes + other forbs (buckwheat, crucifers, phacelia, and oilseeds)
- Grass-legume bicultures can cover many functions.



Spring mix of barley, oats, mustard, and pea (left). Summer mix of millet, buckwheat, sorghum-sudan, and cowpea (right).



## Cover Cropping for Soil Health

### Goal: Break hardpan and retrieve leached N

- *Characteristics:* deep, robust root system
- *Examples:* radish, canola, alfalfa, sweet clover, pearl millet, and sorghum-sudangrass



Mix of pearl millet, sudangrass, and tillage radish sends roots 5 - 7 feet deep, opening soil profile and retrieving nutrients.



## Cover Cropping for Soil Health

### Goal: Optimize nutrients for crops, soil, and water quality

- *Characteristics:* N fixation, nutrient retention, and mobilization of insoluble P and K
- *Examples:* legume-grass bicultures, such as oat + pea or rye + vetch



Rye alone ties up N and vetch alone can leach N. A rye + vetch mix provides slow-release N and can mobilize insoluble soil P and K.



## Cover Cropping for Soil Health

### Goal: Prevent erosion and suppress weeds

- *Characteristics:* rapid canopy closure; robust root system and strong competition
- *Examples:* buckwheat, cowpea, radish, grains, and sorghum-sudangrass.
- Mix tall grasses with spreading or climbing legume.



NCAT / ATTRA

Cowpea closes canopy at 37 DAP (left). Tall oats and climbing peas fully exclude weeds (right).



## Cover Cropping for Beneficial Insects

### Goal: Harbor natural enemies of crop pests

- *Characteristics:* abundant, accessible nectar and pollen; ground cover
- *Examples:* buckwheat, phacelia, vetches, mustard, sunflower, clovers, and cowpea
- Use low-growing covers for generalist predators.



NCAT / ATTRA

Soldier beetle feeding on buckwheat nectar (left). Its larvae prey on many pests. Phacelia (right) fights weeds and erosion as well as supports beneficials.



## Cover Crops for Challenging Soils

### For cool, wet soils:

- Japanese millet, oats, and annual ryegrass

### For low-fertility soils:

- Sunnhemp, pearl millet, cowpea, and buckwheat

### For acidic soils:

- Oats, rye, vetch, cowpea, sunnhemp, and buckwheat

### For alkaline soils:

- Barley and crucifers



Wet, slow-draining soils often have poor tilth and favor certain weeds (left). Japanese millet (right) tolerates wet soils and chokes out weeds.



## Other Cover Crop Challenges

### Stand establishment:

- Soil moisture
- Seed quality, planting method

### Termination:

- Tillage → SOM loss
- No-till → weeds

### N release from residues:

- Succulent legume → too fast
- Mature cereal → N tie-up



Low-vigor seed (right) makes a weedy cover crop.



## Cover Cropping in a Maritime Mediterranean Climate

### Early fall planting:

- Moisture may be limiting

### Late planting:

- Excessive moisture
- Low cover crop biomass
- Weeds get head start

### Strategy:

- Interplant covers into cash crops.



Cool season legumes and cereal grains will thrive in a coastal Oregon winter, *if* they can be planted on time!



## Interseeded Cover Crop in Organic Vegetables



Legumes interplanted with kale (left); eggplant oversown with oats in western Oregon (center); butternut squash oversown with red clover (right). Photo credits: (left) Washington State University; (center and right); Nick Andrews Oregon State University, provided by NCAT/ATTRA.



## Dryland Challenges

In dry regions, cover crops may:

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

During fallow without cover, dryland soils are prone to:

- Wind erosion.
- SOM loss.
- Reduced fertility.

Cover crop



Grain crop



Doug Crabtree

Soil  
H<sub>2</sub>O



Weeds



## Cover Crops for Semiarid Climates

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

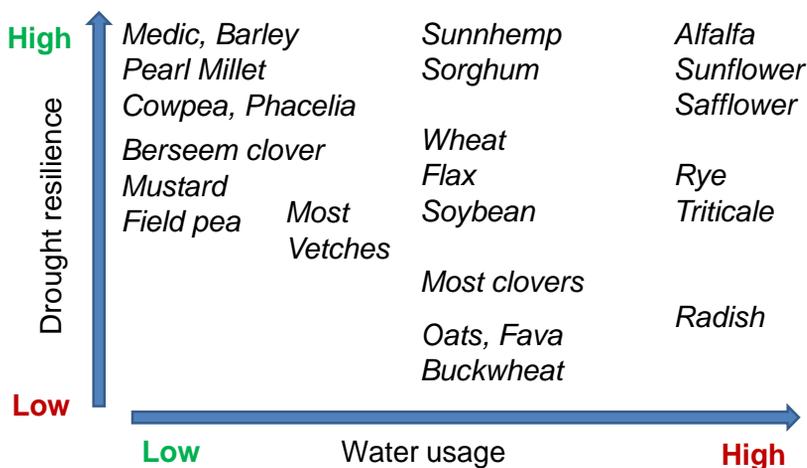
New Mexico Stat U



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



## Drought Resilience and Water Use



## Some Less-known Cover Crops for Moisture-Limited Regions

Winter cover crops for CA Central Valley:

- 'Cucamonga' California brome
- 'Bracco' white mustard

Drought and salt tolerant species for Northern Great Plains:

- Russian wild rye
- Wheatgrasses
- Alkali grass



USDA NRCS

Cucamonga brome and Bracco white mustard cover ground in April, on just 6 inches of moisture.



## Cover Cropping for Organic Dryland Grains in the Northern Great Plains

### Cover crops provide:

- Nitrogen (legumes).
- Beneficial rotation effects.
- SOM and soil moisture capacity.

### Tips:

- Plant in early fall, if practical.
- Terminate at early bloom.
- Winter pea is best for N, water efficiency, and grain yield.
- Avoid “water hogs” like alfalfa.



Montana State Extension

Winter pea in organic  
dryland grain rotation



## Western SARE Cover Crop Trials in Montana Organic Grains

- Cover crops planted in spring and terminated in summer:
  - Grew well and suppressed weeds.
  - Depleted soil moisture and N.
  - Significantly reduced grain yields.
- Earlier planting (~ Apr 1) and termination (~ July 15):
  - Increased cover crop biomass.
  - Reduced moisture depletion and grain yield cost.
- Winter pea gave similar biomass and higher wheat protein than multispecies mix.



## Montana Farmer Survey Findings

- 30% use cover crops
- Half of these planted mixes.
- Most will continue cover cropping for:
  - Soil health (primary).
  - Grazing.
  - Nutrients, especially N.
- A few may stop because of:
  - Direct costs.
  - Water use concerns.



Doug Crabtree, Villicus Farm in Montana

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



## Organic Dryland Cover Cropping in the Interior Pacific Northwest

- 20 farms in eastern WA
- 11" precipitation/yr, mostly winter snow
- Shallow, stony soils
- Control = winter wheat / fallow
- Cover crops Sep-Apr, Apr-Jul, or May-Jul of fallow year
- Rye and vetch weedy (self-seed)
- Field pea outperformed fava bean, sunnhemp, and cowpea.



Sunnhemp, known for its drought and heat tolerance, did poorly in eastern WA.



## On-farm Trial Outcomes

- Spring planting gave best cover crops.
- Fall-planting was limited by dry soil and weeds.
- Best seeding rates ~ 12 - 14 seeds/sq ft.
- Wheat yields after cover crop ranged 34% - 122% of control.
- Depth to moisture at wheat planting was critical; yields dropped if  $\geq 4$  inches.
- Terminating cover at 10% bloom gave best results.
- Farmers took soil cores to monitor cover crop water use.



## Blade Plow for Terminating Dryland Cover Crops

Undercuts vegetation just below surface:

- Knocks out weeds
- Leaves surface residue
- Leaves soil profile undisturbed
- Reduces wind erosion
- Saves moisture
- Improves crop yields



Photos by Drew Lyon,  
U. Nebraska.



## Nationwide Information Resources

### **Sustainable Agriculture Research and Education (SARE)**

*Managing Cover Crops Profitably*, 3<sup>rd</sup> ed.

*Crop Rotation on Organic Farms: A Planning Manual*

<https://www.sare.org/Learning-Center/Books>

Learning Center Topic Room

<https://www.sare.org/Learning-Center/Topic-Rooms/Cover-Crops/>

- Provides articles, decision tools, annual farmer surveys, other resources



## Nationwide Information Resources

### **Cover Cropping in Organic Farming Systems**

eOrganic on Extension website

[https://articles.extension.org/organic\\_production](https://articles.extension.org/organic_production)

- Cover Cropping under “general topics”
- Webinars and videos

### **USDA Cover Crop Chart** (updated 2018)

<https://www.ars.usda.gov/plains-area/mandan-nd/ngprl/docs/cover-crop-chart/>

- Info on 58 cover crops: moisture use, drought and salt tolerance, life cycle, N fixation / recovery



## Resources for Western Region

**Cover Crop (340) in Organic Systems: Western States Implementation Guide.** R. Dufour et al, 2013.  
<https://attra.ncat.org/organic/>

**Cover Crop and Organic Fertilizer Calculator**  
<http://smallfarms.oregonstate.edu/calculator>

**Oregon State University**

<https://extension.oregonstate.edu/crop-production/vegetables/>

- Bulletins on cover crops for vegetables

**Soil Nutrient Management on Organic Grain Farms in Montana.** Montana Extension bulletin EB0200, 16 pp.



## Resources for Western Region

**Meeting the Challenges of Soil Health in Dryland Wheat.**  
 NRCS webinar, Leslie Michel, Oct 9, 2018.

**Principles of Cover Cropping for Arid and Semi-arid Farming Systems.** New Mexico State Extension.  
[https://aces.nmsu.edu/pubs/\\_a/A150.pdf](https://aces.nmsu.edu/pubs/_a/A150.pdf)

**Cover Crop Chart: Common Cover Crops for California.**  
[https://efotg.sc.egov.usda.gov/references/public/CA/CA\\_CCC\\_with\\_Links\\_Rev\\_1-2018\\_508R.pdf](https://efotg.sc.egov.usda.gov/references/public/CA/CA_CCC_with_Links_Rev_1-2018_508R.pdf)

**Western Cover Crops Council** is in formation.



# Questions?

