

Selecting and Managing Cover Crops for Rotations in the Western Region

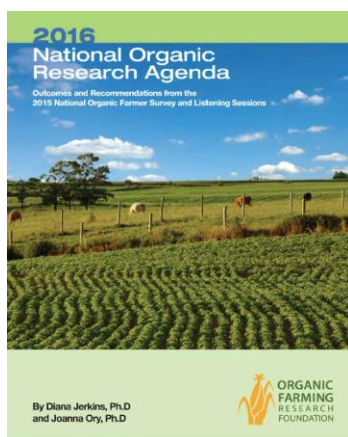
Research-based Practical Guidance for Organic and Transitioning Farmers

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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:

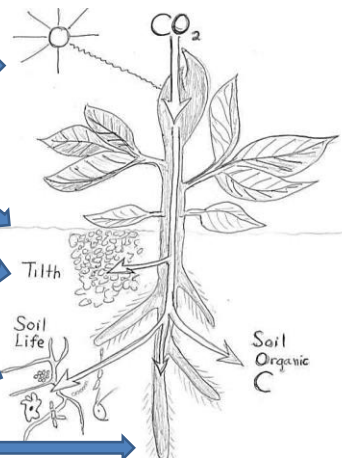
Provides carbon through photosynthesis.

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



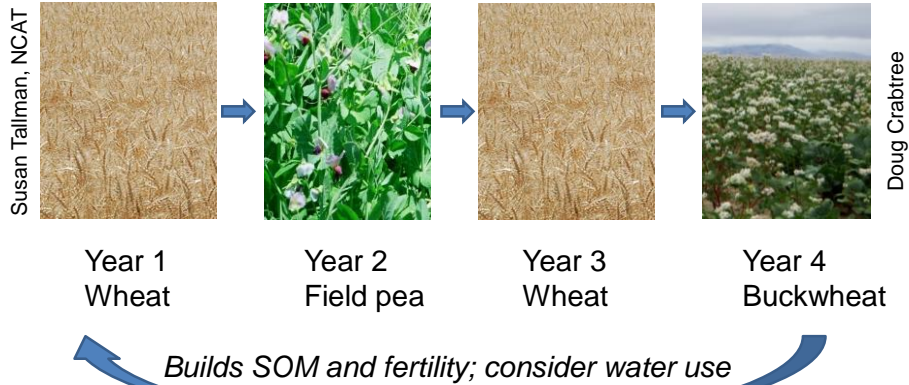
Year 4
Fallow

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>



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



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.

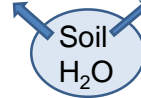
Cover crop



Grain crop



Doug Crabtree



Weeds



Cover Crops for Semiarid Climates

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

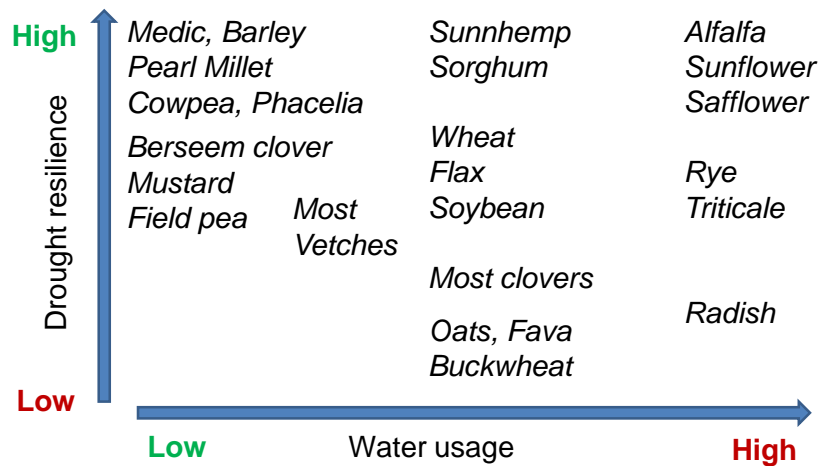
New Mexico Stat U



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, Vilicus 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 ≥ 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, 3rd 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

- 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

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

Western Cover Crops Council is in formation.



Questions?

