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# Cover Crops for Soil Health: Selection and Management 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.*



## Presenters



Mark Schonbeck



Diana Jerkins



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# How Cover Crops Protect and Build Soil Health Basic Concepts and Research Findings



## Soil Health Benefits of Cover Crops

- Prevent erosion.
- Build soil organic matter (SOM).
- Feed soil life.
- Improve soil tilth, drainage, and aeration.
- Fix nitrogen (*legumes*).
- Recover, retain, and cycle nutrients (*most covers*).
- Enhance the soil's capacity to hold moisture and nutrients.



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

Soil fertility and crop nutrient management practice standard:

*“The producer must manage crop nutrients and soil fertility through rotations, **cover crops**, and the application of plant and animal materials.”*

Crop rotation practice standard:

*“The producer must implement a crop rotation including ... **sod, cover crops, green manure crops, and catch crops** that:*

- *maintain or improve soil organic matter content*
- *provide for pest management*
- *manage deficient or excess plant nutrients*
- *provide erosion control.”*



### Living plant cover:

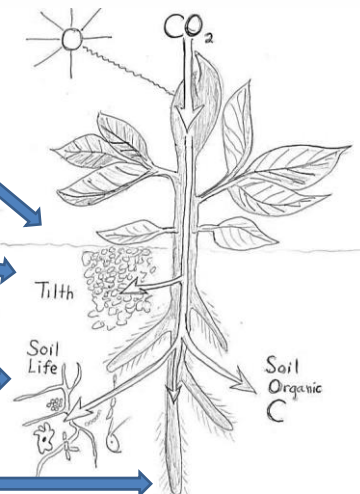
Provides carbon through photosynthesis

Protects the soil surface

Builds SOM and enhances soil structure

Feeds the soil life with root exudates, promotes beneficial organisms

Opens and deepens the soil profile



## Cover crops work with organic amendments and careful tillage to build healthy soil.



## Sustainable Crop Intensification



SOM, soil life, and soil health increase with:

- Total annual plant biomass production.
- Days per year in living plant cover.
- Extent, depth, and duration of living roots.
- Soil coverage by living plants or residue.

*Sustainable crop intensification practices:*

- Grow high-biomass cover crops.
- Add perennial sod to rotation if practical.
- Keep orchard floor and alleys between berry crops in living plant cover.





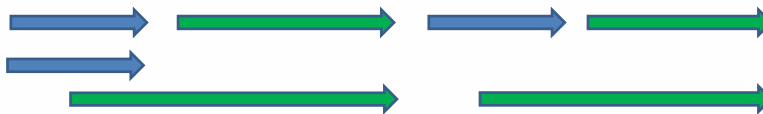
## Two-year Corn-soy Rotation without Cover



In a typical Corn Belt rotation without cover crops, the soil is occupied by living vegetation only about four months of the year. Even without tillage, the limited soil coverage and lack of organic inputs from living plant roots leaves the soil vulnerable to SOM losses and erosion, especially after a low-residue crop such as soybean.



## Sustainable Intensification in a Corn-soybean Rotation



Post-harvest planting of rye after corn, and vetch after soybean (top) reduces duration of soil exposure. Further intensification can be achieved by relay interplanting clovers or grasses into standing row crops (bottom).

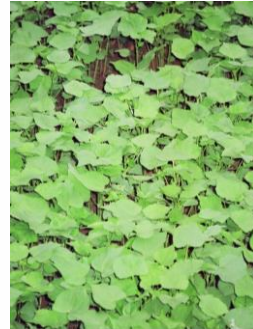


## NRCS Principles of Soil Health

### 1 – Keep the soil covered.

Year-round coverage by living plants or residues protects the soil from rain, wind, and sun, preventing erosion and crusting, and conserving SOM and soil life.

- Winter cover crops can eliminate extended bare fallow in most of the U.S.
- In vegetable or winter cereal rotations, warm-season cover crops can “fill” summer fallow periods
- Leaving frost-killed cover crops on surface provides winter protection ahead of early spring crops.



Buckwheat can cover the ground within 14 days after planting.



## NRCS Principles of Soil Health

### 2 – Maximize living roots in soil profile.



Sorghum-sudan (above), radish, and pearl millet send roots 5-7 feet deep.

- Plant root exudates and fine root sloughing provide a continuous supply of food for beneficial soil organisms.
- The deep, extensive root systems of mature cover crops enhance drainage and aeration, relieve hardpan, and bring organic matter and soil life deeper into the profile.
- Cover crop roots recover leached nutrients, thereby protecting water quality, reducing fertilizer bills, and building long term soil fertility.



## NRCS Principles of Soil Health

### 3 – Build crop diversity for soil biodiversity.

- Diversifying the crop rotation enhances soil food web functional diversity and builds SOM and overall soil health.
- Adding just one cover crop to a low-diversity rotation can make a big difference.
- Many cover crops host highly beneficial mycorrhizal fungi.



Each plant species harbors its own root zone microbiome. Thus, a diverse crop rotation builds soil biodiversity.



## NRCS Principles of Soil Health

### 4 – Minimize soil disturbance.

Managing cover crops in organic systems can involve disturbance in the form of tillage. However cover cropping also:

- Maintains better continuity of food supply for soil life.
- Improves soil fertility and reduces fertilizer needs.
- Reduces weed pressure and need for cultivation.



When the soil is cleared of vegetation, the food supply for the soil life is cut off. Prolonged fallow without tillage may be more “disturbing” than tillage followed promptly by planting.





# Cover Cropping for Soil Health in Organic Systems

## Challenges and resources to help you meet them.



### Challenge #1: Selecting the Cover Crop

#### Site considerations:

- Goals and priorities
- Climate – frost dates, rainfall, etc.
- Soil conditions
- Rotation niche – dates, duration
- Preceding and following cash crops
- Production system
- Tools on hand



#### Cover crop traits:

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



## Other Cover Crop Challenges for Organic Systems

- Timely planting and best technique to ensure good stands (right).
- Effecting cover crop termination without excessive tillage that would compromise soil health benefits.
- Optimizing nutrient release from residues:
  - All-legume or succulent green manure may release N too fast.
  - All-grass or overmature cover may tie up N.



## Nationwide Information Sources

### Cover Cropping in Organic Farming Systems

- eOrganic articles on Extension web site  
<https://articles.extension.org/pages/59454/cover-cropping-in-organic-farming-systems>.
- View eOrganic video clips at  
<https://www.youtube.com/user/eOrganic/playlists>

### SARE Learning Center – Cover Crops Topic Room

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

- Articles, decision tools, links to other resources
- Annual SARE farmer surveys (latest 2016-17)



## North Central Region

### Leading challenge: **short growing season**

- Limited time to grow cover crop biomass, fix N.
- Delayed cash crop planting.
- Cool, wet soil under rolled covers can hinder stand establishment.

#### *Meeting the challenge:*

- Interseed or overseed cover into cash crop (*right*)
- Plant cash crop before terminating cover ("planting green")



Clover was seeded into rye, thus eliminating the bare soil period between grain harvest and cover crop establishment.



## Resources for North Central Region

### Midwest Cover Crop Council <http://mccc.msu.edu/>

- Decision tools to help farmer select cover crops.
- Annual Conference – Feb 20-21, 2019, Springfield, IL.
- Information resources on web site organized by:
  - *State.*
  - *Cover crop species.*
  - *Topics – planting, equipment, termination, etc.*
  - Example: video showing organic soybeans planted into rye, which was roll-crimped as soybeans emerged.  
<https://www.youtube.com/watch?v=YuvSbmumgcl>.



## Northeast Region

Leading challenge: **short growing season**



*Soybean interplanted with sweet corn (left) will winter-kill, but enhances organic matter and N return to soil. Red clover interseeded with tomato (center) will grow into the next season and fix substantial N. Potato (right) was planted into rye + vetch, which were rolled as potatoes emerged.*



## Resources for Northeast Region

### Northeast Cover Crop Council

<http://northeastcovercrops.com/>.

- Extensive state by state information.
- Annual Conference – Nov. 15-16, 2018, State College, PA.
- Guidance for doing on-farm cover crop trials.
- Interactive website, invitation to share results.
- *Decision tool for cover crop selection coming in fall 2018.*

**Pennsylvania State University**

**Cornell University**




# Southern Region

## Leading challenge: **intense summer heat**


- Most crops are stressed by prolonged temperatures above 90°F.
- Pest and weed pressures are intense.
- Dry spells can thwart cover crop establishment.

*Meeting the challenge:*

- Grow soil with heat-loving, drought-resilient cover crops during hot season.



Clockwise from top left: sorghum-sudangrass, sunnhemp, indigo, and lablab thrive in coastal NC summer.



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## Southern Region

### Secondary challenge: low fertility soils


- Highly weathered soils (Ultisols); clays and nutrients leached from topsoil (A horizon) to subsoil (B).
- Sandy, coastal plain soils have very low SOM, and leached, compacted E horizon between A and B.
- Limited root depth restricts cash crop access to moisture, and nutrients

*Meeting the challenge:*

- Grow deep rooted, high biomass cover crops to build SOM, relieve hardpan, and retrieve nutrients.



A cover crop of winter cereal rye can relieve subsurface compaction and allow the next crop to send roots deeper.



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## Resources for Southern Region

**Southern Cover Crop Council** - *website and decision tools in development at:* <https://southerncovercrops.org>

- Planting and termination methods, tools, timing.
- Equipment tips for cash crop planting in coastal plain soils.

**Southern SARE Cover Crop Conference** (July, 2016)

<https://www.southernsare.org/Events/Southern-Cover-Crop-Conference>. Information sheets and videos on:

- Cover crop selection and mixes
- Soil biology and soil health
- Equipment for no-till and strip-till termination, including implements for small scale 2-wheel tractor system.
- Economics of cover cropping.



## Western Region

### Leading challenge: **limited moisture**

- Cover crops use precious soil moisture while growing, yet build soil health and moisture holding capacity over the long run.
- Yield impacts vary widely .
- Two-year wheat-fallow rotation degrades SOM and soil health.

*Meeting the challenge:*

- Shallow-rooted, moisture-efficient cover crops.
- Residue cover in summer.
- More research is needed.



A winter field pea cover crop improved soil health and maintained dryland grain yields in MT and interior WA. However, spring-planted field pea succumbed to weeds.



## Resources for Western Region

**Cover Crop (340) in Organic Systems: Western States Implementation Guide**, R. Dufour et al, 2013. 20 page information sheet based on NRCS conservation practice, available at <https://attra.ncat.org/organic/>.

Working with university and agency personnel, with support from Western SARE, Jerry Hall, research director of seed vendor Grassland Oregon, is launching a **Western Cover Crops Council**. Article at <https://www.no-tillfarmer.com/articles/7907-new-cover-crop-council-taking-shape-in-western-us>.



## SARE Cover Crop Surveys: 2012 - 2016

- Corn, soy yields up 10% in 2012 (drought) 1 – 4% in 2013-16.
- Farmer adoption increasing.
- Benefits cited include better soil health (85%), weed suppression, and yield stability.
- In 2016:
  - 65% planted mixes (33% in 2012)
  - 27% interseeded covers into standing cash crops.
  - 39% used or tried “planting green”



Rye, crimson clover, and radish were most often planted by farmers in survey.

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



# Selecting and Managing Cover Crops for Soil Health Some tips and guidelines



## Cover Cropping for Soil Health Getting Started



A winter cover crop of rye:

- Stops erosion.
- Builds SOM.
- Improves soil tilth.
- Absorbs and holds nutrients.
- Suppresses weeds.

- The first step is to add a cover crop during winter or other fallow season.
- Adding just one new cover crop to an existing rotation can improve soil health.
- Cover crops or their residues in lieu of bare fallow is good insurance against soil erosion.



## Timely cover cropping averts disaster in Floyd, VA flood of 2015.

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 temporarily flattening the cover crop (D). However, not one shovelful of soil was lost.



## Cover Cropping for Soil Health

**Goal: Protect the soil surface, stop erosion**

- *Characteristics:* rapid establishment and canopy closure, persistent (high carbon) residues.
- *Examples:* buckwheat, cowpea, radish (canopy); cereal grains, millets, sorghum-sudangrass (residues).



A mixture of foxtail millet and cowpea protects this organically-managed soil in Virginia by quickly covering the ground (cowpea) and forming high-carbon biomass (millet).



## Cover Cropping for Soil Health



High biomass annuals like pearl millet + sunn hemp (top) and perennial grass-legume-forb sod (above) build SOM.

### Goal: Build Soil Organic Matter

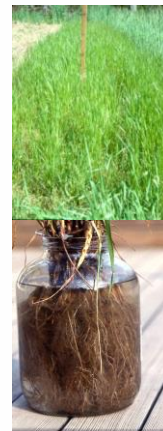
- *Characteristics:* high biomass, deep, extensive root systems, persistent residue, moderate to high carbon:nitrogen (C:N) ratio.
- *Examples:* sorghum-sudan, millets, cereal grains, sunflower, sunn hemp; perennial sod.



## Cover Cropping for Soil Health

### Goal: Improve topsoil tilth

- *Characteristics:* extensive, fibrous root systems
- *Examples:* ryegrass (right); cereal grains, millets, other grasses.
- *For best results:* include companion legume or succulent broadleaf to provide available organic N and C and thereby support soil microbial activity.



Italian ryegrass foliage and root mass.





## Cover Cropping for Soil Health

**Goal: Break subsurface hardpan, open soil profile**

- *Characteristics:* Deep taproot or deep, robust, fibrous root system.
- *Examples:* Radish, canola, alfalfa, clovers, sweetclover (taproot), pearl millet, sorghum-sudangrass (fibrous).



This late-summer mix of pearl millet, sorghum-sudangrass, and tillage radish sends roots five feet or deeper, breaking hardpan and retrieving nutrients.



## Cover Cropping for Soil Health

**Goal: Feed soil life, build soil biodiversity**

- *Characteristics:* diversity of species, including both high and low C:N; mycorrhizal hosts.
- *Examples:* grasses (high C:N, mycorrhizal, fibrous roots) + legumes (N fixing, low C:N, deep taproot, mycorrhizal).
- Add buckwheat, crucifers, phacelia, sunflower, etc. for greater functional diversity.



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



## Selecting Cover Crops for Challenging Soils

For cool, wet soils:

- Japanese millet, oats, alsike clover

For low-fertility soils:

- Sunnhemp, pearl millet, cowpea, buckwheat

For acidic soils:

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

For alkaline soils:

- Barley, crucifers.



Wet, slow-draining soils often have poor tilth and favor weeds that tolerate these conditions, (left). Japanese millet (right) can thrive under these conditions and may help correct the problem.



## Stacking Functions: Cover Crop “Cocktails”

Multi-species cover crop mixes or “cocktails” address multiple cover cropping goals, and can maximize biomass and soil health benefits.

- Challenges include planting logistics, domination of the stand by one or two species, and non-synchronous maturity that limits management options.
- Start with a two-species legume + grass mix, which can enhance soil health outcomes over either alone.



Winter cover crop of triticale + winter pea has developed 5 tons/ac biomass.



## Cover Cropping for Nutrient Management

**Goal: optimize nutrient levels for crop nutrition and water quality.**

- *Characteristics:* N fixation, nutrient retention, making P and K more available to the next crop.
- *Examples:* legumes (fix N); radish, pearl millet (take up and hold subsoil N); buckwheat and legumes. (P); grasses (K).



Rye alone ties up N; vetch alone can leach N when terminated. A rye+ vetch mix provides slow-release N and can mobilize P and K from insoluble sources.



## Cover Cropping for Weed Management

**Goal: suppress weeds**

- *Characteristics:* rapid early growth and canopy closure; aggressive competition for nutrients; complementary growth habits fully occupy niche.
- *Examples:* buckwheat, cowpea, radish (rapid cover); rye, sorghum-sudangrass (nutrients); mixtures of tall grasses with spreading or climbing legume (growth habit).



'Iron-Clay' cowpea forms dense canopy by 37 DAP (left). Oats + bell bean cast heavier shade and suppress weeds more effectively than either alone (right).



## Cover Cropping for Pest Management: Attracting Beneficial Insects

**Goal: harbor natural enemies of crop pests**

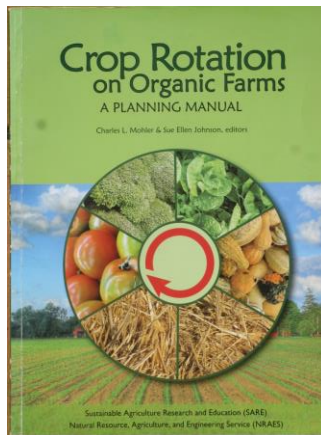
- *Characteristics:* abundant nectar and pollen in shallow, accessible flowers or extrafloral nectaries; ground cover for beneficials.
- *Examples:* buckwheat, phacelia, vetches, mustard, sunflower (flowers); cowpea (extrafloral nectaries); low-growing clovers, residues (ground cover).



Pennsylvania leatherwing feeding on buckwheat nectar. Its larvae prey on cucumber beetles and other pests.



## Cover Cropping for Pest and Disease Management: Crop Rotation



**Goal: disrupt life cycles of crop pests and pathogens**

- *Characteristics:* non-host for pests and pathogens of cash crops in rotation; suppressive toward nematode pests.
- *Examples:* cover crops unrelated to preceding or following cash crops; cover crop cultivars that suppress specific pest nematodes.
- Design crop rotation to deter prevailing pests and diseases



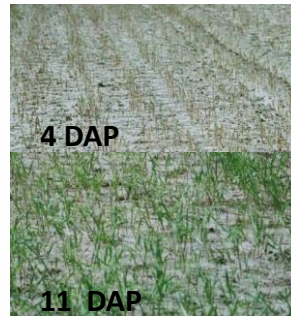


## Cover Crop Planting Tips

- Timely establishment is vital.
- Use compost or manure if soil nutrient levels are low.
- Use recommended seeding rates and depths.
  - Increase rates 1.5 – 2X for late planting or weedy field.
  - For grass + legume, reduce grass rate by half or more.
  - Divide recommended sole-seeding rates by number of specie in a cocktail; adjust as needed.
- Use best planting equipment and technique.
  - No-till drill or planter for untilled or high residue fields.
- Irrigate if needed to ensure establishment.



## Example of Cover Crop Planting Technique



Charlie Maloney of Dayspring Farm (Cologne, VA) broadcasts rye + hairy vetch at 50 + 25 lb/ac with a spin seeder (left), then rototills one inch deep, taking out small weeds while planting the cover (center). This technique results in prompt establishment and excellent stands (right).





## Tips on Terminating Cover Crops



Winter cover crop terminated by flail mowing followed by tillage, or mowing alone in field trial.

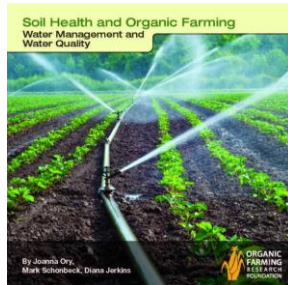
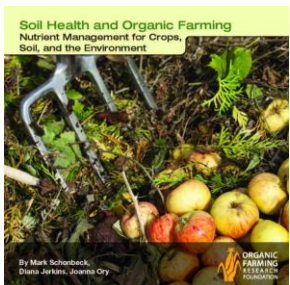
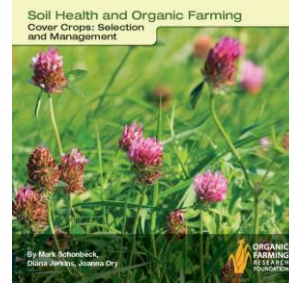
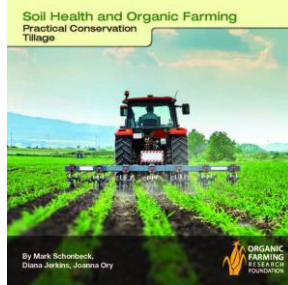
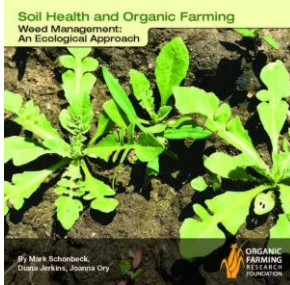
### Terminate mature (flowering) cover crop by:

- Spading machine or plow.
- Mowing followed by shallow non-inversion tillage (left).
- Sweep plow undercutter.
- Winterkill.
- Roller-crimper or flail mower for no-till or strip till planting.

*No-till and reduced till methods are best for soil.*



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## Questions?

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- Have an organic farming question? Use the eXtension Ask an Expert service at <https://ask.extension.org/groups/1668>
- Please send your feedback! We will email you a survey about this webinar later today.
- Thank you for coming!

