Practical Conservation Tillage for Western Region Organic Cropping Systems

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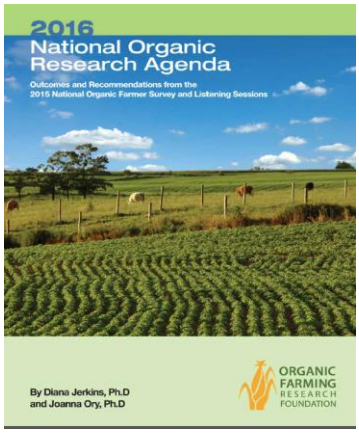
Research Priorities Identified by Western Region Organic Farmers



71% cited soil health as a research priority.

Tillage questions included:

- Effects on soil biology
- Effects on soil carbon
- Building soil organic matter with minimum till
- Tillage and crop rotation effects on weeds and soil
- Managing bindweed

Download full report at http://ofrf.org/

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How Tillage Affects Soil Health

- Exposes soil surface to:
  - Wind and water erosion
  - Surface crusting
  - Higher soil temperatures
- Aerates and pulverizes soil causing:
  - Increased erodibility
  - Compaction
  - Reduced moisture holding
  - Oxidation (breakdown) of soil organic matter (SOM)

This tillage operation is burning up SOM and losing soil to the wind.

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How Tillage Affects Soil Health

- Speeds microbial respiration
  - Nutrients released
  - SOM consumed
- Kills larger organisms
  - Earthworms, arthropods
  - Fungal networks
- Removes living plant cover
  - Hiatus in root exudates
- Inverts soil (plow)
  - Habitat disruption

Plowing this maritime Pacific Northwest muck soil brought subsoil to the surface and likely consumed topsoil SOM.

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The Organic Farmer's Dilemma: Tillage, Weeds, and Soil Health

"The [organic] producer must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion."

National Organic Rule, Section 205.203(a), Soil fertility and crop nutrient management practice standard.

Cover crop residues feed soil life and add organic matter, but will the tillage compromise these benefits?

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NRCS Principles of Soil Health

- Keep the soil covered.
- Maintain living roots.
- Build soil biodiversity.
  - Diversified crop rotation
  - Crop-livestock integration
- Minimize soil disturbance.
  - Conservation agriculture eliminates *physical* disturbance (continuous no-tillage).
  - Organic agriculture eliminates *chemical* disturbance (synthetics prohibited).

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Putting No-till into Perspective

- Continuous no-till builds SOM near the soil surface.
- Much of this SOM is lost after one tillage pass.
- Continuous no-till *cannot* prevent SOM loss in wheat-fallow rotations.
- Diversified rotations with deep-rooted crops build SOM throughout the soil profile.
- Integrated organic systems with some tillage build as much or more SOM than conventional continuous no-till.

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Cover Crops and Bio-tillage

In tilled organic systems that build SOM:

- Crop rotations maintain soil cover and living roots through much of the year.
- Cover crops play a central role.

Deep-rooted cover crops:

- Penetrate hardpan.
- Promote deeper rooting in following cash crops.

Cover crops like tillage radish (left), pearl millet (right), sorghum-sudan, and sweet clover send roots to 5 feet or more.

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Perennial Sod Phase in Rotation

A legume-grass sod break:

- Restores soil with continuous living roots.
- Enhances soil biodiversity.
- Rebuilds fertility.
- Reduces the weed seed bank.
- Boosts subsequent crop yields.

In low-rainfall climates, sod may:

- Deplete soil moisture.
- Reduce yields of following crops.

Perennial forage crops protect and build soil, but may consume too much moisture in drier regions.
Photo: USDA NRCS

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Organic Reduced-till Strategies

- Fewer passes
  - Weed IPM
- Shallow tillage
  - Power harrow
  - Blade plow
- Non-inversion tillage
  - Chisel plow
  - Spading machine
- Strip tillage, ridge till
- Rotational no-till

Straw mulch can eliminate one or more cultivations in vegetable crops.

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Is Tillage Really Needed Now?

Small-seeded crops like carrot need a fine seedbed (left), but potatoes, transplants, and larger seeds may not need as much tillage before planting. When a cover crop is frost-killed (right), let it be until spring to save soil moisture and give ground beetles time to consume weed seeds.

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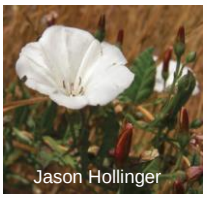
Managing Invasive Weeds with Less Tillage

IPM for field bindweed and Canada thistle:

- Biocontrols
- Grazing, mowing
- Crop diversification
- Crop competition
- Flame, steam, solarization
- Tillage and cultivation



Bindweed

Bindweed moth

Canada thistle …

with rust fungus

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Taming the Rototiller

Charlie Maloney, Dayspring Farm

Photo by Rick Felker, Mattawoman Creek Farm

Rototilling to 1” takes out small weeds and incorporates cover crop seeds (left). Lowering rototiller PTO speed and increasing tractor forward speed conserves soil aggregation during bed preparation (right).

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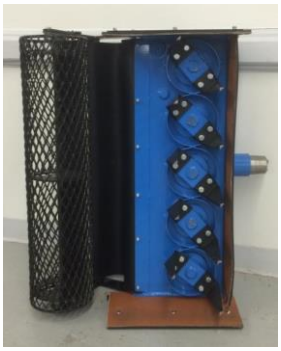
Shallow Tillage

- Makes seedbed.
- Incorporates amendments and light residues.
- Takes out small weeds.
- Leaves most of soil profile undisturbed.
- Reduces harm to soil life.
- Can build soil health in conjunction with organic practices.



BCS Power harrow tool works top 2 – 3 inches gently, leaving crumbly seedbed.

Photo by bdk, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=16007844

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Blade Plow

- Undercuts vegetation just below surface for:
  - Cover crop termination.
  - Fallow weed control.
  - High residue cultivation.
- Leaves surface residue.
- Leaves soil profile undisturbed.
- Reduces wind erosion.
- Saves moisture.
- Improves crop yields.

Photos by Drew Lyon, U. Nebraska.

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Deep Tillage without Inversion

Moldboard plow turns cover crop … and soil life upside down.

- Deep tillage may be needed to:
  - Break hardpan.
  - Break sod.
  - Manage larger weeds.
- Non-inversion tools:
  - Chisel plow
  - Spader
  - Broadfork

The broadfork is an excellent tool for garden scale applications.

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Rotary Spader

- Is gentle on soil aggregates.
- Does not create tillage pan.
- Can incorporate high-biomass cover crops.
- In Washington State U. trials:
  - Reduced compaction at 5 – 12 inches.
  - Sometimes improved crop yields.

Washington State U. Extension

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Tilling Only Part of the Field:

Soil Functional Zone Management

- Tillage functions in crop rows:
  - Seedbed preparation
  - Weed removal
  - Nutrient release
  - Soil warming
- Undisturbed soil between rows
- Other zone management strategies include:
  - Zone-planted cover crops
  - In-row drip fertigation

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Tilling Only Part of the Field: Strip Tillage

Washington State U.

Washington State U.

NCA&TSU

Two types of tractor-drawn strip tillers work a narrow strip for each crop row, leaving 70 – 80% of the soil surface undisturbed and covered with residues.

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Crops Thrive in Strip Tilled Soil

USDA

Tomatoes growing in wide strip tilled beds made with walk-behind rototiller, with mowed rye cover in alleys (left). Peanut crop has established well from a strip till planting (right).

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Tilling Only Part of the Field: Ridge Tillage

USDA NRCS

Soybeans planted into ridge tilled corn residue. Living or winter- killed cover crop can also be ridge tilled.

- Soil shaped into narrow beds or ridges on contour
- Cover crop planted in fall
- Ridge tops cleared and tilled in spring for planting
- Post-plant cultivation:
  - Rebuilds ridges.
  - Moves organic residues into crop row.

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Rotational No-till for Organic Crops

Step 1: Grow high biomass cover crop to maturity.

Triticale + winter pea

Pearl millet + sunnhemp

Oats + bell bean

Foxtail millet + cowpea

← Ready for roll-crimping →

← Not yet flowering – wait →

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Rotational No-till for Organic Crops

Step 2: Terminate cover crop without tillage or herbicides.

Washington State U.

Cover crops may be terminated by roller-crimper (left), flail mower (center), or frost-kill (right).

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Rotational No-till for Organic Crops

Step 3: No-till planting of the production crop

No-till transplanter sets pepper starts through a heavy residue of roll-crimped cover crops.

Organic summer squash planted no-till into vetch + rye residue yielded 15 t/ac.

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Rotational No-till for Organic Crops

Step 4: Manage weeds as needed

Manage weeds in cash crop with high residue cultivation tools such as:

- Finger weeders.
- Sweeps or undercutters.

After harvest, till as needed for:

- Late season weed control.
- Planting the next cover crop.

Finger weeders, UCCE Sonoma County

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Weeds: The #1 No-till Challenge

Organic rotational no-till may fail if:

Cover crop is thin.

Weed seed bank is large.

Perennial weeds are present.

Cover crop self-seeds.

Cover crop is planted just after breaking sod.

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Other Organic No-till Challenges

Yields may be limited by:

- Delayed planting.
- Planting problems or poor seed-soil contact.
- Delayed soil warming.
- Slower N mineralization.
- Moisture consumption by the cover crop.

Late snap beans in rolled pearl millet are not vigorous and yields are low. The millet may have consumed soil moisture or tied up N.

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When Organic Rotational No-till is Most Likely to Succeed

- High biomass cover crop
- Warm climate with adequate rainfall, e.g., Hawaii.
- Healthy soil, good tilth
- Light textured (sandy) soils
- Strong N-fixer planted into high-carbon residues
- Farmer has equipment and experience for no-till

Soybean planted no-till into rye residues. USDA

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Tips for Organic Rotational No-till

- Roll-crimp twice to ensure cover crop termination.
- Adjust planter for high residue:
  - Row cleaners
  - Coulter type
  - Add weight on toolbar
- Lay opaque tarp or weed mat over rolled or mowed cover to:
  - Ensure cover crop is killed.
  - Suppress weeds.

Landscape fabric (weed mat) between crop rows offers solution to no-till challenges in small-scale operations.

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Meeting the Challenges of Organic Reduced Till in the Western Region

Research findings and practical applications

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Organic Minimum-till Challenges in the Maritime Pacific Northwest

- Short growing season
- Residues delay soil warming.
- Rainy spring, wet soil
  - Planting delays
  - Cannot roll-crimp vetch
  - Cover crops regrow after undercutting.
- In-row weeds after planting
- Slugs in cover crop residues
- Late summer drought

Wet soils and yellow nutsedge can thwart organic no-till in PNW.

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Washington State University Trials:

vetch + rye, **no-till** (NT) vs. **strip till** (ST) vs. **spader**

Vetch and rye established well.

Residue clogged strip tiller:

- Need PTO strip tiller

Spader:

- Reduced compaction
- Soil warms and dries faster
- Too dry in August

Squash yields and soil type:

- Loamy sand ST > spader
- Fine sandy loam spader > ST, NT
- Silt loam ST, NT *crop failure*

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Practical Tips and Resources for Maritime Pacific Northwest

- Vigorous, early, easy-to-terminate cultivars:
  - 'Aroostook' rye
  - 'Purple Bounty' vetch
- Use high residue sweep cultivator to take out weeds and leave residues.
- Flail mow vs. roll-crimp cover
  - More flexible termination date
  - Easier to cultivate / control weeds
  - Farmers more likely to adopt

Organic Reduced Tillage in the Pacific Northwest. http://eorganic.info/node/4988).

WESTERN SARE Sustainable Agriculture Research & Education

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Strip Tillage for Organic Broccoli in Coastal Oregon

- Fewer weed seedlings and flea beetles in strip till (ST) than full tillage (FT)
- Lower crop foliar N in ST than FT
- Yields 15-19% lower in ST than FT
  - Slower N release in ST
  - Between-row weeds
- Additional research planned:
  - Wider, deeper strip till
  - Thermal weeding between rows

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Organic Conservation Tillage in a Drier Mediterranean Climate

Tomato trials in Meridian, CA:

- 15” rain/year, mostly winter
- Slow-draining Nueva loam
- Legume or legume + grain cover, mowed and:
  - Tilled before tomato planting
  - Tilled 3 weeks after planting
  - Strip tilled or
  - No-till.

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Outcomes of Meridian, CA Organic Reduced Till Trial

2000 season: Dry soil, low soil N at tomato planting

- Grain + legume tied up N.
- Cover crop reduced soil moisture in spring.
- Yields sharply lower in:
  - No-till or strip till
  - Grain + legume cover

2001 season: Moist soil at tomato planting

- Adequate soil N in all treatments
- Good tomato yield (~40 t/ac) in all treatments
- More weeds in no-till and strip till than full till

Delayed till: yields > strip or no-till, adequate weed control, saves 1 – 2 cultivations over pre-plant till

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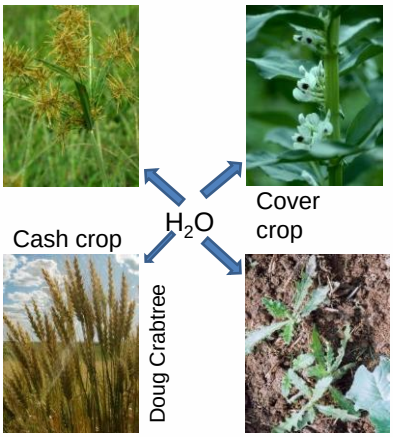
Organic Conservation Tillage Challenges in Dry Interior Climates

Semiarid soils are seriously impacted by tillage:

- Erosion.
- SOM loss.

Organic minimum-till is more difficult because of:

- Limited moisture.
- Weed pressure.
- Low SOM and N.
- Lower cover crop biomass.



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Two Approaches to Reduced Tillage in the Northern Great Plains

Montana State University

Researchers at Montana State U. are using sheep to graze cover crop, eliminating tillage for three out of five years in the rotation.

Doug Crabtree Vilicus Farms

Kamut-flax intercrop yields two cash grains and leaves no room for weeds. Part of the rotation with cover crops is terminated by blade plow.

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Other Research Findings in Dryland Organic Grain Rotations

- Severe yield tradeoffs in no-till (WY, NE)
- Reduced frequency tillage (once per year) compatible with soil health (WY, NE)
- Shallow tillage – rotary hoe, rotary harrow – for annual weeds (WA)
- Blade plow vital tool for dryland
- Winter pea cover best for N, weed suppression, and low water use

Washington State U Organic Grains
http://smallgrains.wsu.edu/organic-production/

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Reduced Till / Living Mulch in Irrigated Organic Vegetables in Montana

Challenge: Limited N

- Legume living mulch
- Annual light tillage in May

Outcomes:

- Greatly enhanced SOM, tilth, soil life
- Excellent yields & quality
- Crops more cold tolerant
- Biodiversity, natural enemies
- Few pests, little disease

At Biodesign Farm in MT, Helen Atthowe kept the soil covered year-round with cash crops and living mulch. Research funded by Western SARE and Organic Farming Research Foundation.

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Fine-tuning the System

No-till, mow, and/or flame:

- Yield decreased in no-till.
- Monthly mowing enhanced soil life, reduced slugs.
- Grasses invaded living mulch.

Adjusting inputs:

- Reduced compost from 10 to 2 t/ac-year.
- Annual shallow till system optimized yields, returns; maintained soil.


May: Clover living mulch lightly tilled, self-seeds


June: Bumper harvests; clovers cover alleys.

Photos by Helen Atthowe

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Summary

- Adapt NRCS soil health principles to your site, soil, and climate.
- Till with care, select best tools
  - Blade plow
  - Spader
  - Rotary harrow
- Manage soil zones – strip till.
- Consider livestock integration.
- Explore no-till on a small scale.
- Be creative.

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Soil Health and Organic Farming
Weed Management: An Ecological Approach
Soil Health and Organic Farming
Practical Conservation Tillage
Soil Health and Organic Farming
Cover Crops: Selection and Management
Soil Health and Organic Farming
Nutrient Management for Crops, Soil, and the Environment
Soil Health and Organic Farming
Water Management and Water Quality
Soil Health and Organic Farming
Plant Genetics: Plant Breeding and Variety Selection
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Questions?
Download the Soil Health and Organic Farming Guides at www.ofrf.org.
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