Welcome to the webinar!

- The webinar will start the top of the hour.
- To type in a question, use the q and a box on your control panel. We'll read the questions aloud after the presentation.
- A recording will be available in our archive at http://www.extension.org/pages/25242 and on the eOrganic YouTube channel.
- Find all eOrganic resources at http://www.extension.org/organic_production
- If you can't hear, go to the top of your screen, click "communicate", "audio settings", then choose whether to listen by computer or phone. If it's the computer, it should allow you to test the sound. Click OK. If you want to call in, choose the phone, and dial the number it gives you.

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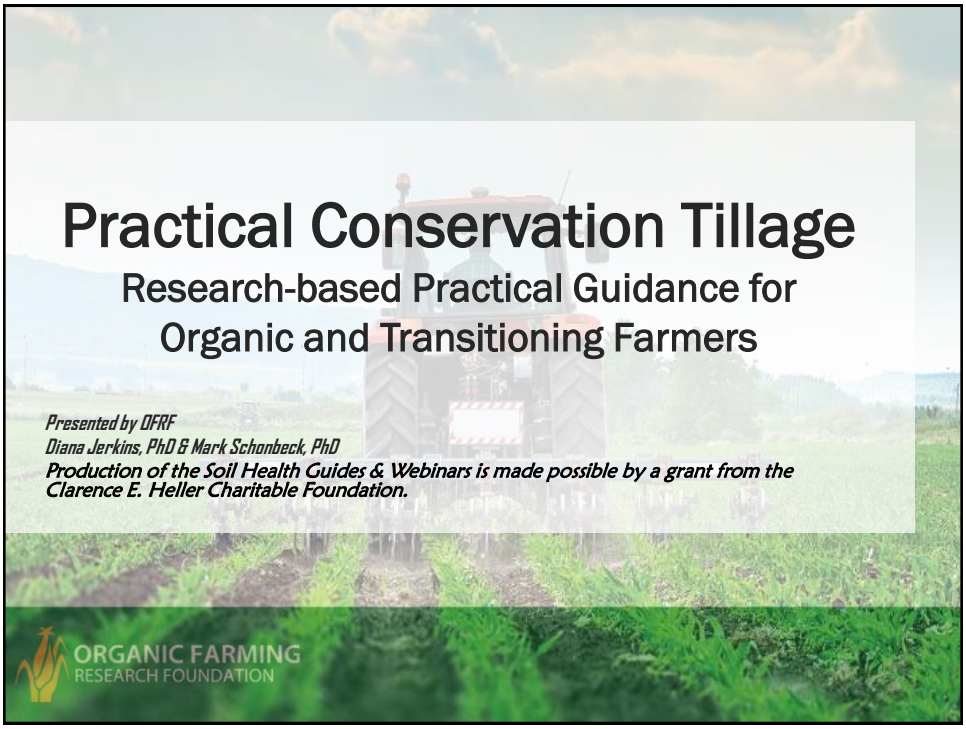

Organic farming is based on healthy soil.

"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), oil fertility and crop nutrient management practice standard.

The cover crop residues will feed soil life and add organic matter, but how will the rotary tillage affect soil health?

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How tillage affects soil physical properties

- Exposes soil surface
  - Increases erosion risk
  - Promotes surface crusting by direct raindrop impact
  - Widens soil temperature swings
- Breaks up soil aggregates
  - Pulverized soil is prone to wind and water erosion
  - Exposes soil organic matter (SOM) to oxidation

This tillage operation is burning up SOM and losing soil to the wind. Tillage tools, soil moisture levels, and wind speed at the time of tillage determine soil impacts.

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How tillage affects soil biology

- Accelerates microbial respiration
  - Nutrients released
  - SOM consumed
- Terminates living plant cover
  - Interrupts the flow of root exudates, the "bread and butter" of microbial nutrition
- Plowing inverts soil
  - Biologically active surface layer buried under subsurface layer

Plowing down a legume cover crop promotes microbial activity and releases nutrients, but may alter soil food web function by inverting the soil profile.

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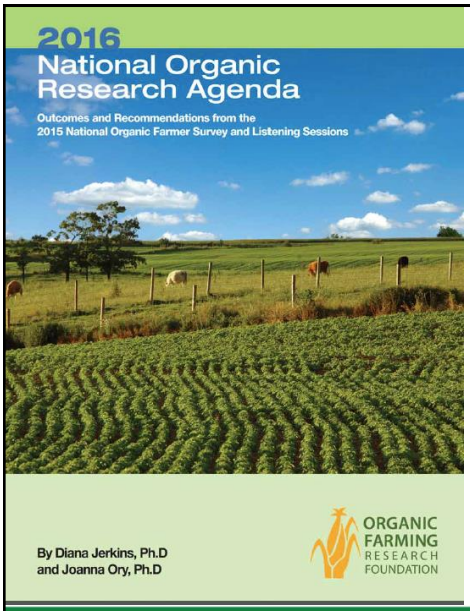

In a survey of more than 1,000 organic farmers conducted by OFRF in 2015:

- 74% cited soil health and quality as a high research priority
- 67% cited weed control
- 66% cited fertility and nutrient management
  - Effects of various tillage practices on soil health and fertility, soil carbon, and weed populations

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

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No-till and Conservation Agriculture

In 2012:

- 96M acres (34% of US cropland) were managed no till
- 77M acres (28%) had conservation tillage with ≥30% residue coverage

Conservation Agriculture integrates:

- Continuous no-till
- High biomass cover crops
- Diversified crop rotation
- Organic amendments for soil health
- Synthetic inputs as needed for fertility, weed, and pest control

Organic broccoli planted no-till into mowed rye + vetch cover crop on Cape Cod, MA.

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Reducing tillage in organic systems

- Continuous no-till is not practical in organic production of annual crops.
- Organic strategies to reduce tillage intensity include:
  - Rotational no-till
  - Non-inversion tillage in lieu of turn plow and heavy disk
  - Shallow tillage
  - Strip or ridge tillage
  - Ecological weed management to reduce need for cultivation
  - Bio-tilling cover crops
  - Perennial sod in crop rotation

The winter rye cover crop was mowed, 2-ft wide strips were tilled for the tomato crop, leaving 60% of field area undisturbed.

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Rotational no-till for organic crops

Step 1: Grow high biomass cover crop, ≥ 3 tons/ac

- Cash crop is no-till planted into a roll-crimped, mowed, or winter-killed cover crop.
- Cover crop residues build soil health and suppress early season weeds.
- After harvest, some tillage is usually done to manage weeds and prepare the seedbed for the next cover crop.

Pearl millet + sunnhemp (left), and triticale + winter pea (right) cover crops at 4 – 5 tons/ac.

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Rotational no-till for organic crops

Step 2: Terminate cover crop without tillage or herbicides

Roll-crimper to terminate cover crops (A); rye + vetch rolled by flail mower with PTO off (B); flail mowing (C), winterkilled pearl millet (D)

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Rotational no-till for organic crops

Step 3: No-till planting of the production crop

No-till transplanter developed by Ron Morse et al. at Virginia Tech, to plant vegetable starts through a heavy residue of rolled cover crops.

Organic summer squash planted no-till into roll-crimped cover crop of rye + vetch. Soil is tilled after harvest to prepare seedbed for next cover crop.

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Rotational no-till for organic crops

Step 4: Manage weeds in cash crop as needed

Use high residue cultivation tools (A) or undercutters.
Do not attempt if:

- Perennial weeds like nutsedge (B), Johnsongrass (C), or Canada thistle are present
- Annual weed populations are high (D)
- Sod was broken just before the cover crop (E)

Finger weeders, UCCE Sonoma County

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More organic no-till challenges

- Farms must have suitable equipment for the system.
- Cover crop must be high biomass with dense even cover.
- Cover crop must be terminated at correct maturity—full bloom to immature (nonviable seed).
  - *Cover crop mixes must have synchronized diversity*
- Termination date must allow timely planting of cash crop.

Timing is right for no-till terminating of crimson clover (left) and the mustard component of the mix (right) but may be too early for the pea and barley components.

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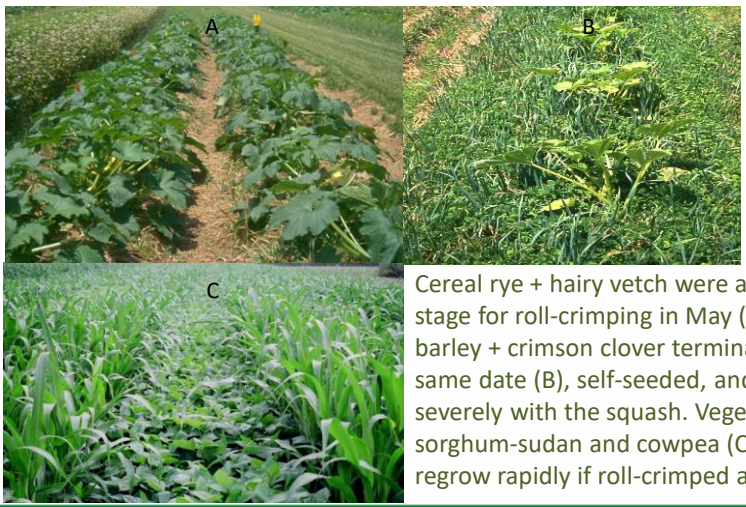
Getting the timing just right



Cereal rye + hairy vetch were at the right stage for roll-crimping in May (A), while barley + crimson clover terminated the same date (B), self-seeded, and competed severely with the squash. Vegetative sorghum-sudan and cowpea (C) would regrow rapidly if roll-crimped at this point.

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More organic no-till challenges

- Heavy cover crop residues can interfere with seed-soil contact, resulting in poor cash crop stands.
- No till with heavy cover crop residues can slow soil warming and delay release of available N to cash crop.
  - As a result, organic rotational no-till systems often give reduced yields.

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 no-till is more likely to succeed

- Warmer climates with adequate rainfall—southeastern and Gulf coast states, Hawaii.
- Healthy, biologically active soils rich in organic matter.
- Lighter textured (sandy) and well-aggregated soils.
- Soybean is a strong N fixer, and thus gains a competitive advantage over N-responder weeds like pigweed when planted no-till after cereal grain cover.

Soybean planted no- till into residues of a high biomass rye cover crop. USDA

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Tips for organic rotational no-till

- Roll-crimp twice to ensure cover crop termination.
- For better seed-soil contact:
  - *Row cleaners ahead of planter.*
  - *Try different coulter types*
  - *Add weight to tool bar*
- Choose cover crop varieties that mature early or roll-crimp easily.
  - 'Abruzzi' rye, 'Purple Bounty' vetch
- Try "planting green"
  - Seed into standing cover, then roll-crimp (*experimental – try on small area*).

Organic potato planted into standing rye + vetch, mowed 3 weeks later, as potatoes emerged. Yields 17% higher than after tilled cover. (Ron Morse, VA Tech)

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Tips for organic rotational no-till

- Opaque tarp or landscape fabric on rolled cover for 2 – 4 weeks before planting cash crop:
  - Ensures cover crop kill
  - Suppresses weeds
  - Squash or cabbage yields ≥ tilled or no-till without tarp
- Clear plastic for two days on mowed summer cover crop:
  - Ensures cover crop kill
  - Releases N, max. broccoli yield without added N

Landscape fabric between crop rows can suppress weeds and cover crop regrowth and can be reused many times.

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Putting no-till into perspective

No-till is challenging for organic growers and is not the only way to build soil health.

- Continuous no-till adds about 900 lb. SOM/ac-year for 10-15 years.
- Most of this SOM accumulates in aggregates near the surface, and is readily lost after a single tillage pass.
- Improved rotations with deep rooted sod and cover crops build SOM throughout soil profile over a longer period.
- Studies show similar SOM gains from no- till and from integrated organic systems with some tillage.

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NRCS four principles of soil health

- Keep the soil covered as much as practical.
- Maximize living roots throughout the rotation.
- Energize the soil system with crop diversity.
  - Crop rotation, intercropping, multispecies cover crops
  - Crop-livestock integrated systems
- Minimize soil disturbance:
  - Physical (tillage, traffic)
  - Chemical (pesticides, herbicides, soluble fertilizers)
  - Biological (overgrazing, invasive exotic species)

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No-till versus organic

- In USDA Beltsville, MD trials, diversified organic rotations with cover crops, poultry litter (0.7 – 1.3 tons/ac-yr), and routine tillage were compared with continuous no-till corn-soy with conventional inputs.
- SOM was measured from surface to 39 inches.
- The organic rotations accrued 6.7 tons SOM/ac in 13 years, while conventional no-till accrued 2.4 tons /ac.

Bottom line:

Integrated organic systems with diverse, tight crop rotations and some tillage can build more SOM than conventional continuous no-till systems.

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Soil-friendly tillage: practical approaches to reducing tillage intensity

- Fewer passes: *do you really need to till now?*
- Shallow tillage: *leave most of soil profile intact.*
- Non-inversion tillage: *avoid turning the soil life's home upside down.*
- Gentler tillage: *just ease up on the PTO.*
- Strip tillage and ridge tillage: *leave inter-row soil undisturbed.*
- Grow cover crops: *let plants do some of the tillage.*
- Sod phase in rotation: *give the land a rest*.

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Can you till less often?

You may need a fine seedbed (left) for carrots or other small-seeded crops, but skip that last pass for potatoes, transplants, and larger seeds, which can tolerate some surface residue. When a cover crop frost-kills (right), let it be until spring to save soil and give ground beetles a chance to consume weed seeds.

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Can you till less often?

Cultivate less with Integrated Weed Management

- *Crop rotation*
- *Competitive crops*
- *Cover crops*
- *Mulching*
- *Mowing, flaming, etc.*

See *Weed Management: an Ecological Approach,* a soil health guide at www.ofrf.org.

Straw mulch applied after the peppers and eggplant became established suppressed later-emerging weeds and reduced the need for cultivation.

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Shallow tillage

- The working depth of many tillage implements including rototiller can be adjusted according to need.
- Shallow tillage can reduce adverse effects on soil life, yet maintain satisfactory crop yields.
- In a long term (21 yr) trial in Germany, “minimum tillage” (3 inches) and organic practices together improved SOM and microbial biomass more than either practice alone.

The rototiller is set to work just one inch deep, removing tiny weeds and incorporating cover crop seed.

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Shallow tillage implements

- The rotary harrow works the top few inches, taking out small weeds and mixing residues into the topsoil.
- Compared to plow-disk, terminating cover crops with the sweep plow undercutter reduces compaction, conserves soil moisture, and can improve yields of the next crop.

This power harrow attachment for the BCS two-wheel tractor includes horizontally rotating tines and roller that till shallowly and gently, leaving a seedbed with soil surface aggregates intact.

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Deep non-inversion tillage

- The chisel plow is the most common implement for non-inversion primary tillage.
- Meta-analysis of 62 studies showed that chisel plowing maintains higher microbial biomass and causes less disruption to soil life than moldboard plow or plow-disk.
- Some market gardeners use the **broadfork** to loosen soil for planting, weeding, or harvest. Its gentle, non-inverting action saves soil tilth.

The broadfork loosens soil to harvest root crops and plant cover crops without inverting or pulverizing the soil.

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Deep non-inversion tillage

- Rotary or reciprocating spading machines offer another option for “primary” tillage, such as that needed at the end of the sod phase of a diverse crop rotation.
- The spader works the soil deeply without inverting.
- In trials in the Pacific Northwest, using the spader to prepare seedbeds reduced compaction compared to plow-disk-rototill, and sometimes improved vegetable yields.

Powerful yet gentle, the spading machine incorporates high biomass cover crops and can even break sod.

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Soil-friendly rototilling

- Rick Felker of Mattawoman Creek Farm in eastern Virginia found a way to “tame” his tractor-mounted rototiller: use a lower PTO gear for tine rotation, and increase tractor forward speed to 2.5 mph.
- The rototiller works 4 - 6 inches deep to incorporate winter cover crops.
- This adjustment adequately prepares the soil for planting without destroying soil aggregates.
- Visible crumb structure has developed in the farm’s sandy soil.

After mowing rye + vetch, beds were shaped and gently tilled to create ideal conditions for planting.

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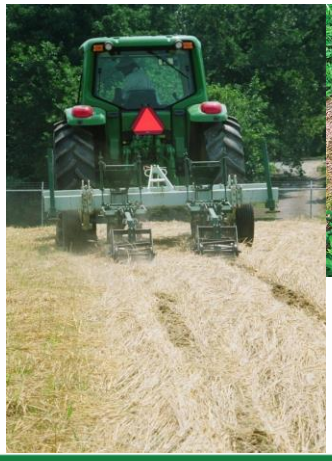
Tilling only part of the field: strip tillage



The strip tiller (left) works a narrow strip for each crop row, leaving 75% of the field undisturbed and covered. Peanut crop thriving in strip tilled field (above; photo credit USDA)

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Tilling only part of the field: ridge tillage

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

- In ridge tillage, the soil is shaped into narrow beds or ridges before planting the winter cover crop.
- In spring, ridge tops are cleared and shallow-tilled for planting.
- After crop establishment, ridges are rebuild with an implement that takes out weeds and moves soil and residues back into crop rows.

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Soil Functional Zone Management (SFZM)

- The ridge tillage system stimulates soil microbes to mineralize nutrients in the crop row while conserving SOM between rows.
- Ridge rebuilding further enhances within-row fertility by moving organic residues into the rows.
- "Zone planting" cover crops (right) and in-row drip fertigation can also enhance soil functional zones.

Sorghum-sudangrass builds stable organic matter in alleys while sunnhemp fixes N in the grow-zone for the next production crop.

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Cover crops: let plants do the tillage

Cover crops such as tillage radish (A, E), biennial sweetclover (B), pearl millet (C), and sorghum-sudangrass (shown previous slide) can send roots more than 6 feet deep, penetrating and loosening hardpan. Rye (D) can also loosen soil.

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Cover crops are fundamental

In virtually every study showing positive trends in SOM and soil health in organic systems with tillage:

- Crop rotations were "tight" with soil coverage and living root much of the year.
- Cover crops played a central role.

For more, see *Cover Crops: Selection and Management, soil health guide at* www.ofrf.org.

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Perennial sod phase in rotation

- Including a perennial sod phase in the crop rotation:
  - Rests the soil for one or more years without tillage.
  - Restores soil health through continuous living roots and increased plant diversity.
  - Rebuilds fertility, especially legume + grass sod.
  - Allows ground beetles and other weed seed consumers to reduce the weed seed bank.

After several years in vegetable crops with tillage, oats + red clover were planted. Clover grew for another year after oat harvest.

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Crop-livestock integration at Elmwood Stock Farm, Scott Co, Kentucky

Rotation:

- 3 years intensive vegetables with winter cover crops
- 5 years pasture with mixed species mob-grazed livestock

U. Kentucky soil health study:

- Year 4 (first year pasture after vegetables) SOM, organic N, and microbial activity “approaching that of his permanent pasture.”

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New Resource for Organic Reduced Till

Reduced Tillage in Organic Systems
Field Day Program Handbook

July 31, 2018 at Cornell University
Willsboro Research Farm, Willsboro NY.

https://rvpadmin.cce.cornell.edu/uploads/doc_699.pdf.

Our 10.5-foot roller at work (top). Organic soybeans no-tilled into rolled rye, (bottom) USDA NRCS http://www.va.nrcs.usda.gov/technical/crop_agronomy.html

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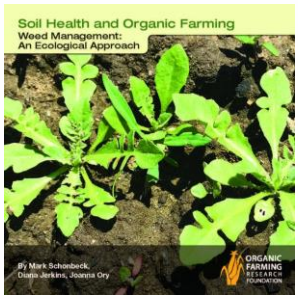

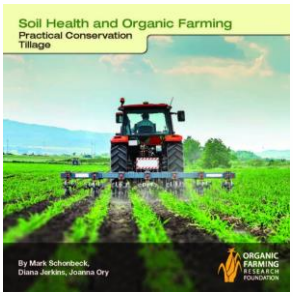

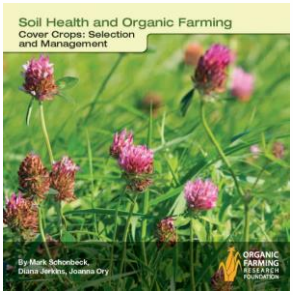

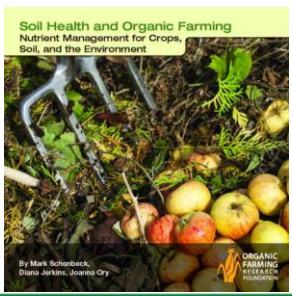

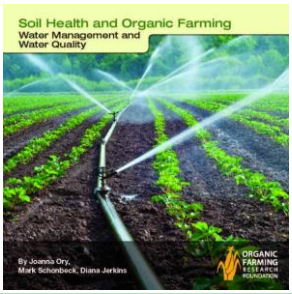

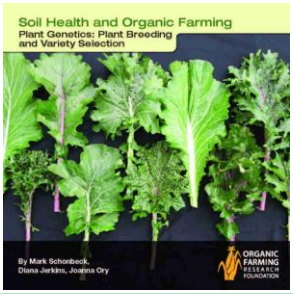

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