Mark Schonbeck

Mark Schonbeck has worked for 35 years as a researcher, consultant, educator, and advocate for sustainable and organic agriculture. He works one-on-one with farmers and homesteaders, taking a site-specific approach to soil test interpretation and organic soil, nutrient, and weed management for vegetables and other crops. In his capacity as Research Associate with Organic Farming Research Foundation (OFRF), he develops research-based education materials including a series of practical guides on *Soil Health and Organic Farming*, available at http://ofrf.org/.

In the past, Mark has led or participated in several on-farm research projects conducted by Virginia Association for Biological Farming (VABF) and collaborated with VABF and National Center for Appropriate Technology (NCAT) to help USDA Natural Resources Conservation Service (NRCS) programs better serve organic producers.

Mark also serves as VABF policy liaison with National Sustainable Agriculture Coalition (NSAC) of which VABF is a member group and writes the policy update column for the monthly VABF e-newsletter. He also works with OFRF to develop policy recommendations to help organic producers mitigate the impacts of climate change on their operations and the communities they serve.

Practical Conservation Tillage for Organic Cropping Systems

Mark Schonbeck
Research Associate

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USDA
Natural Resources
Conservation Service

The Costs of Tillage

- Wind and water erosion
- Degraded structure, plowpan
- Surface crust, runoff
- Loss of soil organic matter (SOM)
- Damage to soil life:
  - Breaks fungal hyphae, earthworms
  - Disrupts habitat (pores) and food supply (root exudates)

Tilling dry soil on a breezy day throws soil to the wind (A). Moldboard plowing turns the “house” upside down and can limit the soil benefits of cover cropping (B).

USDA National Organic Standards on Tillage

"The 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."

USDA NOP Regulations, §205.203
Soil fertility and crop nutrient management practice standard

Weeds and Cultivation: the Organic Farmers' Dilemma

The goal

Too much

Too little

What Organic Farmers Say about Tillage and Soil

Production challenges:

- Controlling weeds – 67% of respondents
- Effects of tillage on soil health – 31%
- Avoiding soil erosion and degradation – 30%

From farmer focus groups:

- *"Having the right equipment to reduce tillage is a big challenge"*
- *"How to manage field bindweed and Canadian thistle while minimizing tillage."*
- *"There needs to be more research around soil health in vegetables"*
- *"Tillage is the bluntest but fastest tool to flip beds"*

When and Why do Organic Farmers Till the Soil?

- **Prepare seedbed for planting:**
  - Mix amendments and residues into the soil.
  - Stimulate microbes to mineralize nutrients.
  - Facilitate seed-soil contact.
- **Plant cover crop seeds (right)**
- **Manage weeds and cover crops**
- **Manage soil physical properties:**
  - Relieve compaction.
  - Improve aeration.
  - Improve water infiltration.

After broadcasting rye + vetch seed, Virginia organic farmer Charlie Maloney tills 1" deep to remove emerging weeds and cover seed (left), resulting in an excellent stand (right).

Tilling for Seedbed Preparation



Small-seeded, direct-sown crops such as mesclun greens (left and center) and carrot (right) require a fine seedbed (left) for successful establishment. This requirement creates a period of soil vulnerability during production of these crops.

Tilling to Get the Most from Organic Nutrient Sources

When compost is surface-applied (left), its slow-release nutrients may not become crop-available, and its beneficial organisms may die from desiccation and solar UV. Flail mowing can terminate certain cover crops and leave a weed-suppressive mulch (center); however, their nutrients may not be released to the current crop. Organic farmers often till these materials into the top 2-4" of soil to stimulate microbial activity and nutrient release (right).

Tillage and Cultivation for Weed Control

A

B

C

D

E

F

Timely, shallow cultivation keeps crops ahead of weeds (A). Repeated tillage may be needed to control creeping perennial weeds like Johnson grass (B), Canada thistle (C), field bindweed (D), and nutsedge (E). Large soil "seed banks" of annual weeds support dense flushes of weed emergence (F). A <u>one-time</u> moldboard plow operation can bury the seeds and reduce weed pressure in organic crops.

Reducing Tillage Intensity in Organic Systems

Low-impact tools for various purposes
and different scales of operation

Soil Tillage Intensity Rating (STIR), Conservation Practice Standards, and Organic Systems

- **CPS 329 No Till**
  - No full-width tillage.
  - Total crop cycle STIR ≤ 20.
  - Difficult to sustain throughout an organic annual crop rotation.
- **CPS 345 Reduced Tillage**
  - Non-inversion tillage only.
  - Total crop cycle STIR ≤ 80.
  - Many organic farmers reduce tillage to this level.

Shallow Non-inversion Tillage: Power Harrow
STIR = 21 *

- Makes seedbed.
- Incorporates amendments and light residues.
- Takes out small weeds.
- Leaves most of soil profile undisturbed.
- Research comparing shallow non-inversion tillage versus moldboard plowing (8-10”):
  - Does less harm to soil life.
  - Maintains higher SOM.
  - May support 2X the microbial biomass.

*STIR ratings obtained from current RUSLE2 program.
For comparison, STIR for moldboard plowing to 8” is 65.

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

Shallow, Non-inversion Tillage: High-speed Disk STIR = 41 (with rolling basket)

Justin Rich, Huntington, VT

- Working depth 2-4 inches.
- Tractor forward speed 7-12 mph.
- Incorporates cover crops, makes seedbed.
- Time and energy efficient for larger acreages.
- Primary tillage for many organic farmers.

"**Vertical tillage**"

- Coulters in line (zero angle) STIR = 9.
- Coulters + spike tooth harrow STIR = 19.

Shallow, Non-inversion Tillage: Blade Plow
STIR = 10

- Undercuts vegetation just below surface for:
  - Cover crop termination.
  - Weed control, high residue cultivation.
- Leaves surface residue.
- Leaves most of soil profile undisturbed.
- Requires moderate soil moisture level to operate properly.
- Compared to disking, the blade plow:
  - Reduces wind erosion, saves moisture.
  - Sometimes improves crop yields.

Drew Lyon, U. Nebraska.

Deep Non-inversion Tillage for Small Scale: Broadfork

STIR ~ 4 *

- **Deep tillage may be needed to:**
  - Break subsurface hardpan
  - Manage larger weeds
- **Other non-inversion tools that can relieve compaction:**
  - Chisel plow (STIR = 53 for 7” depth with coulter).
  - Para-plow, subsoiler (STIR = 18).
  - Vertical tillage tools – coulter, followed by narrow shank to prepare seedbed (STIR = 19).

* Highest value listed for “manual cultivation.”

The broadfork is an excellent tool for root crop harvest and working raised beds in high tunnel and market gardens.

Moderate-impact Deep Tillage: Spading Machine
STIR = 31

Rotary or reciprocating spaders:

- Do not pulverize soil aggregates.
- Do not create tillage pan.
- Mix rather than inverting soil.
- Can incorporate cover crops or sod in one pass.
- In Washington State U. organic vegetable systems trials, the spader:
  - Reduced compaction at 5-12 inches.
  - Sometimes improved yields over plow-disk.

Washington State U. Extension

Tilling Part of the Field: Strip Tillage

STIR = 5 - 7

Washington State U

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

Crops Thriving in Strip Tilled Soil

USDA

Tomatoes growing in zone-tilled beds made with walk-behind rototiller with mowed rye cover in alleys on an organic vegetable farm in Floyd, VA (left). Peanut crop has established well in a strip-till planting (right).

Tilling Part of the Field:
Soil Functional Zone Management

- Ridge tillage (upper right) and strip tillage focus soil disturbance within and near crop rows for:
  - Seedbed preparation, weed removal
  - Nutrient mineralization
  - Soil warming
- Undisturbed, residue covered soil between rows:
  - Builds stable SOM, slows erosion.
- Zone planted cover crops (lower right):
  - Legumes or crucifers provide N in grow zone.
  - High biomass grasses build stable SOM, stop erosion, and suppress weeds between rows.

USDA NRCS

Organic Rotational No-till Systems

Based on high-biomass cover crops

Termination by roller-crimper

Rotational tillage as needed

Many challenges

Rotational No-till for Organic Crops

Step 1: grow high-biomass cover crops to maturity

Barley + crimson clover

Triticale + winter pea

Pearl millet + sunnhemp

Oats + bell bean

Foxtail millet + southern pea

← Full bloom, pollen shed, ready for roll-crimping →

← Not yet flowering – wait →

Rotational No-till for Organic Crops

Step 2: Terminate cover crop without tillage or herbicides

Washington State U.

Most often, organic no-till famers terminate cover crops with a roller-crimper (left). Some cover crops can be terminated by flail mowing (center), and warm season cover crops such as pearl millet can leave sufficient mulch after winterkill (right).

Rotational No-till for Organic Crops

Step 3: No-till planting of the production crop

USDA

Organic no-till soybean in roll-crimped rye (left). No-till planter sets pepper starts through cover crop residue (center). Summer squash planted no-till into roll-crimped rye + vetch yielded 15 t/ac (right).

Rotational No-till for Organic Crops
Step 4: manage weeds

Manage weeds in the cash crop:

- High residue cultivators, finger weeders, sweeps, or undercutters.
- Interrow mowing.
- Manual weeding or landscape fabric for small scale operations

After harvest, till as needed for:

- Late season weed control
- Planting the next cover crop

UC Sonoma County Cooperative Extension

Finger weeders take out in-row weeds (left). Opaque weed mat laid on rolled or mowed cover crop ensures termination and can be left in place for season-long weed control (right).

Organic No-till is Challenging and May Fail if:

Cover crop is thin.

Weed seed bank is large.

Perennial weeds are present.

Cover crop Is planted just after breaking sod.

Overmature cover crop self-seeds. Barley + crimson clover (left, self seeded) vs rye + vetch (right).

Cooler soil under residue slows N mineralization or cover crop consumes N or moisture, causing yield loss.

Organic No-till Challenges in a Mediterranean Climate

NRCS Conservation Innovation Grant – three midscale organic vegetable farms and one consultant in California.

Baseline soil health systems of cover crops + organic amendments.

Experimental reduced till practices:

- Diversify cover crops – up to 12-species mixes.
- Reduce tillage depth and frequency.
- Terminate cover crops by roller-crimper or grazing + shallow tillage.

Outcomes:

- More earthworms, better water infiltration, greatly improved tilth.
- Significant N limitation and yield drag.
- Hot dry summer hinders N release from cover crop residues on surface.
- Plastic mulch over drip line restores yield but creates landfill waste.

Next steps – farmers will try:

- Aerated subsurface drip to release N.
- In-row N boost (NOP-allowed source)
- Bio-based, compostable film mulch.

When Organic Rotational No-till is Most Likely to Succeed

- High biomass weed-free cover crop.
- Warm rainy climate, e.g., southeastern US.
- Healthy soil, good tilth.
- Light textured (sandy) soils that warm up quickly.
- Strong N fixer planted into high-carbon residues (right).
- Farmer has equipment and experience for no-till.
- Tips:
  - Roll-crimp twice to ensure termination.
  - Adjust planter for high residue – coulter type, row cleaner, added weight on toolbar

USDA

Organic no-till soybean in roll-crimped rye.

Soil Disturbance: A Broader Perspective

Judicious tillage in the context of a system of best organic practices is compatible with soil health

Types of Soil Disturbance

Type of disturbance	Damaging impacts	Research findings
Physical – tillage	Damages fungi and larger soil organisms, oxidizes SOM, causes compaction and erosion.	• Shallow or chisel tillage reduced harm. • Shallow tillage supports 2X microbial biomass vs. either plowing or no-till.
Biological – fallow	Starves soil life (no living root), increases risks of erosion.	• Residue removal is especially harmful to SOM and soil life.
Chemical – pesticides, herbicides	Adverse effects on soil life and soil biological functions.	• Meta-analysis: harm to soil macrofauna • Impacts on soil microbes and earthworms may be greater than that of tillage.
Chemical – soluble NPK	Can oxidize SOM and compromise soil microbial functions.	• Organic amendment + soluble NPK sustains SOM and soil life but may increase N_2O.

USDA National Organic Standards on Tillage and Soil Health

"The 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."

"The producer must manage … soil fertility through rotations, cover crops, and the application of plant and animal materials … to maintain or improve soil organic matter content.

"The producer must implement a crop rotation including … sod, cover crops, green manure crops, and catch crops that … maintain or improve SOM … [and] provide erosion control."

NOP Regulations, §205.203 Soil fertility and crop nutrient management and §205.205 Crop rotation practice standard

Three Components of the Soil Conditioning Index (SCI)

- Organic Matter
  - Crop residues + cover crops + organic amendments – SOM decomposition.
- Field Operations: related to STIR.
- SOM Losses through erosion =
  - Soil erodibility, topography, climate (rainfall intensity).
  - Management practices.



Cover crops, cereal grain/perennial clover overseed, and compost add organic matter.


Annual cropping on a 10% slope can lead to severe erosion (left). A system of berm-and-swale terraces stops erosion on a 10% slope in VA (right).

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Crop Rotation and Residue Return in Long-term Trials

Conventional system: corn-soy with winter fallow

Many organic crop rotations include winter covers and a cereal grain overseeded with perennial legume-grass forage, and thus return more organic matter to the soil.

Organic system: corn-cover-soy-cereal-overseeded perennial pasture (2-3 yr)

Comparison of Soil Disturbance in Three Cropping Systems

Soil Disturbance	Organic *	Conservation*	Conventional
Tillage intensity	Low to moderate	None or minimal	Low to high
Bare fallow	Minimal	Minimal	May be prolonged
Pesticides, herbicides	Low	Low to moderate	Moderate to high
Soluble nutrients	Low	Low to moderate	Moderate to high
Soil Health Practices			
Soil cover, living root	Most of year	Most of year	Often limited
Crop diversity	Substantial	Substantial	Often limited
Organic amendments	Used regularly	Used often	No or limited use

* *With best regenerative practices*

Reducing Tillage Intensity in Organic Systems

Developing a Site-specific Strategy

Examples from working organic farms

Tips for a Site-specific, Soil Friendly Tillage Strategy

- Implement an integrated soil health system based on living cover.
- Reduce tillage frequency and intensity whenever practical.
- Clarify your goals for each tillage operation.
- Choose the best tool for the job:
  - Adjust tools for greatest efficacy and least harm to the soil.
  - Rotate implements and working depth to prevent hardpan.
- After tillage, plant the next cash or cover crop without delay.
- Plant steeper, erodible land to perennial pasture, orchard or agroforestry.

Tips for a Site-specific, Soil Friendly Tillage Strategy

- Take an adaptive approach to tillage based on current soil and weather conditions.
- Use ecologically-based weed IPM to reduce the need for cultivation.
  - Develop strategic rotations and relay interplanting to thwart weeds, minimize bare soil, and reduce number of tillage passes.
  - Use non-soil-disturbing tactics – flame, mowing, grazing, mulch, etc.
  - Follow aggressive tillage with weed-competitive cover crops.
- For small-scale operations, use tarps and manual tools to manage weeds and cover crops.

Minimizing Soil Disturbance in a One-Acre Market Garden

Jesse Frost and Hannah Crabtree

Rough Draft Farmstead, Lawrenceburg, KY

- Intensive mTight vegetable rotations:
- ulti-cropping of short season (≤ 60 day) crops.
- Long-season crops, e.g., cover crop → tomatoes → garlic → winter squash → cover crop → popcorn, etc.

- Same-day “bed flips.”
- Manual tools.

Interplanting lettuce and onion starts for maximal use of limited space.

Minimizing Soil Disturbance in a One-Acre Market Garden

Diverse intercropped vegetables nearing maturity at Rough Draft Homestead

<u>Soil health and tillage practices</u>:

- Broadfork to open soil (≤ 1x/year); rake in amendments.
- Cut – don't pull – spent crop plants (saves ≥ 2 tons soil + root mass/ac).
- Living cover in alleys to stop erosion and protect soil health in beds.
- Intercropping tall and low, deep- and shallow-rooted crops.
- Relay planting for continuous cover and living root during multicropping.

<u>Outcomes</u>: healthy soils, good yields.

Landscape Fabric for Organic No-till Vegetables

Bryan Hager

Crager Hager Farm, Bremen, GA

- Two acres organic vegetables and strawberries.
- Depleted farmland where “most of the topsoil washed to the Gulf of Mexico decades ago.”
- Fields in four-year rotation, winter cover crops and one full year cover.
- High tunnels multi-cropped with a cover crop every two years.

Heavy (3.0 oz/yd^2) black landscape fabric (water permeable) to terminate cover crops and block weeds, replaced by fabric with holes at planting time.

Landscape Fabric for Organic No-till Vegetables

Strawberry harvest in landscape fabric-covered beds at Crager Hager Farm.

<u>Soil health and tillage practices</u>:

- After harvest, broadcast amendments and cover crop seed, pack (rototiller, PTO off).
- One month before planting, mow cover, till shallowly if needed, lay landscape fabric.
- For planting, remove fabric, add fertilizers, lay drip and fabric with planting holes.
- Infrequent shallow tillage or broadforking.
- All crop residues returned to the soil.

<u>Outcomes</u>:

- Healthy soil, SOM now 5-8%.
- High yields.

Gearing-down the Rototiller to Restore Sandy Soil

Rick and Janice Felker

Mattawoman Creek Farm, Cape Charles, VA

- Bojac loamy sand (Ultisol), low SOM.
- 11 acres field + 0.35 ac high tunnels, vegetables for four-season CSA.

<u>Soil health and tillage practices</u>:

- Tight crop rotation (no bare fallow) of diverse vegetables and cover crops.
- Cover crops mowed and incorporated 3-4” with organic amendments at moderate rates.
- Rototiller operated at low PTO speed and 2.5 mph tractor speed to protect soil aggregates.

Rick Felker

Aerial view of Mattawoman Creek Farm on the Eastern Shore of Virginia

Gearing-down the Rototiller to Restore Sandy Soil

<u>Soil health and tillage practices, continued</u>:

- All residues returned to the soil.
- Subsurface in-row drip to promote deeper roots.

<u>Outcomes</u>:

- Sandy soil has developed visible crumb structure.
- SOM has increased to 2.0-2.2% (excellent for this soil).
- Soil fertility has steadily improved; crops no longer need fish-seaweed fertigation.
- Soil test P has not exceeded optimum range.

In the farmer's words, "the soil gets better every year, and we have excellent growth."

Rick Felker

Mattawoman Creek Farm crew sets vegetable starts into healthy, fertile soil.

Maintaining Healthy Soil in a Tilled System

Justin Rich

Burnt Rock Farm, Huntington, VT

- 35 acres mixed vegetables
- Sandy, low-SOM soil
- Short growing season
- Regulatory constraints on compost use

<u>Soil health and tillage practices</u>:

- Intensive cover cropping; summer or winter cover crops after each harvest.
- 10 acres in year-long cover each year.

Justin uses a summer cover crop of sorghum-sudangrass, Japanese millet, oats, and peas to restore a depleted hay field for organic vegetables. The cover crop grew 5 feet tall in 57 days; here, it is flail-mowed before disking.

Maintaining Healthy Soil in a Tilled System

High-speed disk incorporates winterkilled cover crop and forms seedbed in one pass at Burnt Rock Farm.

<u>Soil health and tillage practices, cont'd</u>:

- High-speed disk works 3-4" deep for primary tillage – observed to be easier on soil structure than the rototiller.
- Diversified crop rotation.

<u>Outcomes</u>:

- Healthy, fertile soil.
- Good yields and a profitable farming operation.

Integrating Crops and Livestock for Soil Health

John Bell, Ann Bell, and Mac Stone

Elmwood Stock Farm, Georgetown, KY

- 200 acres cropland and 350 acres in permanent pasture.
- 800-member CSA, vegetables, beef, pork, lamb, poultry, and eggs

Soil health practices:

- Crop rotation: 3 years vegies or feed grains + winter covers, 5 years pasture.
- Multispecies rotational grazing.
- On-farm cycling of manure and residues, minimal off-farm NPK inputs.

Sloping land is kept in permanent pasture. An open stand of mature trees provides shade and enhances biodiversity and carbon sequestration.

Integrating Crops and Livestock for Soil Health

Tillage practices:

- Moldboard plow and disk to terminate sod.
- Annual covers disked.

Outcomes:

- Thriving, resilient, profitable operation.
- Excellent production sustained on just 5 lb/ac off-farm nutrients per year.
- 5 years sod restore SOM, microbiome.
- Breaking sod causes burst of CO_2, N_2O.
- Perennial weeds build up in sod phase.
- Cropland produces only 3 harvests in 8 years.

Five years in grass-legume sod with multi-species rotational grazing restores cropland soil health to that of the permanent pasture.

Fine-tuning the Crop-Livestock System: Reduced Till

<u>System modifications</u>:

- Terminate sod in fall of year 5 by grazing severely, then shallow (2-3”) rotary tillage in lieu of plowing.
- Rototiller run with tailgate open and 3 mph forward speed to take out sod without pulverizing soil aggregates.
- In spring second shallow tillage pass, lay drip tape, plant long season vegetable crops. *Yields remain high*.
- Roll-crimp winter annual covers for no-till feed grain planting when practical. *Learning curve*.
- Experimenting with alternative rotation: annual cover crops with grazing and one production crop (vegetable or feed grain) every two years. *Abundant, nutritious forage*.

Strategic Rotations for Minimum-Till Organic Grains in Upstate New York

Klaas Martens and Mary Howell Martens

Martens Organic Farm, Penn Yan, NY

- 1,900 acres organic grains, forages, dry beans, peas, and vegetables.
- Silt-loam soils: silt plugs soil pores after plowing, hinders roots.

<u>Soil health and tillage practices</u>:

- Tilling only when needed to:
  - Release N, relieve hardpan, prepare seedbed.
  - Manage weeds.
- Omit some tillage passes to protect soil life, reduce weed flushes, aid crop establishment.

Klaas Martens

Sorghum-sudan residue provides favorable micro-climate for rye + peas sown no-till. Peas enhance rye biomass for roll-crimping.

Strategic Rotations for Minimum-Till Organic Grains in Upstate New York

<u>Soil health and tillage practices, cont'd</u>:

- For compaction, narrow chisel subsoiler on 30-inch centers, forage brassica sown in slots.
- For heavy residue, shallow (4-6") partial inversion plowing (European moldboard plow design).
- Diverse, strategic rotations with cover crops based on interactions among crops, weeds, and soil, e.g.:
  - Adding winter cereal to a corn-soy rotation greatly weakens the weed velvetleaf.
  - Adding winter barley / buckwheat double crop to corn-soy-wheat-clover controls perennial thistles.
  - Adding mustard or buckwheat to a grain + legume rotation reduces root rots and weed pressure.

Velvetleaf

Canada thistle

Strategic Rotations for Minimum-Till Organic Grains in Upstate New York

<u>Outcomes</u>:

- Improved soil structure from reduced tillage and correct use of implements.
- Reduced weed and disease pressures.
- Erratic weather requires adaptive tillage management.
- Extended organic no-till when conditions are favorable (example at right).

Barley grain → *Sudangrass forage* → *Rye + peas cover* →

Soybean harvest → *Triticale + peas cover*

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Strategic Rotations for Dryland Organic Grains in the Northern Great Plains

Doug Crabtree and Anna Jones Crabtree

Vilicus Farms, Havre, MT

- 12,500 acres dryland grains, pulses, oil seeds, cover crops (25 spp. total).
- Cold-temperate semiarid climate, 11.7”/yr.
- Most farms in region use a wheat-fallow rotation.

Soil health and tillage practices:

- Complex, 7-yr rotation with 5 production crops and 2 green fallow years.
- Native prairie strips cover 26% of acreage.

Native prairie strips provide wildlife and pollinator habitat, reduce wind erosion, sequester carbon, and improve microclimate for crops.

Strategic Rotations for Dryland Organic Grains in the Northern Great Plains

Soil is protected by leaving residues in the field (left) and interseeding sweet clover into grain before harvest (right).

<u>Soil health and tillage practices, cont'd</u>:

- Rotating tillage tool and depth:
  - Speed disk (2-3")
  - Chisel plow with wide sweeps (3-4")
  - Moldboard plow (6-8") once per 7 years.
- Primary tillage 7-10 days before cash crop planting
- Sweeps on planter take out emerging weeds.
- Adaptive timing of green fallow termination based on current season moisture conditions.

Strategic Rotations for Dryland Organic Grains in the Great Plains

<u>Soil health and tillage practices, cont'd</u>:

- Composted manure on heavy feeding grain (once per 7 years).
- Now integrating livestock into system, grazing in lieu of tillage to terminate green fallow.

<u>Outcomes</u>:

- Substantially improved SOM.
- Resilience to weather extremes.
- Soil surface coverage (living or residue) and prairie strips minimize wind erosion.




The diverse rotation at Vilicus Farms includes sunflower, spelt, black lentil, buckwheat, and over 20 other crops.

Questions?

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