Reducing Organic Crop Production Risks through Soil Health Practices

Organic Soil Health Education Webinar for Farmers and Ranchers in the Southern Region

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Three Springs Farm

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Farming is Risky!

- Adverse weather
- Pests, diseases, weeds
- Crop nutrient deficiencies
- Soil erosion and degradation
- Fickle markets, low prices
- ***Yield X Price < Production Costs***

Stop, thief! *Some Southern region soils have lost* ***all*** *topsoil.*

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Leading Production Risks in the South

- Intense weed pressure
- Intense pest, disease, and nematode pressure
- Low SOM and soil fertility
- Excessive rainfall, floods
- Drought
- Excessive heat
- Untimely freezes

Timely cultivation can save crops, but also speeds loss of soil organic matter (SOM).

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How Organic Farming Mitigates Risk

- Emphasis on **soil health** and **biodiversity** promotes:
  - Stress resilience.
  - Yield stability.
  - Input efficiency.
- Exclusion of synthetic inputs protects:
  - Soil life.
  - Beneficial insects.
  - Water quality.

Non-use of herbicides facilitates crop rotation and enterprise diversity.

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Risks Related to Organic Production

- Greater reliance on optimal soil health
- Tradeoff between soil health and weed control
- N-P balance of organic nutrient sources
- High cost of organic amendments

Newly organic fields with conventional history often have low SOM, poor tilth, and depleted soil life.

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Soil Health, Bad Weather, and Risk in Organic Production

What has always been true
is even more so
in the era of climate change.

Climate Change Exacerbates Risks

- Extreme, erratic rainfalls
  - Runoff and soil erosion
  - Crusting and compaction
  - Flash drought
- Hotter summers
  - Accelerated SOM loss
  - Stress on soil life
- Untimely spring freezes
- Weeds, pathogens, and pests changing life cycles and ranges

Heat-loving weeds like Palmer amaranth (left), and purple nutsedge (right) become more aggressive and spread north as climates warm.

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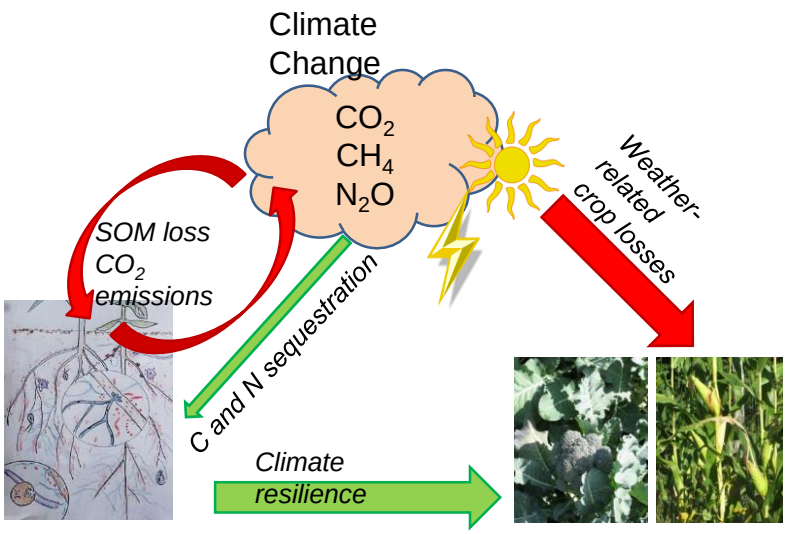

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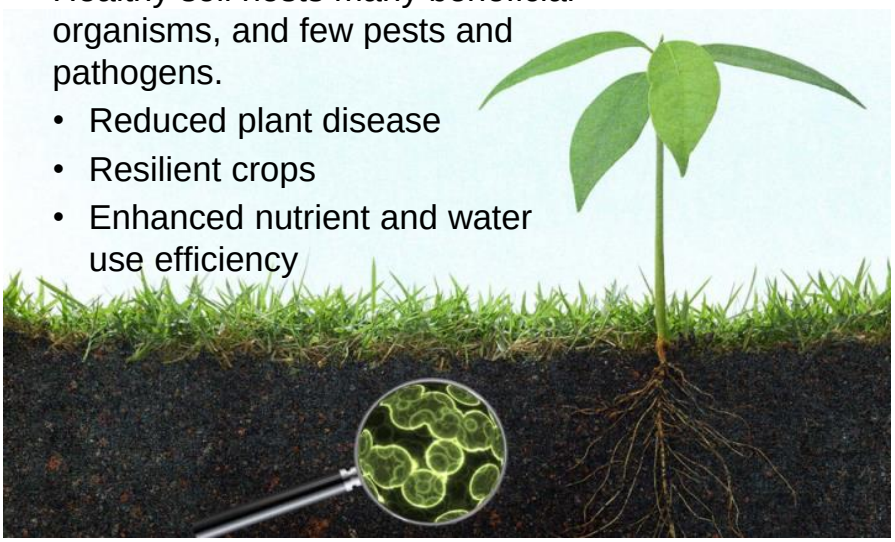
How Healthy, Living Soils Reduce Risks in Organic Crop Production

Resilient crops
Access to nutrients and water
Lower production costs

How Healthy Soil Reduces Risk: Soil Life

Healthy soil hosts many beneficial organisms, and few pests and pathogens.

- Reduced plant disease
- Resilient crops
- Enhanced nutrient and water use efficiency



Plant-Soil-Microbe Partnerships

- Mycorrhizal fungi
  - Water and nutrient uptake
- N-fixing bacteria
  - Legume nodules
  - Root zone of other crops
- Disease suppression
  - Competition
  - Predation, antibiosis
  - Induced systemic resistance (ISR)

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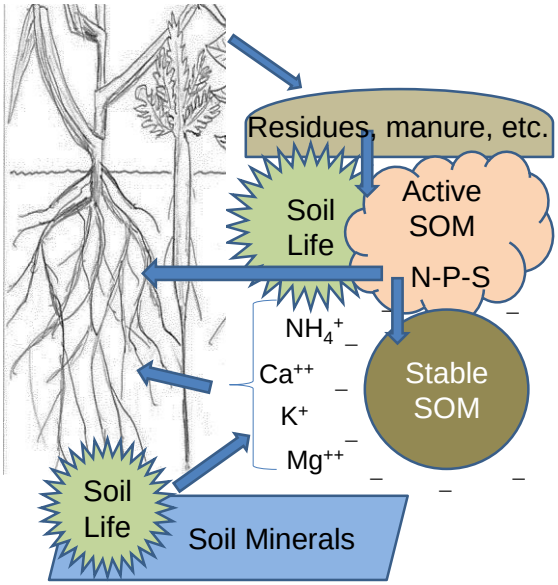
How Healthy Soil Reduces Risk: Nutrients

Soil organisms hold, cycle, and deliver crop nutrients to:

- Sustain yield and quality.
- Protect water quality.
- Reduce input costs.



How Healthy Soil Reduces Risk: Physical Properties

Good soil structure facilitates:
- Seedbed preparation.
- Timely planting.
- Crop emergence.
- Cultivation for weed control.

Porous, well-aggregated soil:
- Resists crusting and erosion.
- Sustains soil life and fertility.

The "crumb structure" of healthy topsoil makes it less likely to erode or become compacted.

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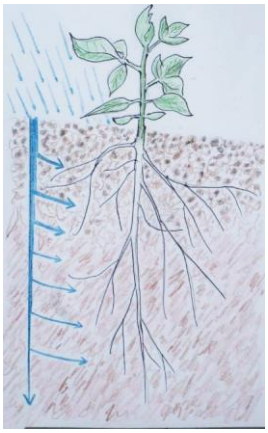
How Healthy Soil Reduces Risk: Water Relations

Absorbs, retains, and delivers moisture
- Drought resilient crops
- Less irrigation needed
- Less runoff and erosion

Drains well
- Deeper, healthier roots
- Less disease
- Fewer planting delays



Healthy soil holds more plant-available water.

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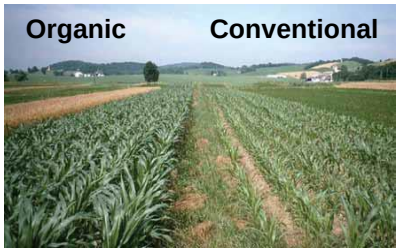
Soil Resilience in Deluge and Drought

Z. Kabir, NRCS, Davis, CA



Rodale Institute

A cover cropped field easily absorbed a 2-inch winter rain while a fallow field ponded in Woodland, CA (left). In the Rodale Farming Systems Trials, corn grown in organically managed soil withstood droughts in 1995 and 2012 and yielded 30% more than conventional corn (right).

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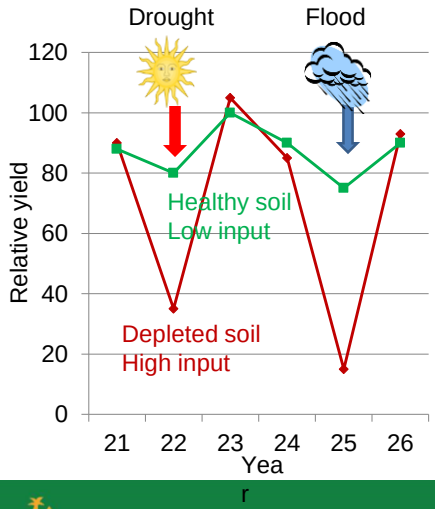
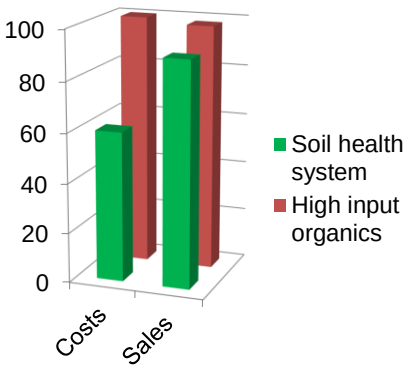
Soil Health, Drought, Flood, and Risk





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Building Healthy Soil to Reduce Risk

Challenges
Opportunities
Practical Steps

The Journey to Soil Health: NRCS Four Principles

1. Keep soil covered

2. Diversify the cropping system

3. Maintain living roots

4. Minimize disturbance

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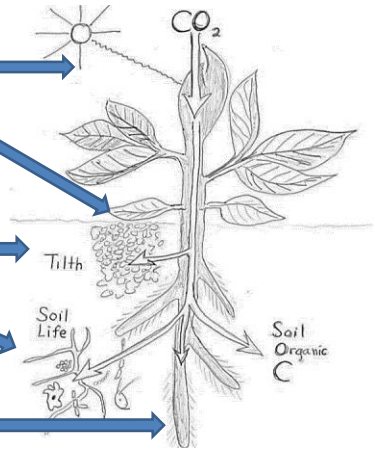
The Living Plant is the Farmer's #1 Tool for Building Healthy, Resilient Soils

Photosynthesis creates organic matter.

Foliage protects soil surface.

Living roots:

- Build SOM.
- Maintain tilth.
- Feed soil organisms.
- Sequester carbon.
- Open and deepen the soil profile.



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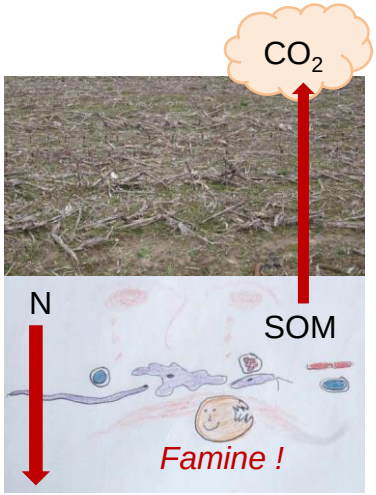
Bare Soil is at Risk!

During bare fallow:

- Soil life goes hungry.
- Nutrients leach and run off.
- Soil loses SOM and water holding capacity.
- Heavy rains seal the surface and runoff increases.
- Soil erodes.
- Weeds proliferate.
- Production costs increase.



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Cover Crops Save the Soil in Floyd, VA

Spring 2015: Potato

Summer: Sorghum-sudan

Melissa Maynard

Sept. 29: Flood waters run 3' deep in field.

Aftermath: Fence toppled … no soil lost.

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The Journey to Soil Health: Investments and Risks

Depleted, sandy soil

Improved soil health practices

- *Direct costs*
- *Learning curve*
- *Income foregone*
- *Yield tradeoffs*

Sandy, but healthy soil sustains crop production.

Photo by Rick Felker, Mattawoman Creek Farm

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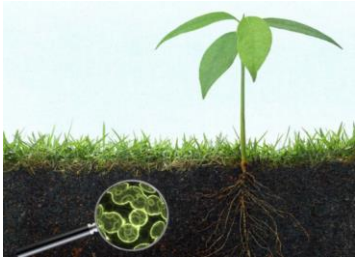
Step 1: Assess your Resources

- Soil inherent properties
  - Texture, drainage, etc.
- Nutrients, SOM, and fertility
  - Soil and crop condition
  - Standard soil test
  - Soil health assessment
- Farm Resources:
  - Knowledge and skills
  - Equipment
  - Financial resources



Read soil tests through the "lens" of living soil. In healthy soil, crops can find more nutrients than the lab sees.

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Step 2 – Review your Practices

- Crop rotation
- Fallow periods
- Cover cropping
- Tillage practices
- Cultivation/weed control
- Fertilizers and amendments

- Soil health impacts
- Benefits, costs, and risks
- Low-cost solutions

Seeding clover with cereal grain replenishes soil N at a fraction of the cost of organic fertilizers.

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Step 3: Build a Resilient Production System for your Site

- Add crops


- Reduce tillage

- Adjust inputs

- Add one new crop, practice, or enterprise at a time:
  - Small scale trial
  - Comparison trial
  - Enterprise budget
  - Partial budget for new practice or cover crop
- Scale up promising crops or practices.

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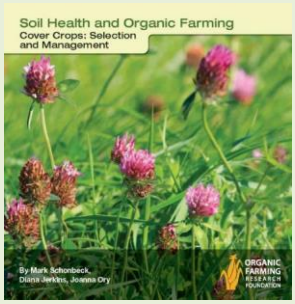
Adding Crops

Cover crops
Cash crops
Forage crops
Sod phase in rotation



Adding Cover Crops

Benefits:

- SOM, soil life, tilth
- N fixation, nutrient cycling
- Drainage, water capacity
- Weed suppression

Costs and risks:

- Seed and planting costs
- Cover crop failure
- Timing for cash crop
- Water use in dry years

Late-summer mix of pearl millet, sorghum-sudangrass, and radish sends roots five feet deep, breaking hardpan and retrieving nutrients.

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SARE Cover Crop Surveys 2012-19

- Benefits cited by farmers include:
  - Healthier soil (85%).
  - Weed management (69%).
  - Yield stability (66%).
  - Higher net returns (33%).
- Cover crops pay off most:
  - After several years' use.
  - As part of an integrated system.
  - When grown for specific goals.
  - When rotationally grazed.
  - When cost-shared (EQIP, CSP).

Survey participants say cover crops are "a form of crop insurance."

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Adding Cash Crops: Diverse Rotation

Benefits:

- SOM, microbial diversity
- Fewer pest problems
- Market opportunities
- Farm economic stability

Risks and costs:

- New skills and equipment
- More complex system
- Market challenges

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Adding a Sod Phase to the Rotation

Benefits:

- Organic matter & soil life
- Erosion control
- Tilth & fertility
- Water holding capacity
- Reduced weed seed bank
- Forage for grazing

Costs and risks:

- Income foregone
- Tillage to terminate sod

Grass-fed dairy in VA

Grass-fed beef in KY

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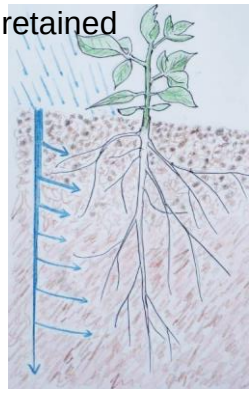
Q. Do cover crops “steal” soil moisture and nutrients from the next crop?

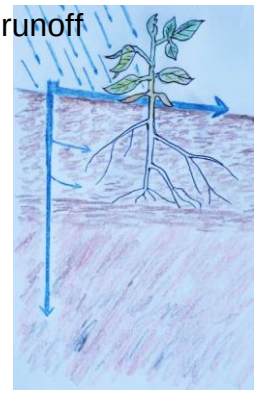
A. They use these resources today to build soil capacity for tomorrow.

Soil Condition and Moisture Capacity

Healthy, open water retained



Compacted, crusted runoff



Depleted, sandy leaching

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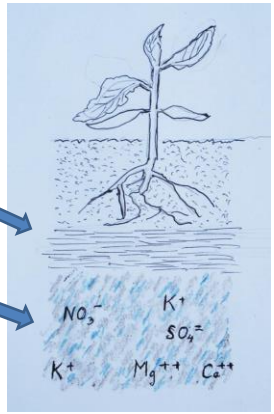
The Challenge of Coastal Plain Soils

Many of these soils offer crops limited access to moisture and nutrients.

- Compaction-prone “E” horizon below “A” (topsoil)
- Roots cannot reach moisture and nutrients in clay-enriched “B” horizon (subsoil).
- Fields are often subsoiled (deep-tilled) to sustain crop yields.



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Winter Rye Improves Cotton Yield in South Carolina Coastal Plain Study

Faceville sandy loam and Fuquay loamy sand have compacted E horizons.

Winter rye cover crops (top right):

- Increased SOM by 0.5% and water content by 1–1.5” in top 18”.
- Relieved compaction, allowing crop to reach B horizon moisture.
- Increased no-till cotton yields 38%.

Marshall et al., 2016. Open Journal of Soil Science 6: 149-158. http://dx.doi.org/10.4236/ojss.2016.610015

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Water Consumption by Cover Crops can be Beneficial

Z. Kabir, NRCS, Davis, CA

Winter wheat cover uses a 2" rainfall to build SOM (left), while ponding in a fallow field delays planting and hurts soil health (right).

SARE Cover Crop Survey:

- 2019 was "a brutal year … wettest spring on record."
- Cover crops facilitated timely cash crop planting.
- Allowing cover crops to grow longer alleviated excess soil moisture.

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Summer Cover Crops Conserve Soil N

- Trial in Goldsboro, NC, Wickham sandy loam
- Hot dry summer, then record rain in September
- All cover crops:
  - Temporarily tied up soluble soil N.
  - Protected water quality.
  - Enhanced soil capacity to mineralize N.
  - Reduced fertilizer costs.

Sudex C:N = 57

Foxtail millet

Southern pea C:N = 15

Southern pea + Foxtail millet

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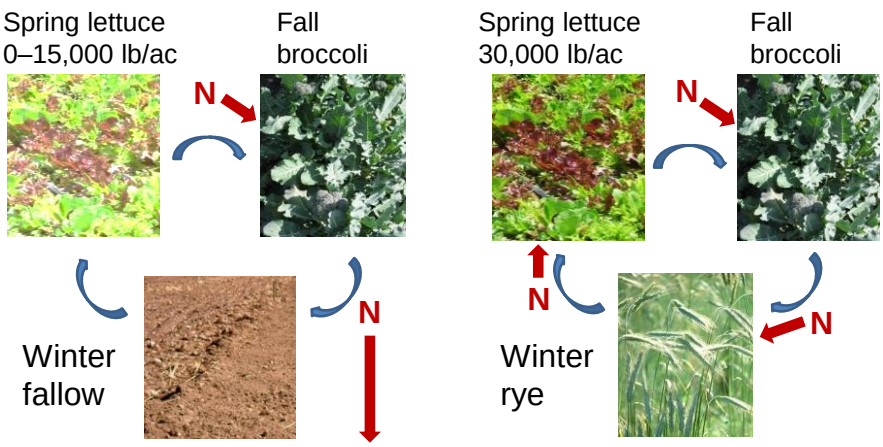
Winter Cover Crops Recycle N During Mild Rainy Winter



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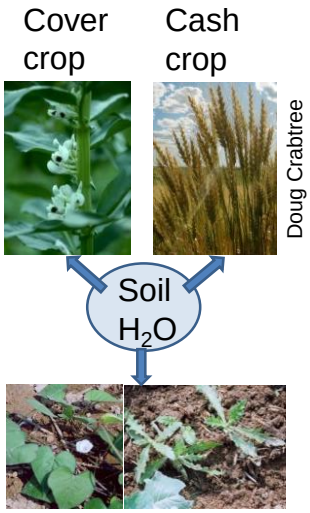
In Low-rainfall Regions

Cover crops may:

- Produce less biomass.
- Become weedy.
- Deplete soil moisture.

Without cover crops, the soil loses SOM, stores less moisture, and blows away.

➢ *Select cover crops and termination dates for water conservation.*



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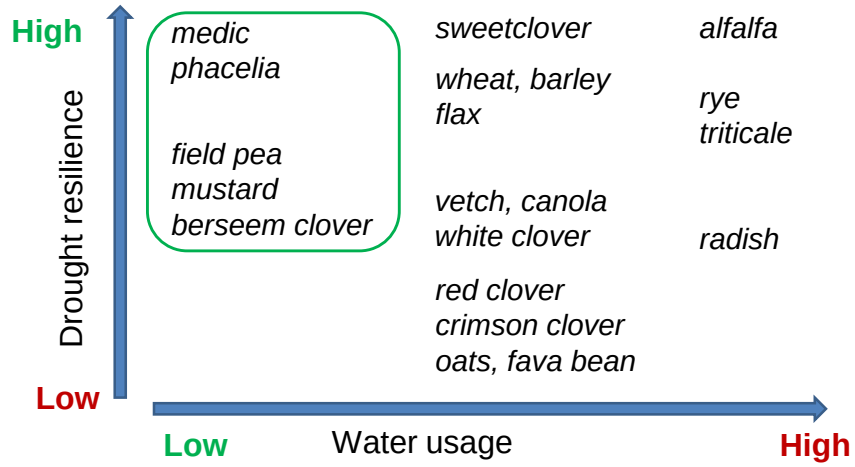
Drought Resilience and Water Use
Cool Season Cover Crops



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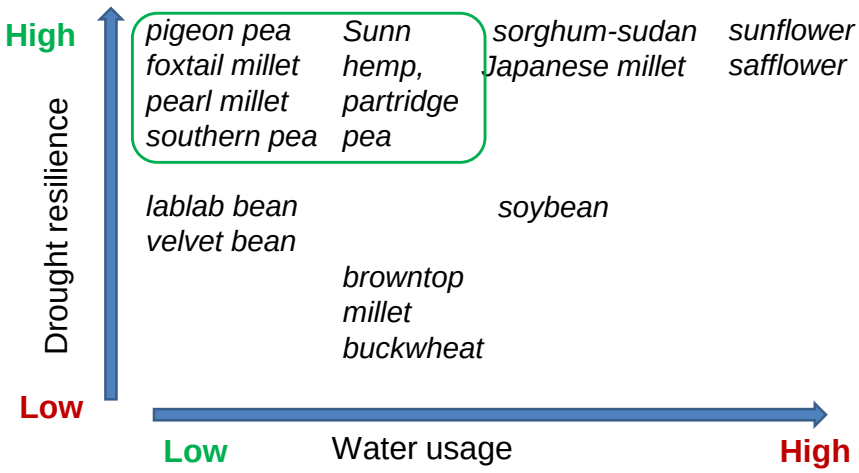
Drought Resilience and Water Use
Warm Season Cover Crops



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What if rainfall is wildly unpredictable?
Plan for both dry and wet extremes.

Drought-resilient:
- Pearl, foxtail, proso, and Japanese millets
- Sunnhemp
- Southern pea
- Pigeon pea
- Sorghum-sudangrass
- Sunflower
- Sweetclover
- Barley, rye

Flood-tolerant:
- Japanese millet
- Italian ryegrass
- White clover

Moderately wet-tolerant:
- Rye, oats
- Red, berseem, and subterranean clovers
- Sorghum-sudangrass

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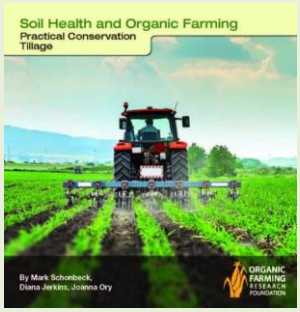
Reducing tillage

You don't have to eliminate all tillage to build soil health during an annual crop rotation.



No-till Planting in Roll-Crimped Cover Crop

Benefits:
- SOM, soil life, and soil health
- Erosion control
- Slower N release in sandy soils

Costs and risks:
- Special equipment and skills
- WEEDS!
- Planting delays and challenges
- Slower N release in clayey soils
- Lower crop yields

Success: summer squash after rye + vetch

Failure: N-deficient, weedy broccoli after rye

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Organic No-till Requirements

Essential:
- Mature (flowering) weed-free, high biomass cover crop ~ 4 tons/ac
- Light weed pressure, no perennials
- Healthy, biologically active soil

Helpful:
- Long, warm growing season
- Sandy, quick-to-warm soil
- N-fixing cash crop after grass cover
- N-demanding crop after legume
- Supplemental mulch application

Soybean in rolled cereal rye (USDA).

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Practical Options for Reducing Tillage Intensity in Organic Systems

- Eliminate a tillage pass by:
  - Mulching, flaming, or mowing weeds in lieu of cultivation.
  - Overseeding cover crop into cash crop.
- Retool:
  - Spading machine (right)
  - Chisel plow
  - Rotary tiller geared down

Spader makes seedbed in one pass, avoids hardpan, and is gentle on soil aggregates.

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Strip Tillage

Washington State U.

NC A&T S. U., Greensboro, NC

Two types of tractor-drawn strip tillers prepare planting strips for each crop row, leaving 70 – 80% of the soil surface undisturbed and protected by residues. This strategy can work well in conjunction with a roll-crimped cover crop.

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Shallow Tillage

- Makes seedbed
- Incorporates amendments and light residues
- Takes out small weeds
- Leaves most of soil profile undisturbed
- Works with cover crops to:
  - Maintain SOM and microbial activity
  - Protect mycorrhizal fungi

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

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Sweep-plow Undercutter

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

Drew Lyon, U. Nebraska.

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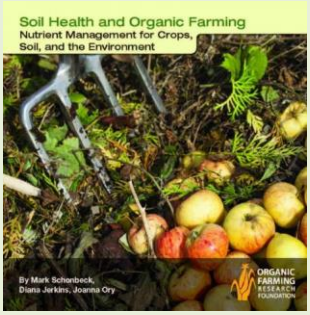
Adjusting Inputs

Less may be better—and it saves money.



Nitrogen Risks in Organic Production

- N limited crop yields:
  - Depleted soil life
  - N tie-up (e.g., rye)
  - Poorly timed N release
- Overusing organic N:
  - Adds costs
  - Consumes SOM
  - Reduces soil N release
  - Can hurt water quality

Clemson U., upstate SC:
- Tomato, squash after rye + clover
- Long-term organic
- Sandy loam, 4.6% SOM
- Good yields, no response to added N

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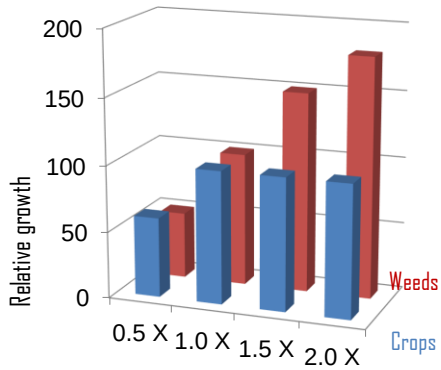
Compost and Manure can Feed the Weeds

Benefits:

- Organic matter
- Crop nutrients
- Microbial inoculum

Costs and risks:

- Purchase and hauling
- N and P excesses
- Weed pressure
- Food safety (manure)



Poultry litter compost rate
(1.0 = recommended)

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Nutrient Strategies and Risks

"Feed the Soil"

- *N limited yields*

Input substitution

- *High costs*

Compost or manure for N

- *P excess*

Replenish nutrients harvested-off

- *Amend for P, fix N, retrieve soil mineral K*

Harvest removal	N	P	K
Vegetables (avg.)	50	8	64
Grains (avg. yields)	150	25	35
Hay (5 t/ac)	180	30	190
Amendments			
Compost (1-1-1), 5 t/ac	100	44	83
Poultry fertilizer (5-4-3), 1 t/a/c	100	35	50

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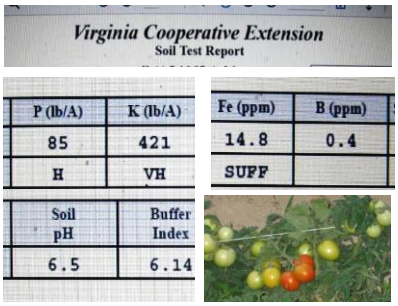
Why Soil Labs Recommend So Much NPK



Virginia Cooperative Extension
Soil Test Report

P (lb/A)	K (lb/A)
85	421
H	VH

Fe (ppm)	B (ppm)
14.8	0.4
SUFF	

Soil pH	Buffer Index
6.5	6.14

Recommendations for tomato:

Fertilizer, lb/A		
N	P205	K20
90	100	50

Standard soil tests:

- Measure top 6” only.
- Ignore soil life.
- Assume soil is “leaky.”
- Overlook nutrient recovery by deep-rooted crops.

Robin Kloot, 2017 Organic Agriculture Research Symposium, Lexington, KY

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“Living Soil Changes Everything”

Robin Kloot, 2017 Organic Agriculture Research Symposium, Lexington, KY

- 5-year trial, corn-soy-wheat with cover crops, organic practices
- Orangeburg loamy sand, South Carolina coastal plain
- No P or K *vs.* recommended rate
- N at half of recommended rate

<u>Results:</u>

- SOM 1.2% □ 1.7%
- Full crop yield without P or K
- Soil test pH, P, and K stable

Southeast coastal plain soil in good health with plant roots accessing subsurface nutrients and moisture.

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Input Frugality

- Reduce need to add nutrients by:
  - Building healthy, living soil.
  - Growing deep-rooted crops.
  - Returning on-farm residues to soil.
  - Integrating crops and livestock.
- Conduct side-by side trials:
  - Did the crop respond?
  - Did soil health improve?
  - Did the yield increase pay for the input?

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Input Frugality

- Test soil, compost, and crop foliage.
- Grow legumes to save money on N.
- Credit N from legumes, SOM, and organic amendments.
- When needed, add concentrated N in band or by in-row drip.
- Avoid over-irrigation (N leaching).
- Adjust compost rates based on P.
- Apply K only when needed.

Pepper and other fruiting vegetables thrive on moderate soluble N levels.

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Information Resources

- **Organic Farming Research Foundation** (OFRF) https://ofrf.org/research/reports/
  - Soil health guidebooks, research database
- USDA **Sustainable Agriculture Research and Education** (SARE) https://www.sare.org/
  - Manuals, bulletins, topic rooms, research database
- USDA **Natural Resources Conservation Service** (NRCS) https://www.sare.org/
  - EQIP and CSP cost share for soil health practices
- **Southern Cover Crop Council** https://southerncovercrops.org/

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Questions?

Reducing Risk through Best Soil Health Management Practices in Organic Crop Production

By Mark Schonbeck & Michael Stein

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USDA U.S. Department of Agriculture Risk Management Agency

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