Climate Disruption Got You Spooked? Invest in Your Soil

21st Annual
Virginia Biological
Farming Conference

Roanoke, VA
January 12, 2020

Mark Schonbeck,
Research Associate

ORGANIC FARMING RESEARCH FOUNDATION

With funding from USDA Risk Management Agency

Part 1: Climate Risks in Agriculture

Farming is Risky!

- Poor crop stands
- Drought
- Excessive heat
- Excessive rain, flood
- Storms, hail
- Untimely freezes
- Pests, diseases, weeds
- Crop nutrient deficiencies
- Soil degradation and loss
- Fickle markets, low prices



Stop, thief! Erosion steals the farm's natural capital and causes ~6% of global annual GHG emissions.

Climate Change Exacerbates Risks

- Poor crop stands
- Drought
- Excessive heat
- Excessive rain, flood
- Hurricanes !!
- Untimely freezes
- Pests, diseases, weeds
- Crop nutrient deficiencies
- Soil degradation and loss
- Fickle markets, low prices





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

Other Climate-related Risks

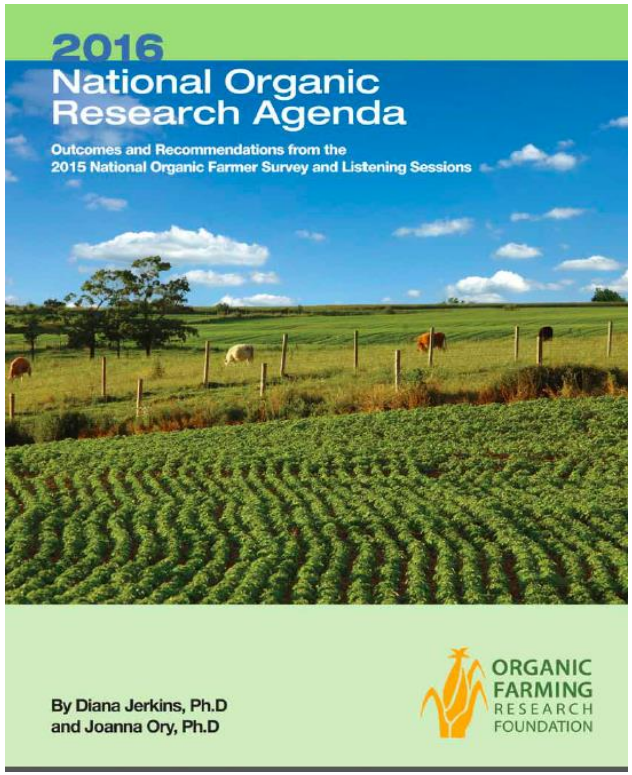
- Warmer winters hurt fruit crops through:
  - Inadequate chill hours for development.
  - Earlier bloom, loss to spring freezes.
- Hotter summers and pest pressure increase risks to farmworker health.
- New weed and pest species



NCAT / ATTRA

Warming climates complicate fruit production and may necessitate adoption of new cultivars or species.

Climate Change and Organic Farming



Available at http://ofrf.org/.

Farmer Research Priorities in the Southern Region

Soil health – 79%

- Cover crops, reduced till
- Optimizing soil life

Climate change – 42%

- Excessive rain, floods
- Increased plant disease
- Weed pressure, invasive species
- Fruit crop losses

Effects of Excessive Moisture on Soil Health

Heavy rain on exposed soil:

- Compacts soil, seals surface.
- Runs off, erodes soil.

Ponding or waterlogging:

- Damages plant roots.
- Kills aerobic soil microbes.
- Increases risk of crop disease.
- Promotes certain weeds.
- Forms greenhouse gases.



Z. Kabir, NRCS, Davis, CA



Effects of Prolonged Drought on Soil Health

During prolonged drought:

- Soil life goes dormant.
- Plant growth slows or stops.
- Organic inputs diminish.
- Wind erosion may increase.

If drought follows wet spell:

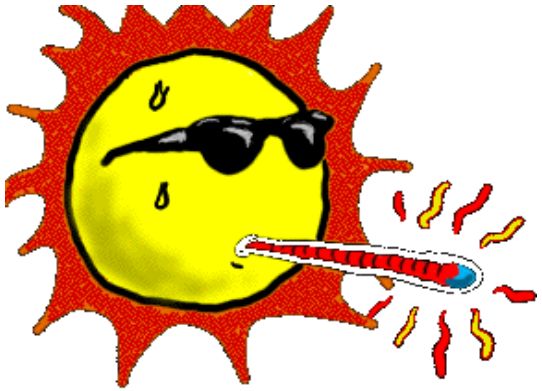
- Compaction may be severe.
- Crops may be shallow-rooted and less resilient.



Helen Attowe

Leaving residues in place during dry seasons prevents wind erosion and protects soil health.

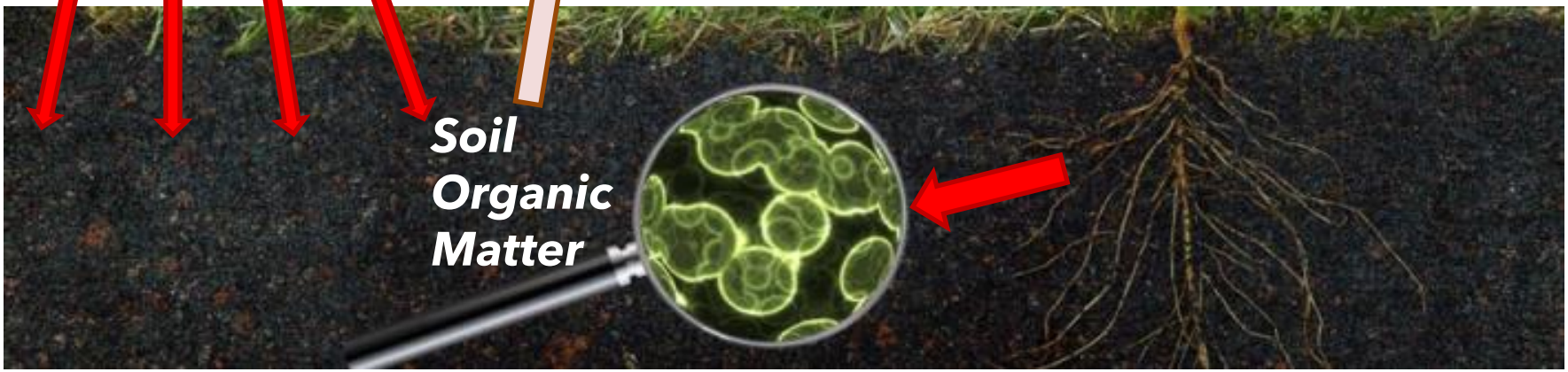
Heat, Exotic Weeds, and Soil Health



CO_2







Part 2: How Healthy Soil Reduces Risk and Mitigates Climate Change

Healthy Soil Mitigates Climate Risks

Soil Function	***Risk Reduction***	***Climate Mitigation***
Accrues organic matter	Better crop stands	C sequestration
Maintains tilth and drainage	Flood resilience	Less N_2O, CH_4
Holds plant-available moisture	Drought resilience	
Cycles nutrients	Better crop nutrition	Less N_2O
Harbors beneficial microbes	Less disease	C sequestration

Healthy Soil and Drought Resilience in Rodale Farming Systems Trials

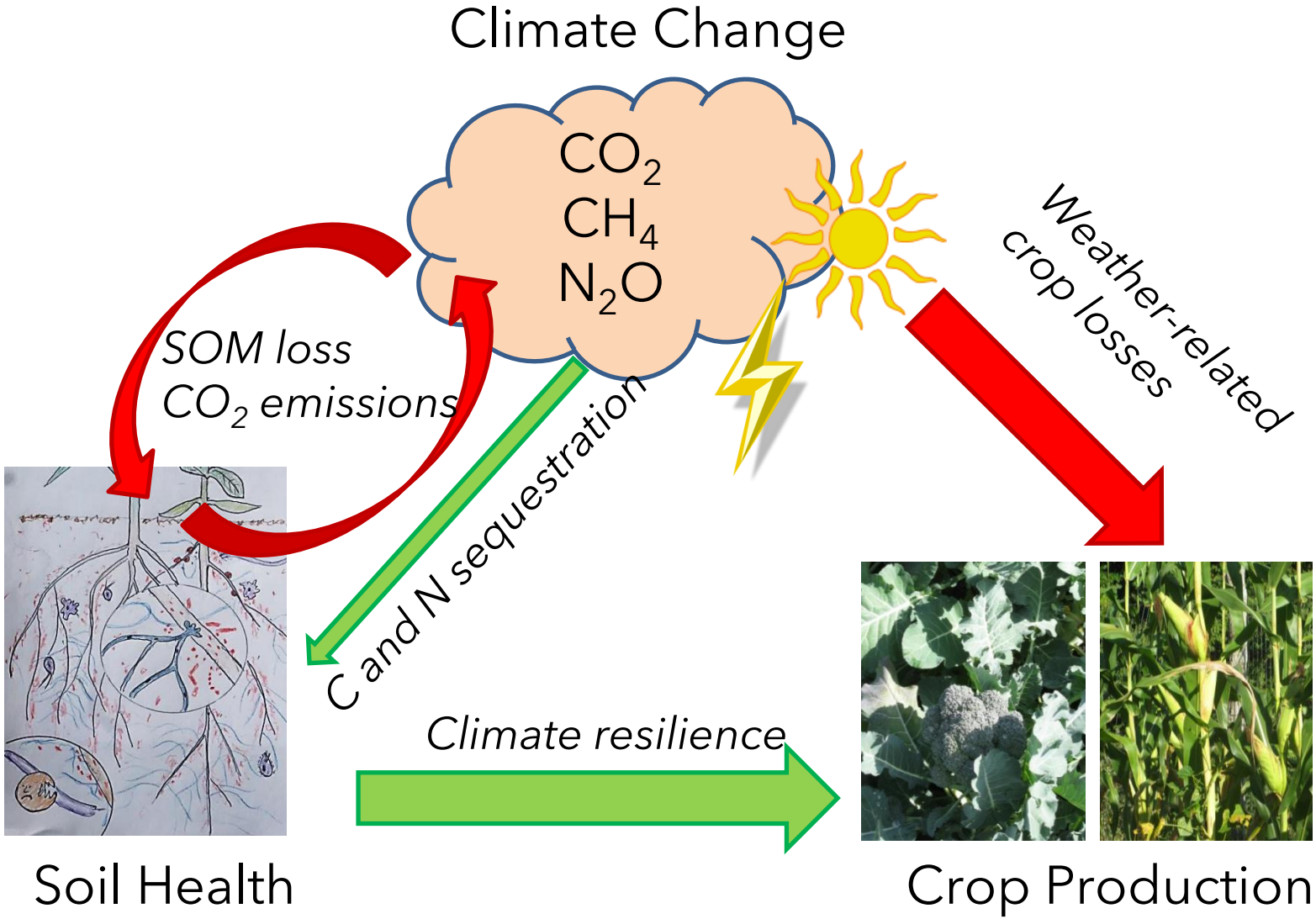
Over a 35 year period, organic farming systems:

- Increased soil moisture uptake by 15-20%
- Reduced runoff
- Created stable soil aggregates
- Improved crop nutrition
- Built soil organic matter (SOM) by 6 tons/ac



Rodale Institute

Organically grown corn (left) withstood the 1995 drought and yielded 31% more than conventional corn (right).


Climate Change
CO_2
CH_4
N_2O
SOM loss
CO_2 emissions
C and N sequestration
Weather-related
crop losses
Climate resilience
Soil Health
Crop Production

How Healthy Soil Reduces Risk: Physical Properties

Good structure (tilth) facilitates:

- Seedbed preparation – easy tillage saves fuel and soil
- Timely planting
- Better crop emergence
- Cultivation for weed control

Resists compaction and erosion

- Reduced soil losses
- Sustained fertility



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

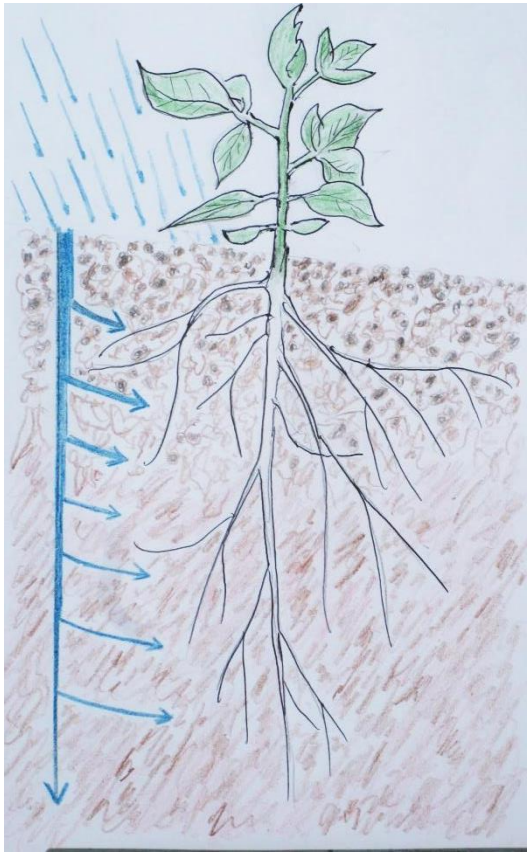
How Healthy Soil Reduces Risk: Water Relations

Absorbs, retains, and delivers plant-available moisture

- Drought resilient crops
- Less irrigation needed
- Reduced runoff and erosion

Drains well

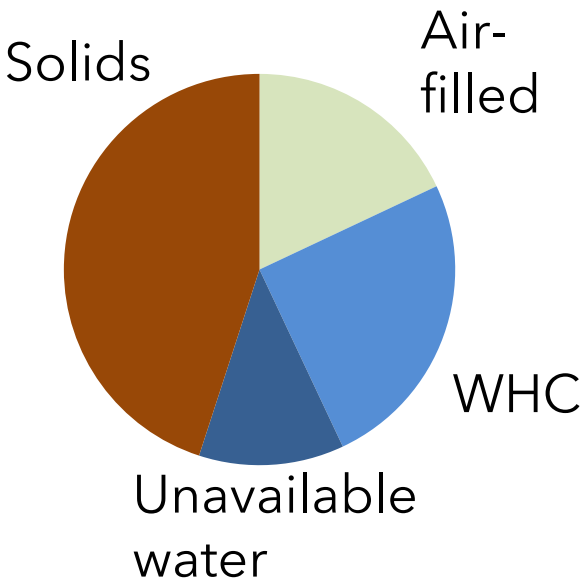
- Healthier roots, less disease
- Fewer planting delays



Healthy soil holds more plant-available water

Plant-available Water in Healthy Soil

Healthy soil at field capacity



Rapid infiltration →

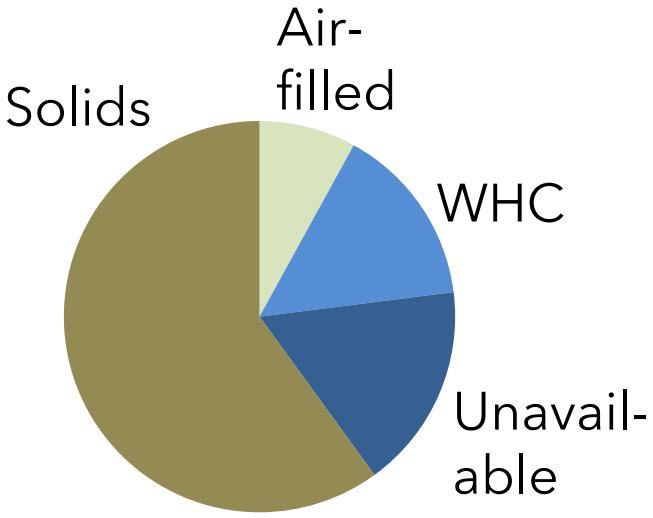
Moisture retained; unrestricted root growth.

Excess drains out →



Plant-available Water in Compacted Soil

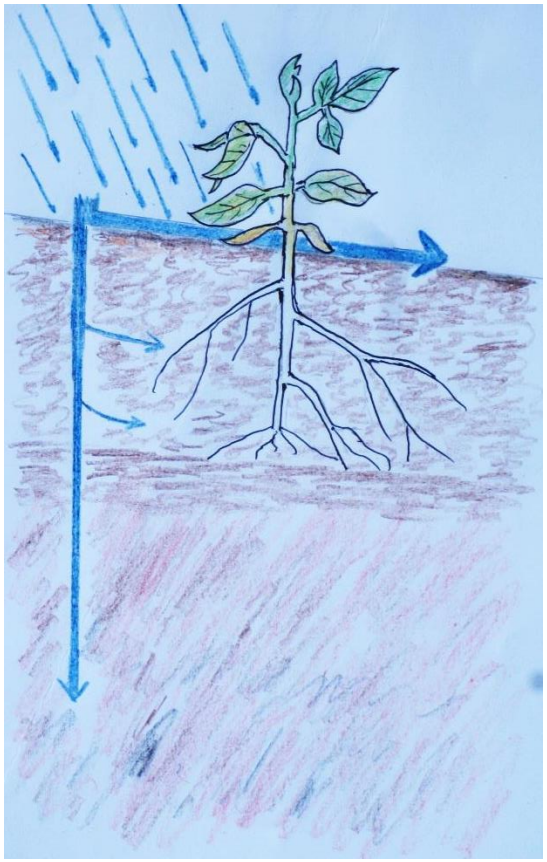
Compacted soil at field capacity



Surface crust, rain runs off.

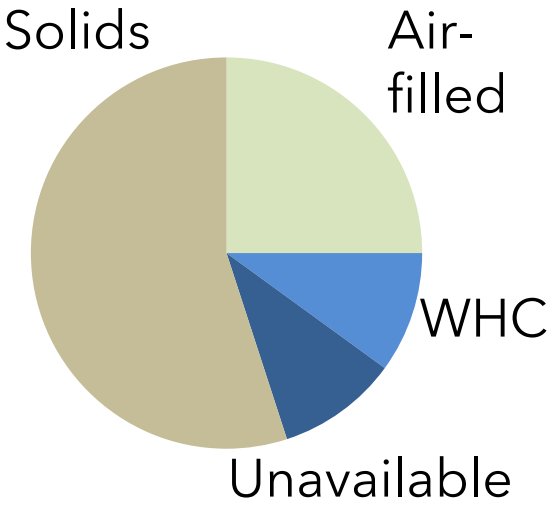
Less water stored.

Hardpan stops roots.



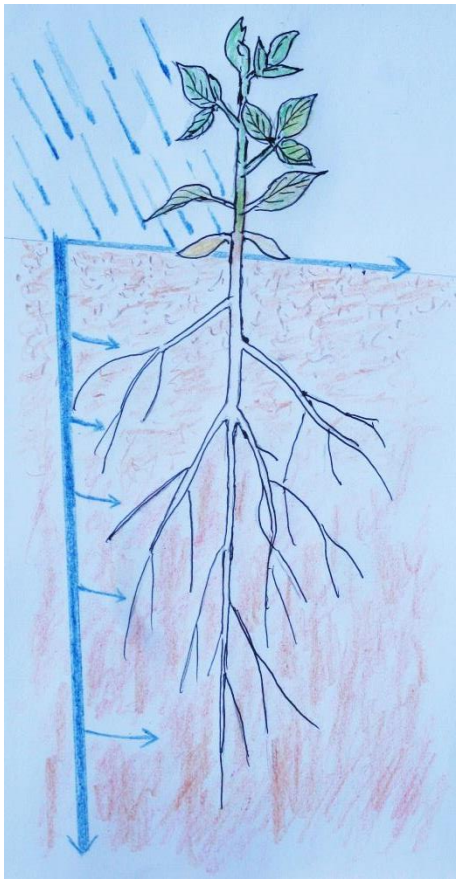
Plant-available Water in Depleted Soil

Depleted soil
at field capacity



Rain enters soil, but less is retained in because of low SOM.

Moisture and nutrients leach below root zone.



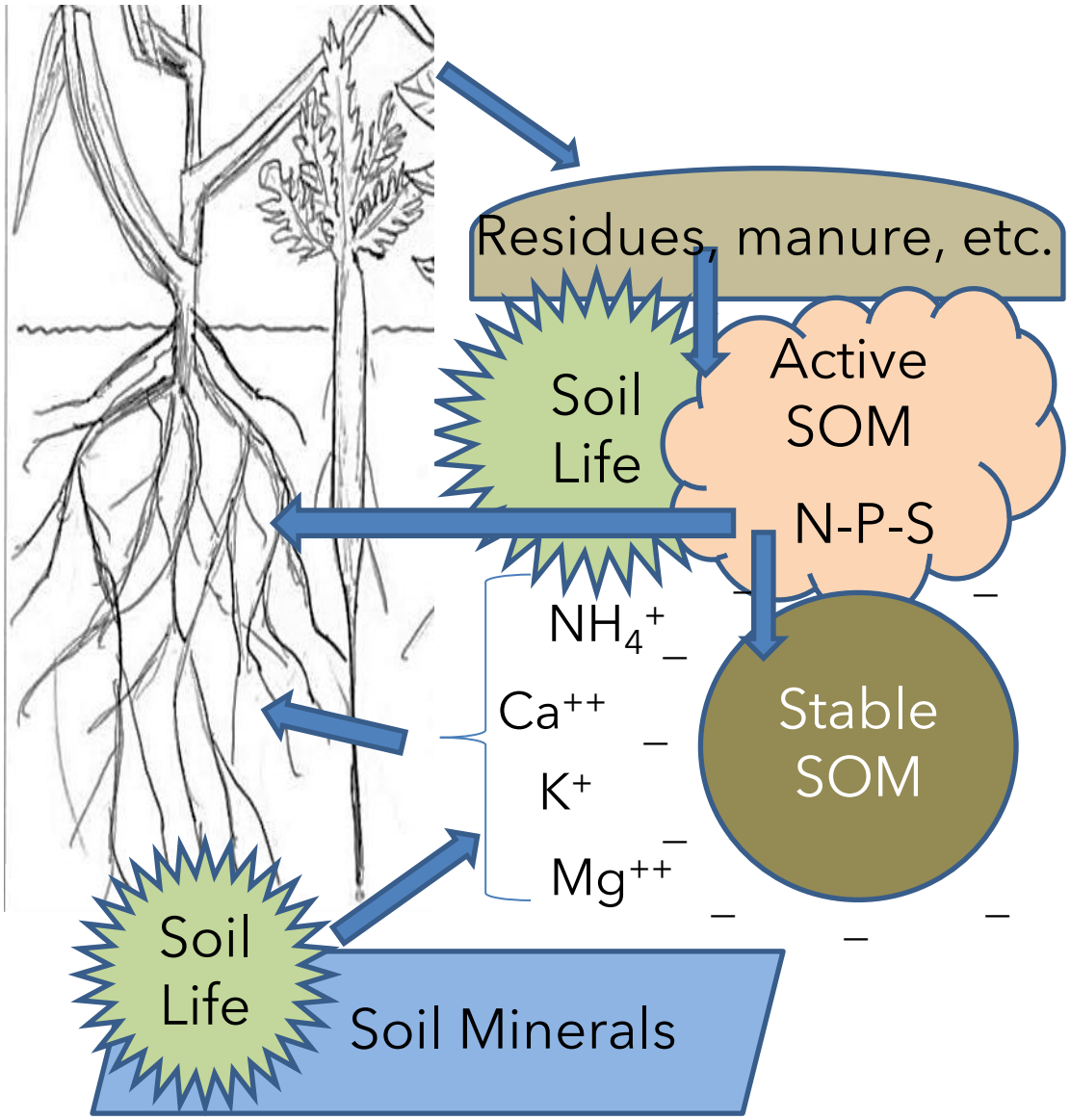
How Healthy Soil Reduces Risk: Crop Nutrients

Retains and recycles nutrients:

- Lower fertilizer costs
- Water quality

Delivers just enough nutrients to crops:

- Yield and quality
- Soil life
- Reduced N_2O emissions.

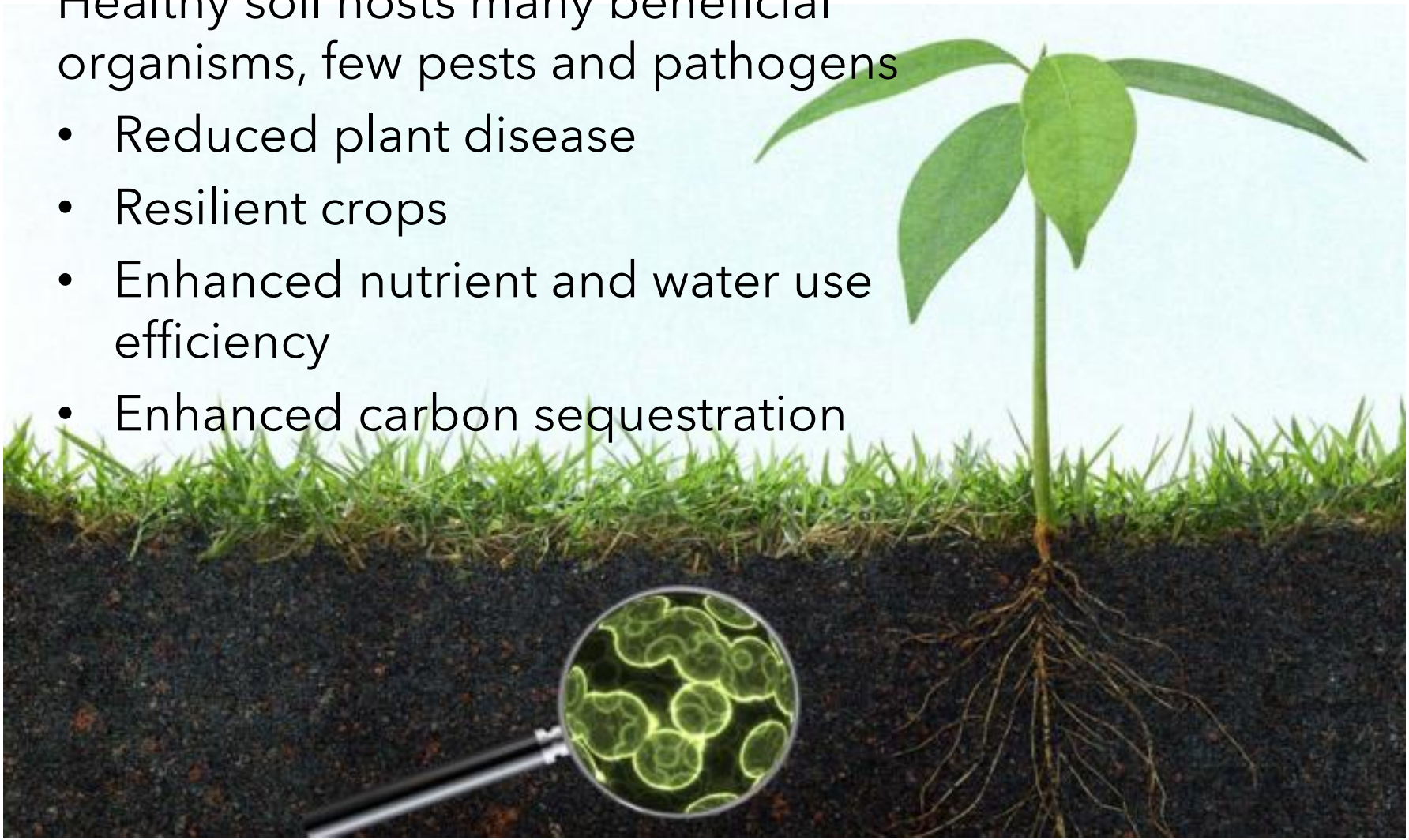


ORGANIC FARMING RESEARCH FOUNDATION

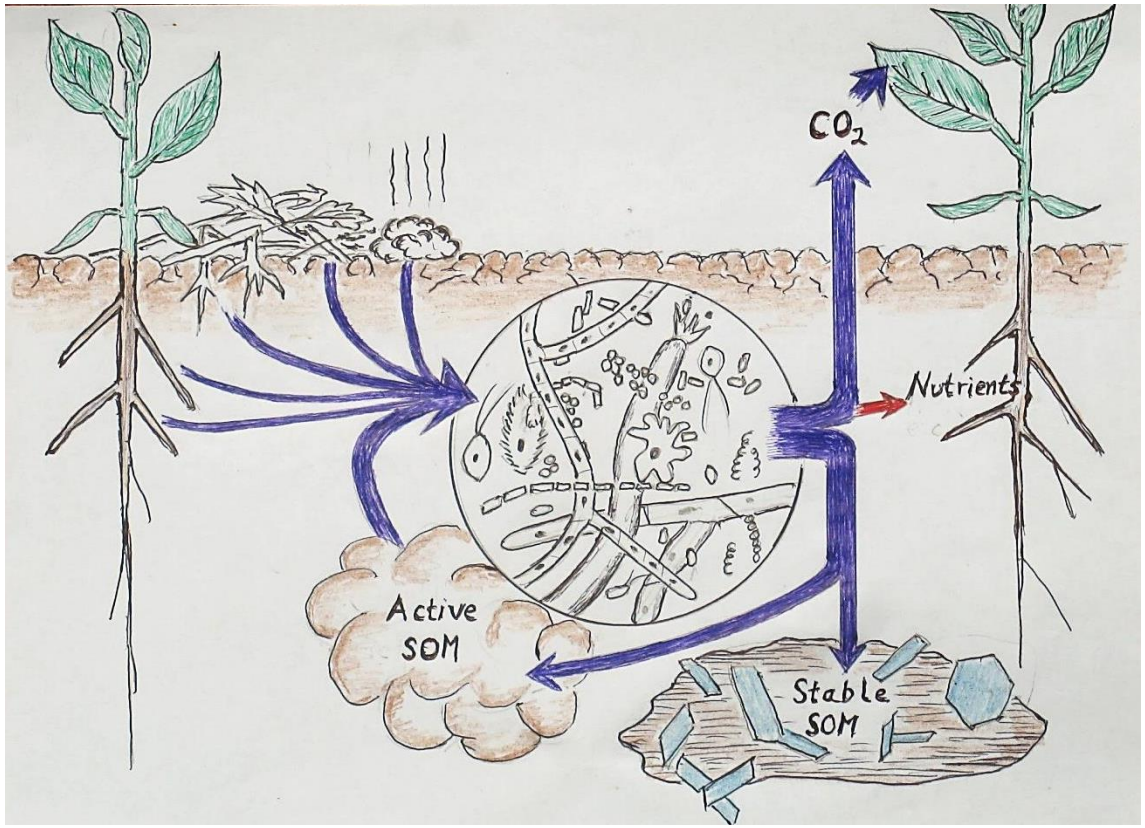
How Healthy Soil Reduces Risk: Soil Life

Healthy soil hosts many beneficial organisms, few pests and pathogens

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



Soil Life Processes Most Organic Inputs

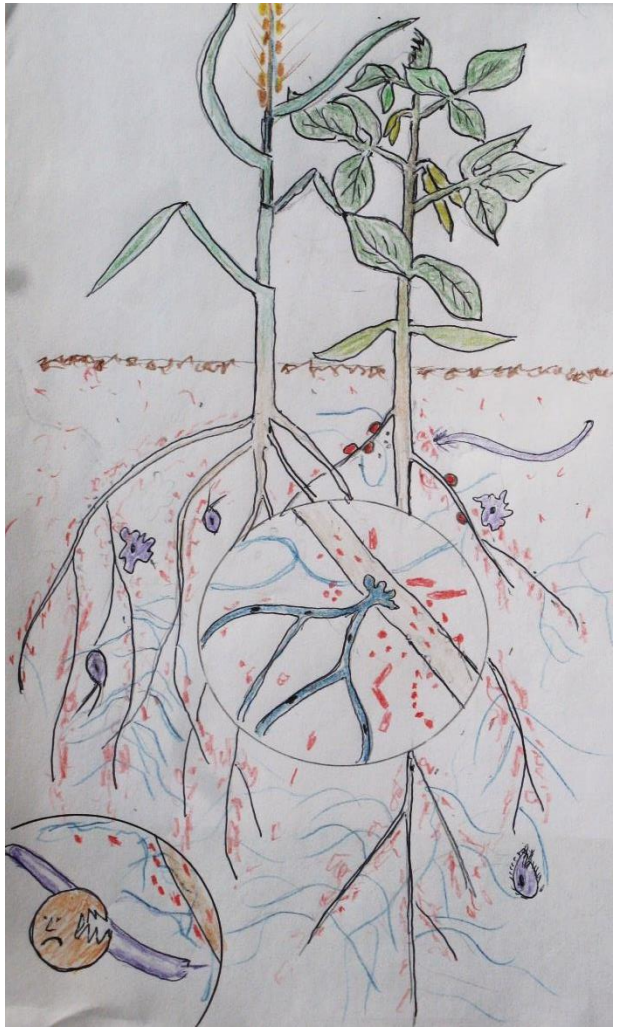


Mineralization
- Plant nutrition and growth

Stabilization
- Soil health
- Tilth
- Carbon sequestration

Plant-Soil-Microbe Partnerships

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



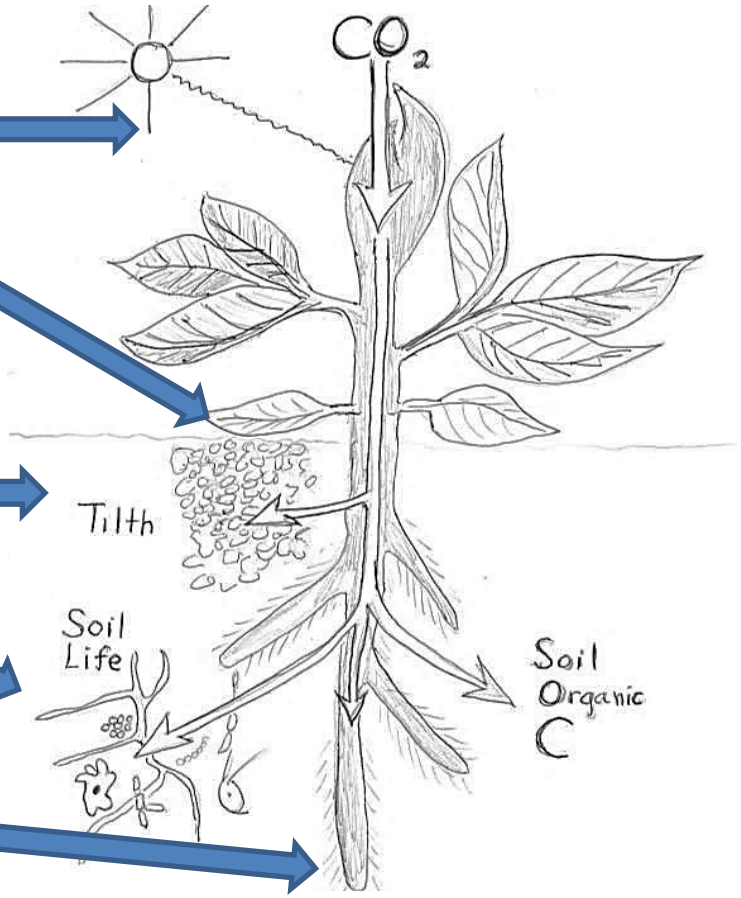
The Living Plant is the Farmer's #1 Tool for Building Resilient Soils

Photosynthesis creates organic matter.

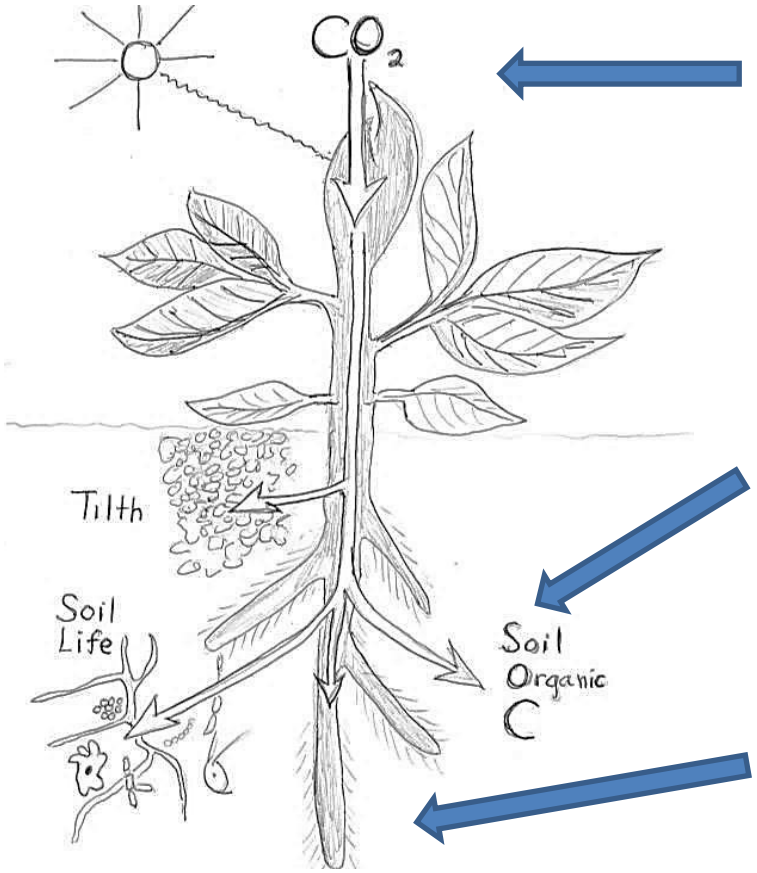
Foliage protects soil surface.

Living roots:

- Build SOM
- Maintain tilth
- Feed soil organisms
- Open and deepen soil profile



The Living Plant is Humanity's Most Practical Means to Sequester Carbon



Photosynthesis removes atmospheric carbon dioxide (CO2).

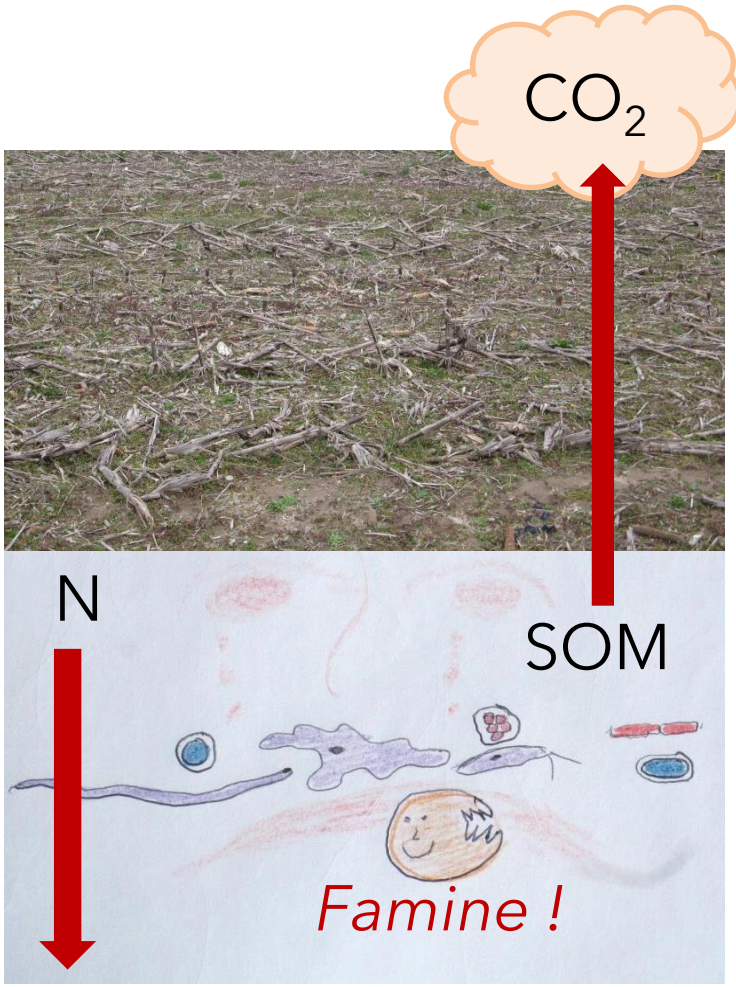
Roots and root exudates build soil organic carbon (SOC).

Deep roots build stable SOC below tillage depths.

Bare Soil is at Risk!

During bare fallow:

- Erosion is imminent.
- Downpours seal surface.
- Soil life goes hungry.
- Mycorrhizal fungi lack "green bridge."
- Weeds proliferate.
- Nutrients leach and run off.
- Soil loses SOM and water holding capacity.
- Fertilizer, irrigation, and cultivation costs increase.



Part 3: Soil Health Management and Practical Risk Reduction

The Journey to Soil Health: NRCS Four Principles



1. Keep soil covered





2. Diversify the cropping system



3. Maintain living roots

4. Minimize disturbance





Annual crop rotations can add 500 lb C/ac-yr

The Fifth Principle: Integrate Crops with Rotationally Grazed Livestock





Management-intensive rotational grazing (MIG, left) builds soil, forage, and livestock health, and can accrue >2,000 lb C/ac-yr. MIG can be done on a cover crop or sod phase in a vegetable or grain rotation. Multispecies grazing (right) further enhances diversity, soil health, and system resilience.

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



Rotation:

- 3 years vegetables with winter cover crops
- 5 years pasture, mixed livestock, mob-grazed
- 3 years feed grains with cover crops
- 5 years pasture

Excellent soil health and agricultural resilience.

The Journey to Soil Health: a Systems Approach



Continuous no-till, cash crop residues only: 510 lb C/ac-yr for 10 yrs. Not stable



Cover crop: 135 – 195 lb C/ac-yr. Many benefits.



Cornell University

Cover crop + reduced till + compost → healthy soil, resilient crops, add 440 – 800 lb stable C/ac-yr.

Diverse Crop Rotations Build Soil Health and Reduce Economic Risks





Crop diversification adds180 – 470 lb stable C/ac-yr

ORGANIC FARMING RESEARCH FOUNDATION

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

ORGANIC FARMING RESEARCH FOUNDATION

Building a Resilient Organic 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.

Cover Crops

Benefits:

- SOM, soil life, soil health
- N fixation, nutrient cycling
- Drainage, water capacity
- Weed and pest control

Costs and risks:

- Seed and planting costs
- Cover crop failure
- Cash crop planting delay
- Water use in dry years



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

SARE Surveys: Making Cover Crops Pay

- Benefits cited by farmers:
  - Healthier soil (85%)
  - Weed management (69%).
  - Yield stability (66%).
- Cover crops pay off the most:
  - After several years' use
  - When used as part of integrated soil health system
  - When grown for specific goals
  - When rotationally grazed
  - When cost-shared (EQIP, etc)







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

Cover Crops and Resilience in Floyd, VA



Spring, 2015: Potato



July: Sorghum-sudangrass



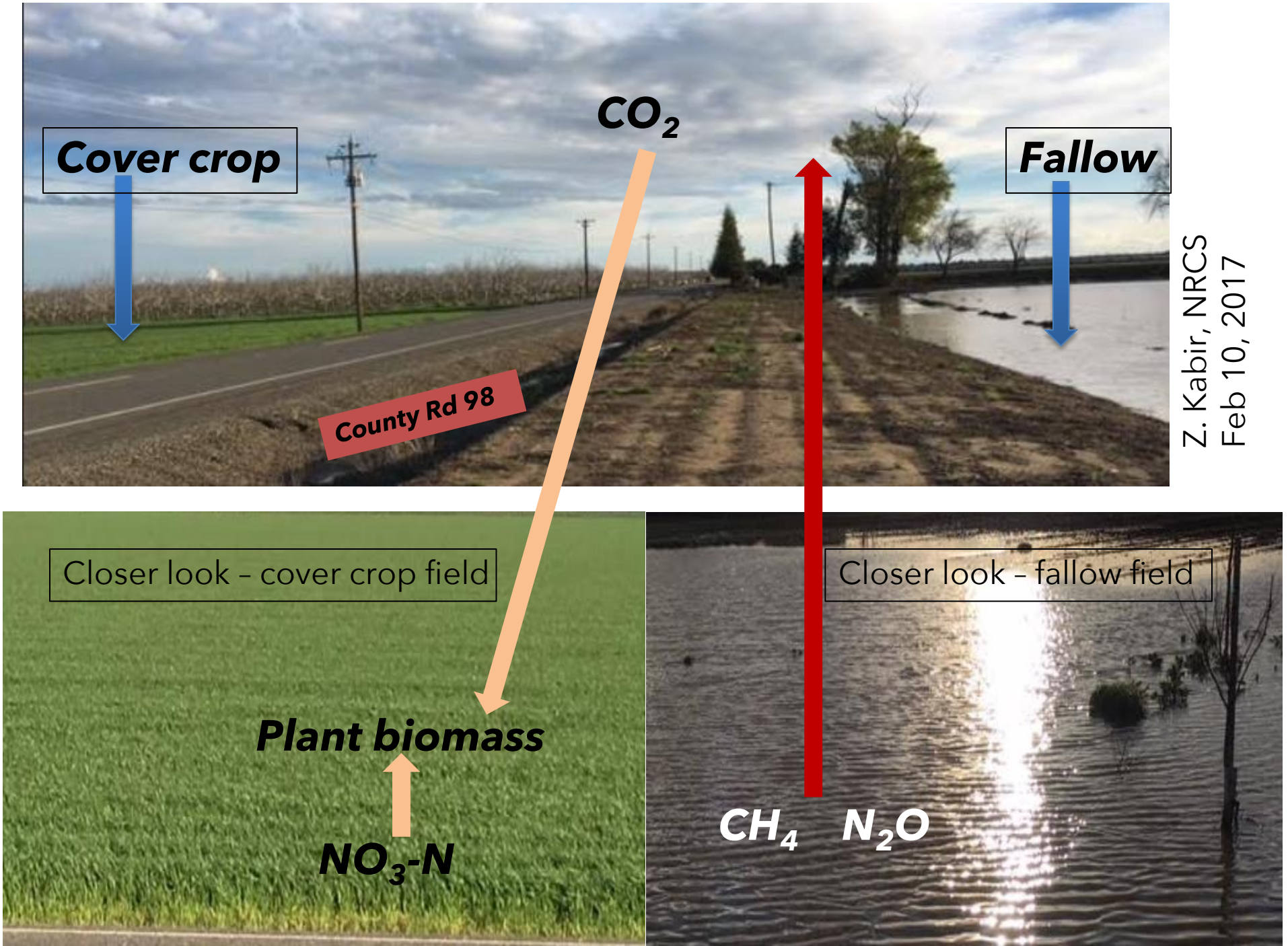
Sept. 29: 7" rain, river runs 3' deep in field

Melissa Maynard



Aftermath: Fence toppled … no soil lost




Cover crop
CO_2
Fallow
County Rd 98
Z. Kabir, NRCS
Feb 10, 2017
Closer look – cover crop field
Plant biomass
NO_3-N
Closer look – fallow field
CH_4 N_2O

Winter Rye Improves Cotton Yield in South Carolina Coastal Plain

Sandy soils with compacted E horizon, usually require annual subsoiling.

Winter rye cover crops (top right):

- Increased SOM by 0.5% and water content by 1 – 1.5″ in top 18″.
- Relieved compaction, allowing cotton to access subsoil 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

ORGANIC FARMING RESEARCH FOUNDATION

No-till Planting in Rolled Cover Crop

Benefits:

- SOM, soil life, and soil health.
- Less erosion and compaction.

Costs and risks:

- Special equipment needs.
- Planting delays and challenges
- Cooler soil, slower N release
- Increased weed pressure
- Lower yields



Success: summer squash after rye + vetch (VA Tech)



Failure: N-deficient, weedy broccoli after rye

Practical Options for Reducing Tillage Intensity in Organic Systems

- Strip or ridge tillage
- Shallow tillage
- Chisel plow
- Spading machine
- Sweep plow undercutter
- Rotary tiller geared down.





Strip tillage (left); breaking sod with spader (right)

Adjusting Inputs

Adding more NPK than needed can:

- Inhibit mycorrhizal fungi and other beneficial root symbionts.
- Burn up SOM.
- Release GHGs.
- Add to production costs

"We need more research on the different fertility inputs. There are many 'snake oil' products out there which cost people money."

Southern region organic farmer in OFRF survey



A little compost goes a long way. Heavy applications can build excess soil P, leach N, and reduce nutrient use efficiency.

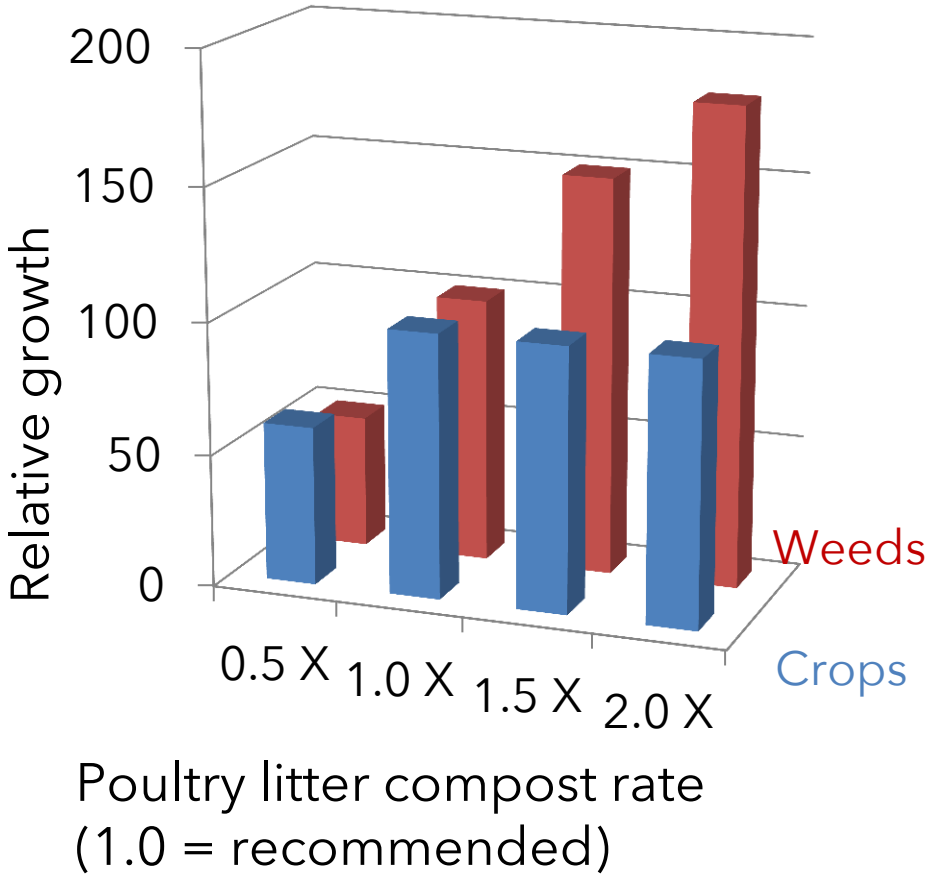
Compost and Manure

Benefits:

- Organic matter
- Slow-release nutrients
- Microbial inoculum

Costs and risks:

- Purchase and hauling
- N & P excesses
  - Deter mycorrhizae
  - Hurt water quality
- Weed pressure
- Food safety (manure)



Nutrients: the Soil Test Paradox

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

Why soil labs recommend more NPK than needed

- Measure top 6" only.
- Ignore soil life.
- Assume soil is "leaky".
- Overlook nutrient recovery by crops.

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

"Living soil changes everything"

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

- 5-year trial, corn-soy-wheat with cover crops (up to 4.5 t/ac).
- Orangeburg loamy sand.
- Organic practices, no fallow.
- No P or K *vs* recommended rate.
- N at half of recommended.

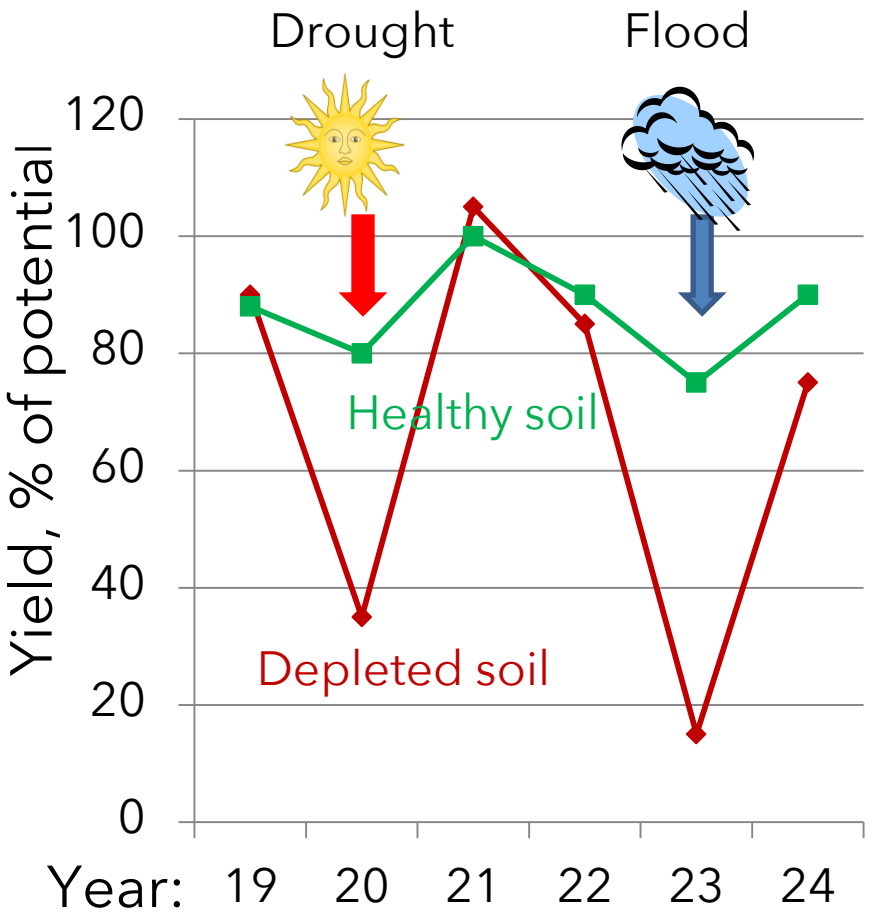
<u>Results:</u>

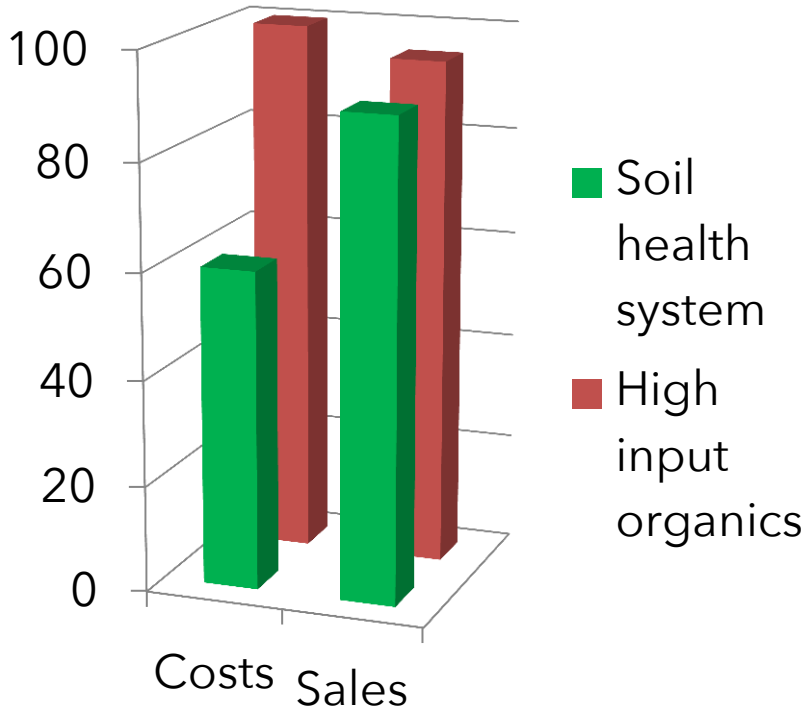
- SOM 1.2 → 1.7%
- Full crop yield without P or K.
- Soil test pH, P, and K stable.



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

Soil Health, Climate, and Risk





Part 4: Crop Insurance and Other Risk Management Tools for Organic Producers

Why Buy Crop Insurance?

- Healthy soil won't prevent *all* losses.
- Protect investment in perennial crops
- Stay in business:
  - During "learning curve" for new practices
  - While restoring soil during organic transition
  - When trying out new crops and enterprises
  - Through the worst weather extremes
  - Through market and price fluctuations.

USDA Crop Insurance Programs: *not only for corn-soy-wheat*

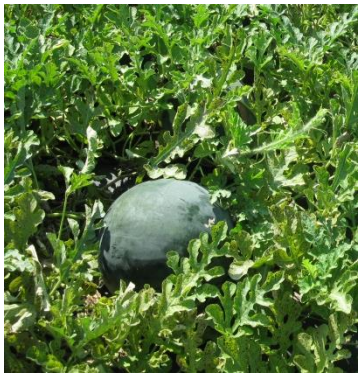
- Multi-peril crop insurance (MCPI) available for most grain, pulse, oilseed, vegetable, and fruit crops.
- Organic price election available for 78 crops, more in future. Insured value based on:
  - Organic yields
  - Organic market prices
- Whole Farm Revenue Protection:
  - Covers *all* farm products including crops not otherwise insurable.

Whole Farm Revenue Protection (WFRP) Tailored for Diversified Operations

- Recognizes risk-reduction value of crop diversity.
- Covers crops and animal products not covered by MPCI.
- Direct-market producers can insure at market prices.
- Better coverage and higher subsidy for diversified farms (3 or more commodities).









Conservation Programs: Technical and Financial Assistance

2018 Farm Bill requires NRCS to prioritize help farmers:

- Build soil health
- Cope with "increasing weather volatility"

NRCS Environmental Quality Incentives Program:

- Cost share for cover cropping (~$50/ac), crop rotation, nutrient management, prescribed grazing, and more

NRCS Conservation Stewardship Program (CSP) supports:

- Comprehensive conservation planning
- Conservation enhancements
- Advanced grazing management

State Conservation Programs

Virginia Agricultural Best Management Practices Cost Share Program.

- Cover crops, nutrient management, and more. https://www.dcr.virginia.gov/soil-and-water/costshar2.

State and Local Soil Health Strategies: Building Soil Health Policy from the Ground Up.

- Listing and description of other state initiatives, including Maryland.
- Isaak Walton League of America. 2019. https://www.iwla.org/docs/default-source/conservation-docs/agriculture-documents/state-soil-health-policies.pdf?sfvrsn=2

Questions?

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



By Mark Schonbeck
& Michael Stein

ORGANIC FARMING RESEARCH FOUNDATION

USDA
U.S. Department of Agriculture
Risk Management Agency