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 for 30 minutes.
- A recording will be available in our archive (see below) and on the eOrganic YouTube channel within 1-2 weeks
- Find more upcoming and archived webinars at https://articles.extension.org/pages/25242
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ORGANIC FARMING RESEARCH FOUNDATION

eOrganic

Mark Schonbeck

ORGANIC FARMING RESEARCH FOUNDATION

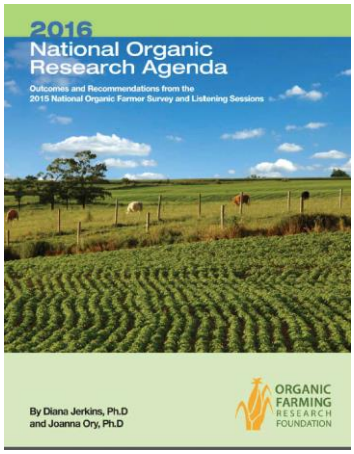
Nutrient Management for Crops, Soil, and the Environment

Research-based Practical Guidance for the Western Region

ORGANIC FARMING RESEARCH FOUNDATION

Mark Schonbeck
Organic Farming
Research Foundation

Research Priorities Identified by Western Region Organic Farmers



71% - soil health

66% - fertility & nutrient management

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

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Western Farmer Identified Priorities

- Role of soil life in fertility
- Soil microbes and nutrient cycling in desert climates
- N-fixing cover crops for arid West and drip irrigated fields
- Liquid fertilizer management to reduce N leaching
- Crop varieties that need less N and outcompete weeds

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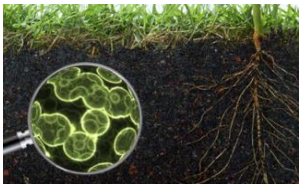
Soil Health and Crop Nutrition

Healthy, living soils:

- Retain and recycle plant nutrients.
- Nourish crops from nutrient reserves in soil organic matter (SOM).
- Minimize nutrient losses, protect water quality.



"Feed the soil, and the soil will feed the plant."

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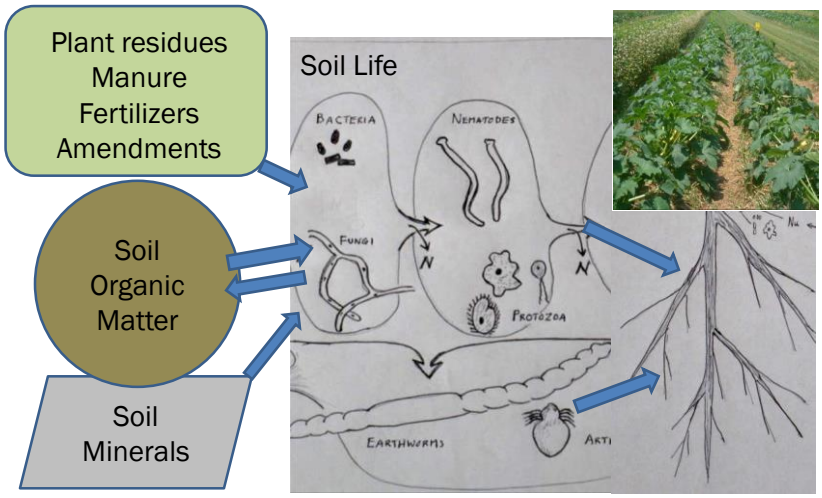
Nutrient Dynamics in Living Soil



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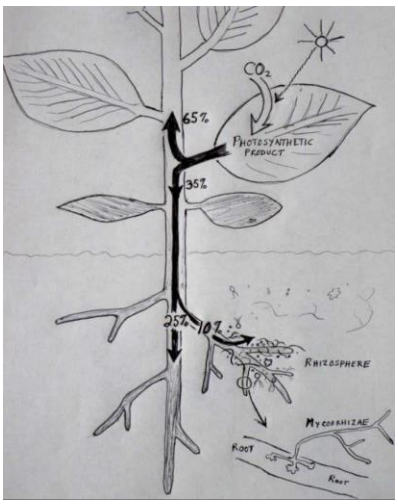
Two-way Exchange

- Plants deliver 10 – 30% of their photosynthetic product to soil life.
- Beneficial microbes in the rhizosphere (root zone) enhance plant nutrition and health.
- Mycorrhizal fungi assist moisture and nutrient uptake, and suppress plant disease.



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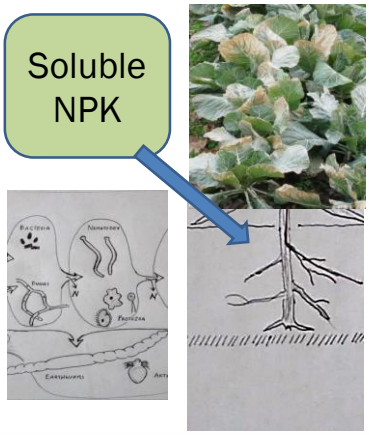
Nutrient Dynamics when Soil Health is Poor



When soil health declines due to:

- Inadequate organic matter inputs,
- Prolonged bare fallow,
- Excessive tillage, and
- Overuse of soluble fertilizer,

Crop production depends more on fertilizer inputs.

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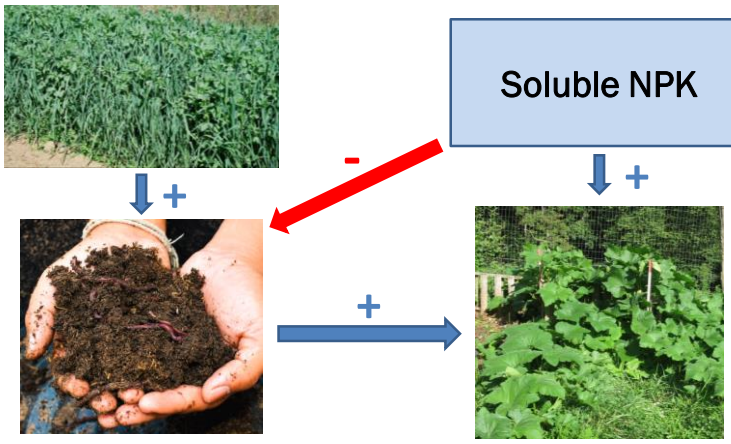
Feedback: Soil Health and Crop Nutrients



Building soil health enhances nutrient release from SOM. Soluble fertilizers stimulate crops, but can undermine soil health.

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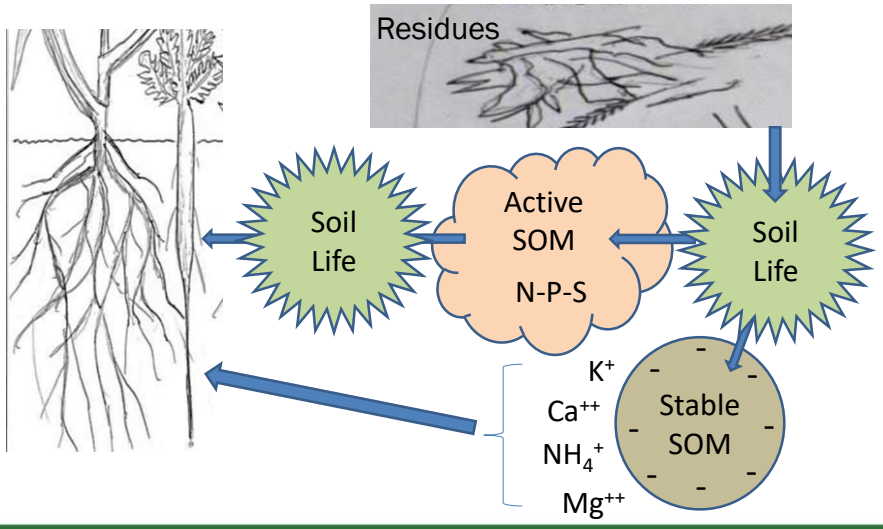
Soil Life and SOM Retain and Deliver Nutrients



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To Maintain Soil Fertility, Organic Farmers Feed Soil Life a *Diverse, "Balanced Diet."*

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Soil Testing

A standard soil test is a "snapshot" of:

- pH (acidity), cation exchange capacity
- Plant-available P, K, Ca, Mg, some micronutrients
- Percent organic matter

Additional fine-tuning tests:

- Nitrate-N
- Estimated plant available N (PAN) from organic matter
- Soil micro-biological activity (*e.g.*, Solvita respiration test)
- Cornell Comprehensive Assessment of Soil Health (CASH)
- Soil health scorecards for field assessment

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Applying Soil Test Results to Organic Systems

Standard soil test recommendations:

- Lime rates based on soil pH and buffer pH index
- N usually based on crop grown and yield goals
- P and K based on soil test P and K levels and crop grown
- Micronutrients as needed based on soil test results
- *Recommended rates often exceed crop uptake because half or more of applied NPK is lost or tied-up in soil*

Challenges for organic producers:

- Complex nature of biologically-based nutrient cycling
- Highly variable nutrient contents of organic inputs
- Lack of research in organically managed soils

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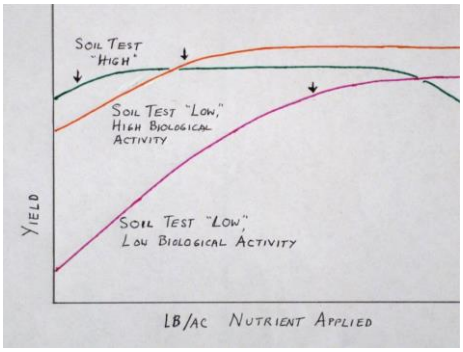
Applying Soil Test Results to Organic Systems

Supplement soil test information with:

- Field observations
- Crop foliar nutrient analyses
- Side-by side trials with and without fertilizer

Most profitable application rate



Can soil biological activity modify crop response to added nutrients?

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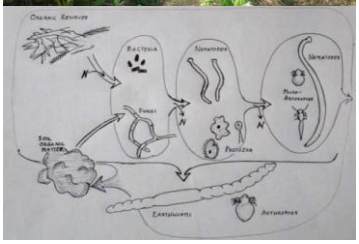
Organic Management: A Balancing Act

"Management of SOM to enhance soil quality is a key determinant of successful organic farming, which involves balancing two ecological processes: ***mineralization*** *of carbon (C) and nitrogen (N) in SOM for short term crop uptake, and* ***sequestering*** *C and N in SOM for long term maintenance of soil quality."*

Delate et al., 2015. *Sustainable Agric. Res. 4(3): 5-14.*(Emphasis added)



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Organic and Natural Mineral Fertilizers

Organic and natural mineral amendments are used to:

- Restore depleted soils.
- Remedy nutrient deficiencies and imbalances.
- Adjust soil pH.
- Sustain crop yields.
- Replenish nutrients removed during harvest.

Several nutrient sources allowed by USDA organic standards

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Goals of Organic Nutrient Management

- Maintain crop yields and quality.
- Protect soil health, water quality, and climate.
- Build healthy soils and reduce need for inputs.
- Attain and maintain optimum levels of all plant nutrients.
- Avoid excess nutrients.

Abundant crops and clean waters

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Nutrient Management Challenges in Western Region

Maritime Pacific Northwest (OR and WA west of Cascades)

- *Generally fertile soils*
- *High rainfall in winter, high risk of N leaching*

Mediterranean climates (much of CA, parts of WA and OR)

- *Generally fertile soils, but moisture-limited in summer*
- *Winter rains may leach N*

Volcanic soils (Cascades, HI, parts of ID)

- *High organic matter and fertility, good structure*
- *Great capacity to "tie up" P*

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Nutrient Management Challenges in Western Region

Semiarid (MT, eastern WA and OR, parts of ID, WY, CO)

- *Prairie soils, fertile, high SOM, but often dry*
- *Alkaline pH, P tied up by calcium*
- *Cover crop and crop rotation options moisture limited*

Arid (NV, NM, AZ, WY, CO, UT, southern inland CA)

- *Saline or alkaline, often shallow or poorly structured soils*
- *Production severely moisture-limited unless irrigated*
- *Irrigation water quality challenges (salinity)*

Tundra and permafrost soils (AK)

- *Cold limits soil biology and crop production*
- *Vulnerable to SOM loss from tillage and climate change*

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Western Region: A Diversity of Climates & Production Systems

Climate	Production System
Maritime	Vegetable crops
Mediterranean	Cereal grains
Inland semiarid	Rangeland livestock
Inland arid	Tree fruit, vineyard, other specialty crops
Arctic/subarctic	
Tropical island	

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Nitrogen Challenges in Organic Systems

Organic crops are often N limited when:

- Soil life is depleted (e.g. early in transition from conventional to organic).
- Soils are inherently low in fertility or biological activity (e.g. arid regions).
- N-poor (high C:N) crop residues or amendments are added to the soil.
- Crops with high N demand are grown.
- Winter rains have leached plant-available N out of the root zone.
- Cool soil conditions in early spring slow biological activity and N mineralization.

Classic N deficiency: older leaves turn yellow

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Nitrogen and Soil Health: Potential Tradeoffs

- Reduced till and high-biomass cover crops enhance soil health, but can reduce plant-available nitrogen (PAN) and yields.
- Supplementing PAN with concentrated N sources can:
  - Leach nitrate-N to groundwater.
  - Increase nitrous oxide emissions.
  - Accelerate SOM decomposition.
  - Reduce beneficial plant root-microbe interactions.

Organic no-till snap beans in rolled pearl millet show visible N deficiency.

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Broccoli: A Heavy Feeder that Responds Well to Organic N Fertilizer

Fertilizer rate trials on five organic farms in Washington State:

- N rate series, applied as feather meal broadcast just before planting
- Linear yield response to feather meal N rates up to > 200 lb/ac
- Each lb feather meal N (cost $6.36) increased broccoli yield from 11 to 88 lb (market value $2.50/lb)
- N rates ≥ 200 lb/ac raised soil nitrate-N to ~30 ppm at 28 DAP, potential for leaching

N deficiency (top) and N sufficiency (lower) in organic broccoli

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Results of Modeling Soil and Environmental Impacts in Organic Broccoli

In central coastal California, broccoli requires 215 lb N/ac for top yields. Providing this N with organic fertilizers can:

- Leach about 180 lb nitrate-N per acre.
- Emit another 23 lb N as nitrous oxide (N_2O).
- Cause a net loss in SOM.

Providing two-thirds of this N via compost and/or cover crops, and the rest as organic fertilizer can:

- Build SOM, reduce N losses as N_2O to 11 lb/ac, but
- Leach N at rates similar to the all-fertilizer treatment.

Li et al., 2009. Proceedings CA Soil & Plant Conference, Feb. 2009, pp 92-98

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Tips for Building Soil while Meeting N Needs of Heavy Feeders

Drip-fertigated broccoli recently set out into shallow-tilled seedbed

- Feed soil life with moderate C:N materials like mixed compost, and high-biomass legume-grass covers.
- Reduce tillage when practical.
- Deliver concentrated N in crop rows.
  - Broadcast, then build beds
  - Fish emulsion, etc. via in-row drip
- Mow or roll covers, then solarize or use opaque tarps to terminate.
- *Long-term solution: breed vegetable crops for nutrient efficiency.*

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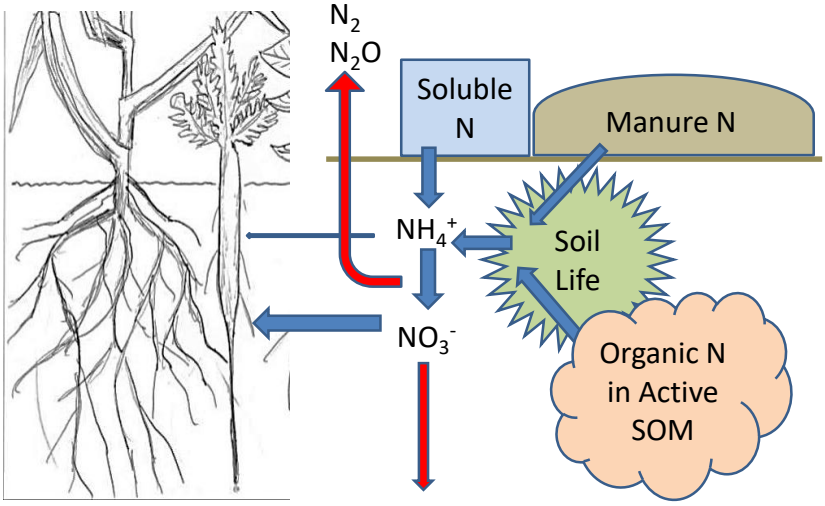
Nitrogen is Challenging for *all* Farmers



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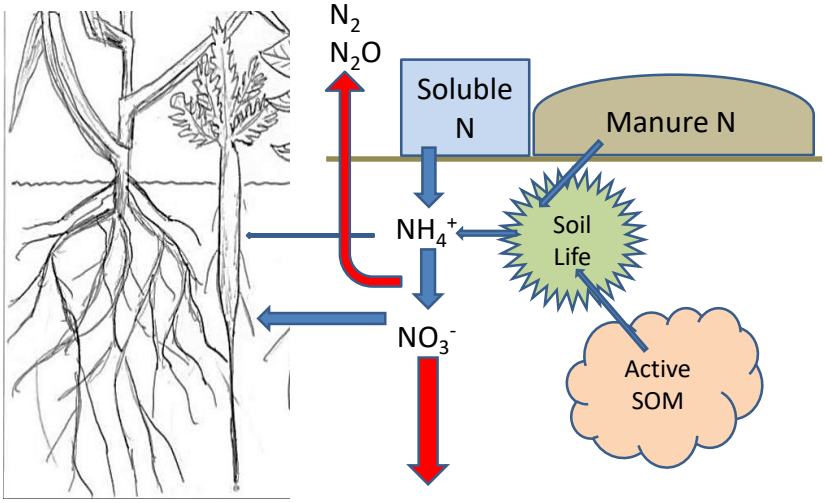
...especially when soil life is depleted.



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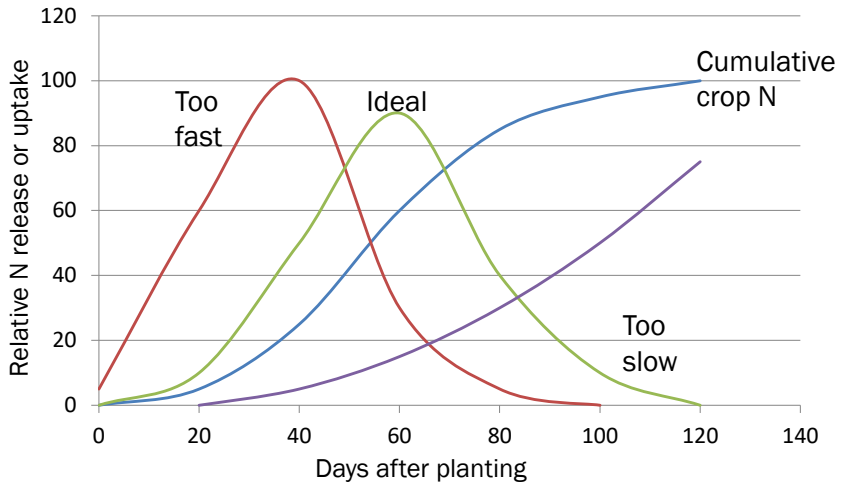
Matching N Release to Crop Demand



Adapted from Sullivan et al., 2017 Oregon State University Extension Bulletin EM 9165

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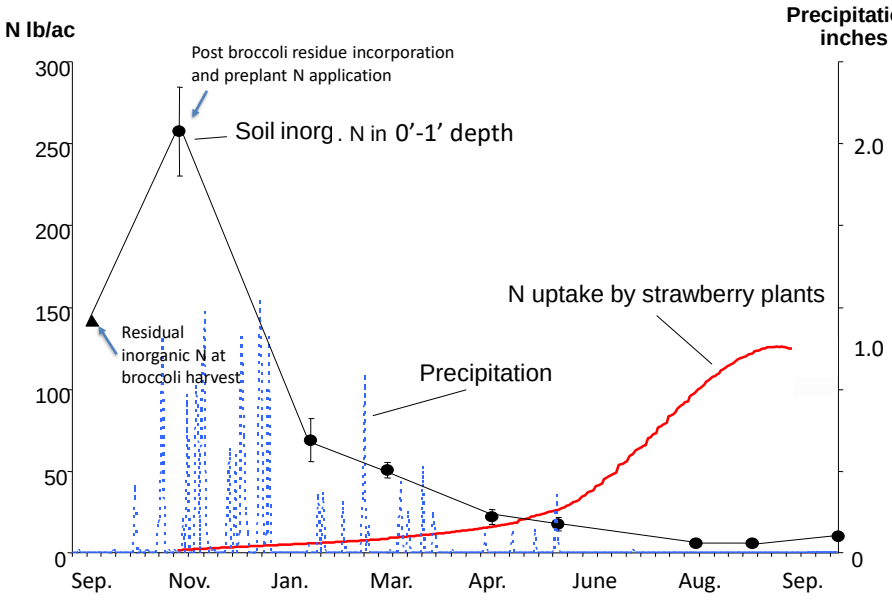
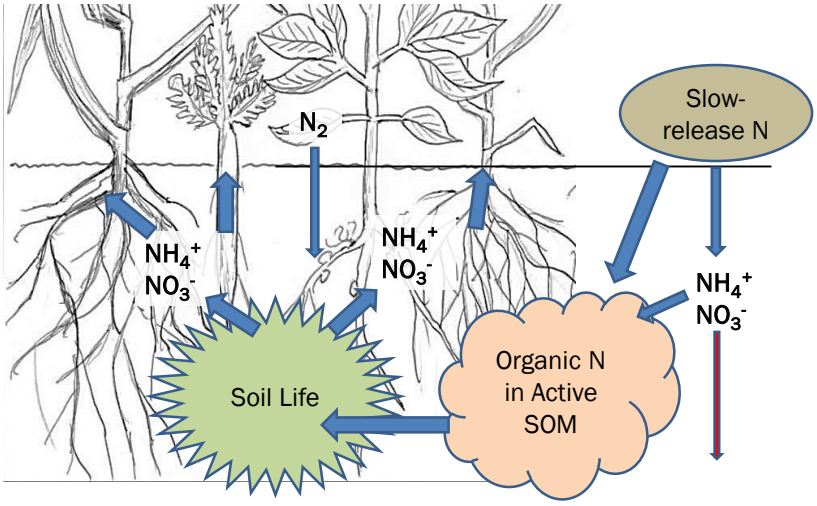
Asynchrony of N supply and N demand in an organic strawberry field in the Northern region, CA



(Muramoto et al., 2004)

Delivering N where it is Needed



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Tightly Coupled N Cycling in Organic Tomato Production in CA

Three nutrient scenarios:

1) *N deficient* – low soluble N, low SOM and microbial activity, low yield
2) *N saturated* – high soluble N and microbial activity, moderate SOM, high yield and high N leaching risk
3) *Tight N cycling* – low soluble N, high SOM and microbial activity, **high yield with minimal N leaching risk**

Vigorous tomatoes grown on moderate C:N compost and no concentrated N.

Bowles et al. 2015. PLOS ONE.

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Managing for Tightly Coupled N Cycling

Drip fertigation can deliver small doses of soluble N to crops without overloading soil with soluble N.

- Feed the soil with a diversity of high- and low-C:N organic materials, including legume-grass or multispecies cover crops.
- Provide crops with small doses (~20-30 lb/ac) of faster-release organic N through in-row drip fertigation or side-dressing.
- Encourage mycorrhizal fungi.
- Avoid over applying N and P.

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Other Zone-management Strategies

N-fixing forage soybean in "grow-zone" of a following broccoli crop, with high-biomass, N-scavenging sorghum-sudangrass in alleys.

- Plant N-rich legume or crucifer cover crops in future crop rows, higher C:N covers in alleys.
- Strip tillage (below) or ridge tillage selectively stimulates N mineralization in crop rows.

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The Challenge of Phosphorus in Organic Nutrient Management

- Crops use N and P in a ratio of 4 – 10 lb N to 1 lb P.
- Manure and compost provide 2 – 3 lb N per lb P.
- Using these materials to meet crop N needs will build soil P.
- Excessive soil P can:
  - Increase P in runoff.
  - Inhibit mycorrhizal fungi.
  - Tie up micronutrients.

Heavy compost use to rebuild depleted soil will make it rich in organic matter – and very high in P. Long term effects on soil health and productivity merit further study.

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Replenishing Nutrients: Vegetable Crops

Crop	Yield t/ac[1]	Nutrient removed, lb/ac[1] N	P	K	Rec. rates, lb/ac[1] N	P	K
Broccoli	8.0	90	9	91	220	<9	0 - 50
Sweet corn	10.0	90	13	50	180	<13	0 - 50
Onion	34.0	120	22	133	180	0	0
Snap bean	20.0	35	7	33	130	0	0
Potato	20.0	100	26	208	220	<26	0 - 50
Mixed compost (1-1-1) at 5 t/ac adds:					100	44	83
Poultry litter fertilizer (5-4-3) at 1 t/ac adds:					100	35	50

[1] Based on Oregon State University Extension bulletins PNW 646 (2013) and EM 9165 (2017). Recommended rates for N = total N from *all* sources, including SOM; recommended P and K for "high" soil test values.

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Adjust Amendment Rates to Soil Test P Levels

Obtain soil tests and total nutrient analysis on compost or manure:

- On low-P soil, amend at rates to meet N and K needs and build P.
- If soil P is high or optimum, adjust compost rate to just maintain P, and grow legumes for N.
- For very high or surplus soil P, use compost sparingly as an inoculant.

A little compost goes a long way for soil health.

Legumes to replenish N

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Cover Crops: A Vital Tool for Organic Nutrient Management

Cover crops:

- Feed soil life, build SOM.
- Fix N (legumes).
- Absorb and retain soluble N.
- Retrieve nutrients from subsoil, protect water quality .
- Enhance plant-available soil P (legumes, buckwheat) and K (grasses) when needed.
- Never aggravate P or K excesses.

Clockwise from top left: pearl millet, hairy vetch, buckwheat, four-way mix

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Cover Crop Types and Nitrogen Dynamics

Mix and match cover crops to manage nitrogen for production and environmental goals.




	LEGUME	CRUCIFER	MIX	GRASS
N fixation potential	High	None	High	Limited
N recovery	Low-mod.	Very high	Mod.-high	High
Residue C:N ratio	Low	Low	Moderate	High
Available N release	Rapid	Rapid	Slow	N tie-up
N leaching & N_2O risk	High	High	Low-mod.	Low

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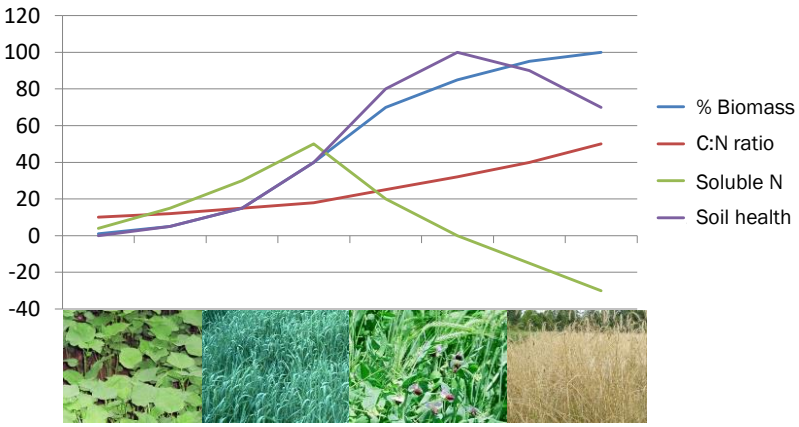
Cover Crop Maturity and Nitrogen Dynamics



Seedling Vegetative Flowering Overmature

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The Dryland Farmer's Dilemma

- Traditional wheat-fallow depletes soil, even in no-till.
- Adding a cover or pulse crop in the "off" year improves soil health and water-holding capacity.
- However:
  - Cover crops can reduce soil moisture and reduce wheat yields.
  - Limited moisture can limit cover crop biomass and N fixation.
  - Soil building payoffs take several years to accrue.

Doug and Ann Crabtree grow organic specialty grains in a diversified rotation in Montana.

www.vilicusfarms.com

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Tips for Organic Dryland Soil Management

- Winter pea green manure adds more N and organic matter than spring pea, and consumes less moisture than other covers.
- Legume covers build soil; yield effects vary with locale and cover crop species.
- Earlier cover crop planting and termination relieves water competition, sustains grain yields.
- Long term organic management builds soil fertility and moisture capacity, reduces N requirements, and improves grain quality.

Winter legume builds organic matter, N, and microbial diversity in organic dryland grain rotations.

www.vilicusfarms.com

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Building Soil Fertility yet Losing Money: An Economic Paradox in Dryland Wheat

One-time compost application in Utah organic dryland farm in 1995:

- Doubled wheat yields through 2010.
- Doubled SOM as of 2010.
- Enhanced soil microbial and enzyme activities.
- Failed to pay for the cost of the compost.

Compost enhanced soil and crop health (back) compared to unamended plot (front).

Photo from 2015 webinar by Jennifer Reeve and Earl Creech, Utah State University

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Organic Nutrient Management Research Priorities for the Western Region

- Build and maintain soil health and fertility in arid and semiarid regions for:
  - Dryland grains and range
  - Irrigated crops
  - Crop rotations and cover crops
- Fine-tuning organic fertilizer recommendations across crops and climates
- Management practices to promote tightly coupled N cycling in a wider range of crops, soils, and climates
- Plant breeding for nutrient efficiency and effective association with mycorrhizae and other soil organisms

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Information Resources: Pacific Northwest

- Searchable database of Extension publications at https://catalog.extension.oregonstate.edu/
- Nutrient Management for Sustainable Vegetable Systems in https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/em9165_0.pdf.
- Cover Crop and Organic Fertilizer Calculator http://smallfarms.oregonstate.edu/calculator.
- Soil Fertility in Organic Systems http://cru.cahe.wsu.edu/CEPublications/PNW646/PNW646.pdf.
- Vegetable Production Guides http://horticulture.oregonstate.edu/content/vegetable-production-guides.

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Information Resources: Semiarid Regions

- Montana State U https://www.msuextension.org/agriculture/.
  - Cover crop study and survey – click on "soil fertility"
  - Organic transition http://msuextension.org/publications/AgandNaturalResources/MT200901AG.pdf.
  - Nutrient management for organic dryland grains http://msuextension.org/publications/AgandNaturalResources/EB0200.pdf.
- Utah State University – organic tree fruit and vegetables https://extension.usu.edu/productionhort/organic/.

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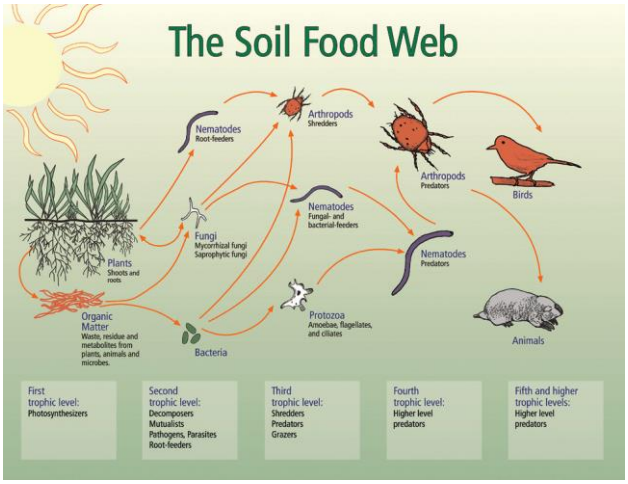
Questions?



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- Find the OFRF Soil Health Guides at http://ofrf.org/soil-health-and-organic-farming-ecological-approach
- Have an organic farming question? Use the eXtension Ask an Expert service at https://ask.extension.org/groups/1668
- Please send your feedback! We will email you a survey about this webinar later today.
- Thank you for coming!

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