

Lola's Organic Farm

**Southern Sustainable Agriculture Research and Education
Producer (SSARE) Field Day**

Funded Producer Grant Project:

*Mechanical and biological strategies to remove invasive,
common Bermuda grass in preparation for organic
vegetable production on raised beds*

Collaborator, Dr. Mark Schonbeck for SSARE field day with Producer's Input

Glenwood, Georgia

June 11, 2015

What is a Cover Crop?

A crop planted, not for income, but to protect the soil from erosion and compaction, and to:

- Add organic matter, feed soil life.
- Scavenge surplus nutrients.
- Fix N (legumes).
- Make nutrients more available.
- Provide beneficial insect habitat.
- Disrupt pest, weed, and disease life cycles, and / or
- Suppress weeds.



*Buckwheat cover crop
in full bloom*

What makes a “good” cover crop?



A cover crop of cowpea and foxtail millet 53 days after planting forms a solid stand 3 feet tall.

It grows like a weed:

- Emerges and grows rapidly.
- Covers the ground quickly.
- Mops up available nutrients.

However:

- It is easy to manage.
- Time of flowering and seed set is predictable.

It also:

- Forms a lot of biomass.
- Fixes substantial N (legumes)
- Outcompetes weeds.

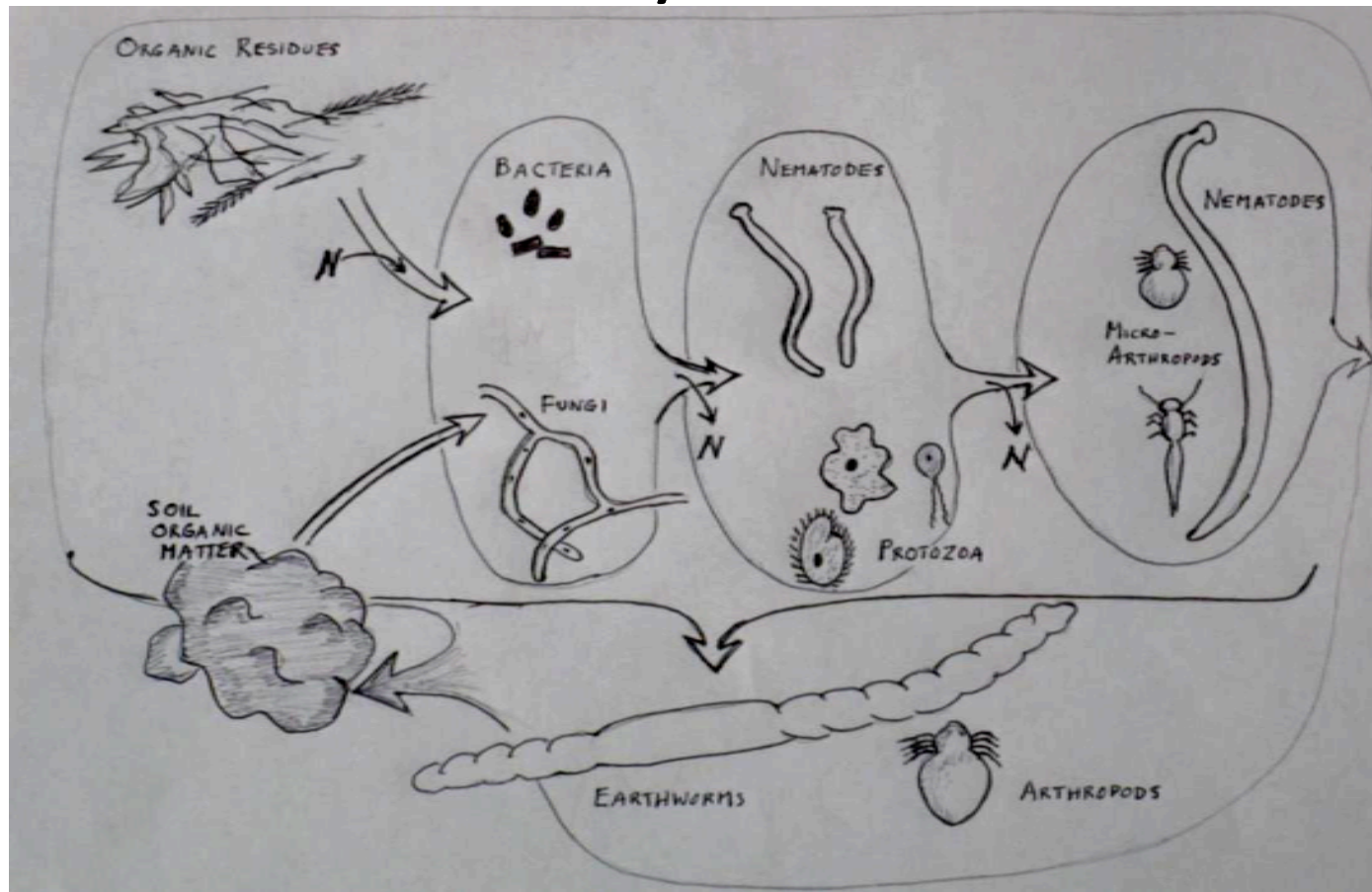
What is Soil Health?

- *Soil health* is the soil's ability to support healthy crops and livestock, retain moisture and nutrients, and protect water quality.
- A healthy soil is a *living system* with many kinds of organisms working together, the ***soil food web***.
- A healthy soil can produce a good crop with few or no external inputs.
- Healthy soil is less prone to erosion.



At Radical Roots Farm in Harrisonburg, VA, David (in photo) and Lee O'Neill maintain soil health by caring for the soil as a living system.

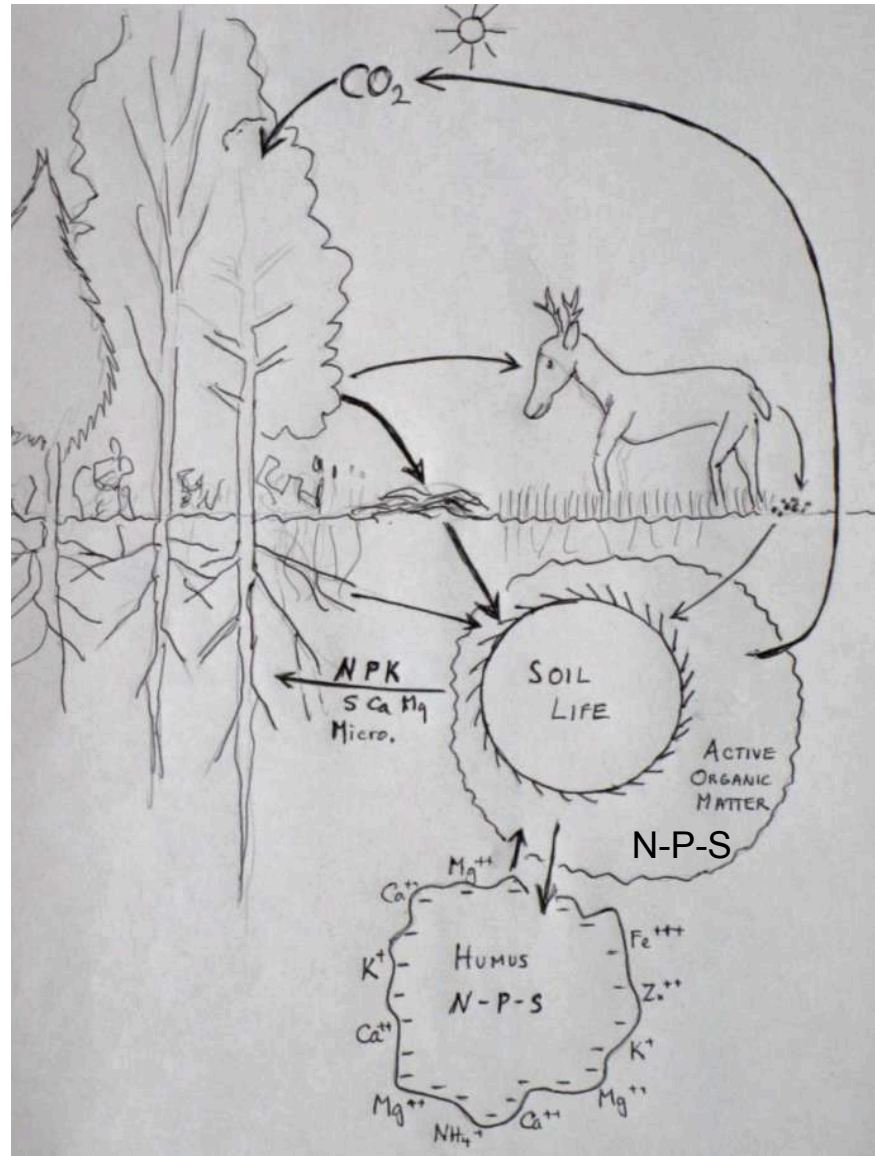
The Soil Food Web: the Community of Life in the Soil



*Soil organisms convert residues to soil organic matter,
and hold and release nutrients*

The Organic Matter Cycle

The soil food web is the engine of soil fertility and plant nutrition. In nature, the breakdown of organic residues is the sole source of plant nutrients, except for nitrogen fixed by microbes.



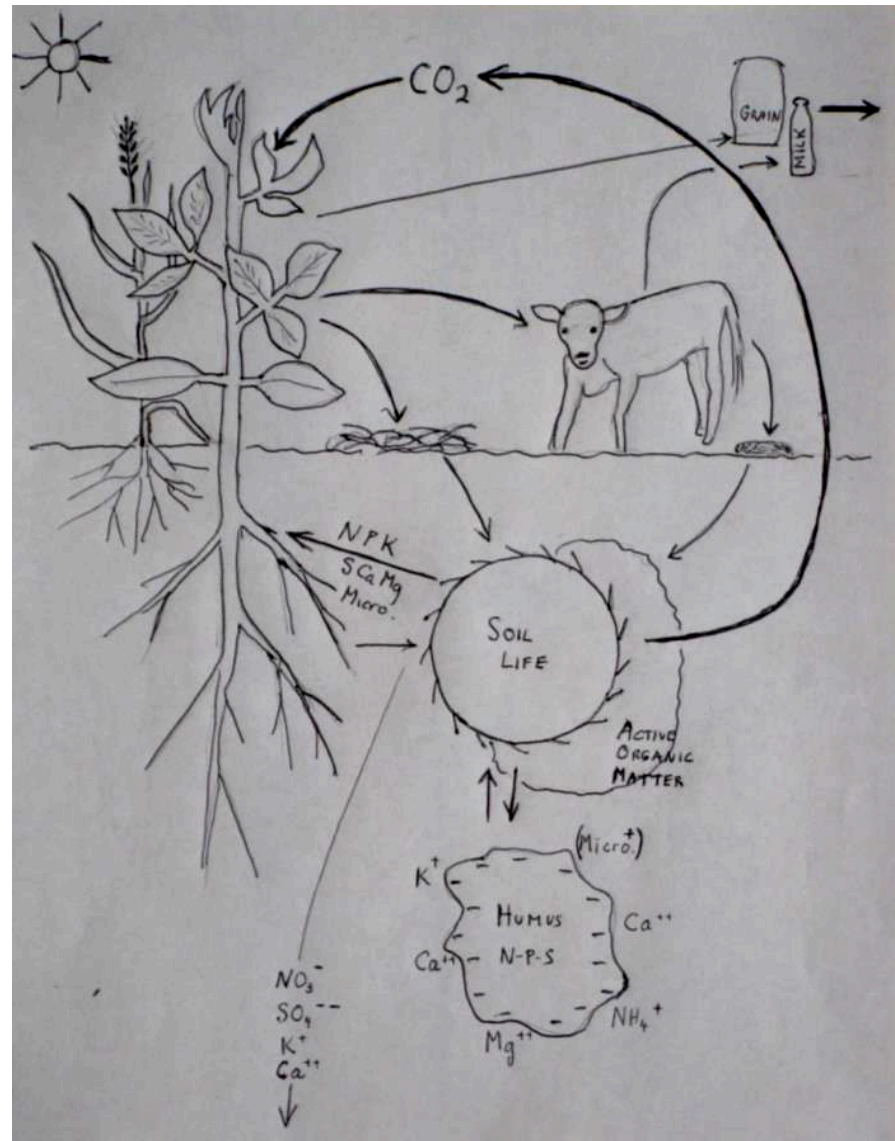
The Organic Matter Cycle in Nature



The organic matter cycle provides all the nutrients for plant growth in natural ecosystems such as this forest.

The Organic Matter Cycle in Agriculture

- *Harvest removes organic matter (OM) and nutrients.*
- *Bare soil periods reduce OM input.*
- *Tillage burns up OM damages soil life, and promotes nutrient leaching.*



Replenishing the Organic Matter Cycle

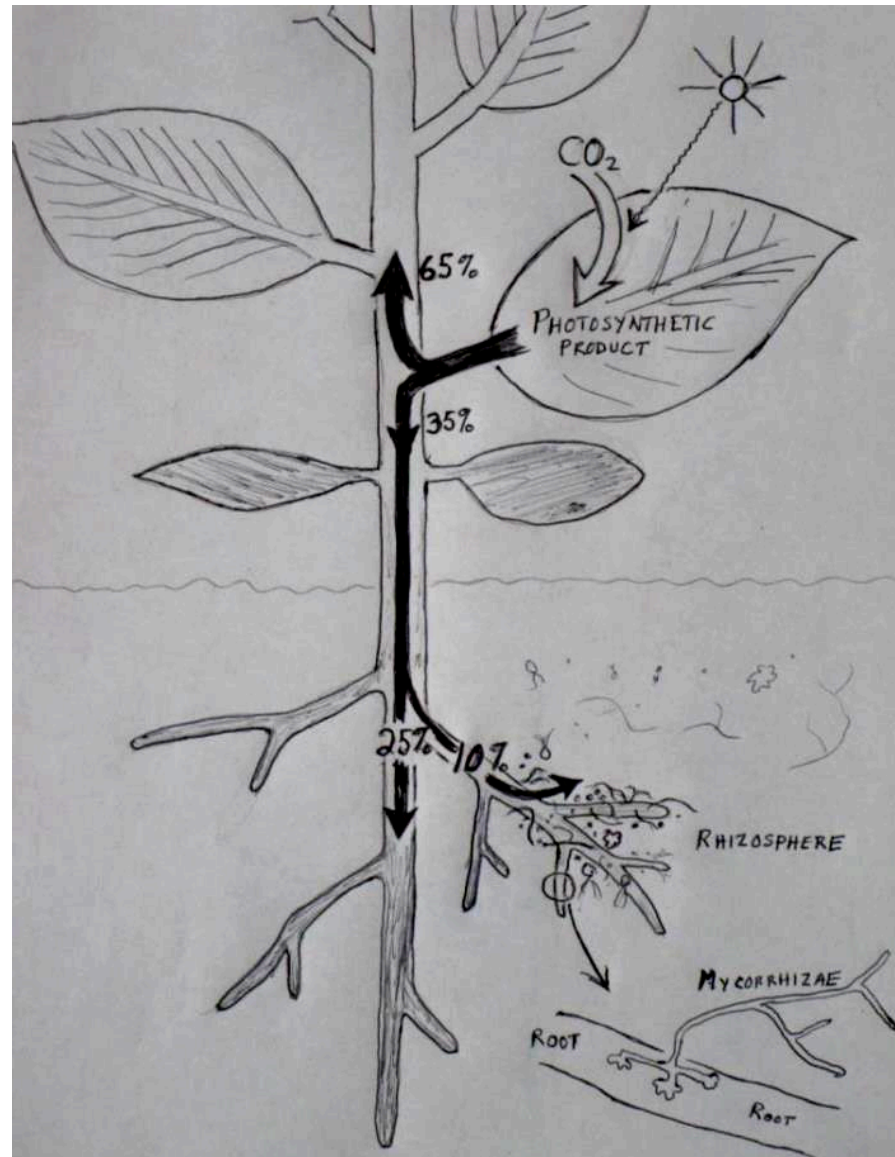
Sustainable and organic farmers feed the soil life a varied and balanced diet of:

- Cover crops and green manures
- Compost
- Organic mulches
- Crop residues
- Manure (multi-species is best)

A diverse crop rotation promotes a more diverse and complete soil food web than a monoculture.

Plant Roots Play a Vital Role in the Soil Food Web

- Root exudates and fine roots feed soil micro-organisms.
- Each plant species “invites” a favored rhizosphere community.
- Many plants host symbiotic mycorrhizal fungi in/on their roots.



Four Principles of Soil Health

- Keep soil covered as much of year as possible.
- Maximize living roots in the soil profile.
- Minimize soil disturbance.
- Energize the soil system with biodiversity.
 - Multi-species cover crops - 5 or more species from 3 or more plant families

Based on the work of the NRCS Soil Health Team in Greensboro, NC – David Lamm, Ray Archuleta, Steve Woodruff, and Terry Briscoe

Four Requirements to have a Thriving Soil Food Web

- Conservation – *keep the soil in the field!*
- Soil life – *the “livestock” on every farm, ~ 1 ton/ac, high functional diversity*
- Food – *living plant cover with roots throughout soil profile; organic inputs,*
- Habitat – *micropores and macropores*
 - Stable organic matter (humus)
 - Good soil structure (tilth)

Cover Crops: the Cornerstone of Sustainable Annual Crop Production

Cover Crops protect, maintain, and improve soil by :

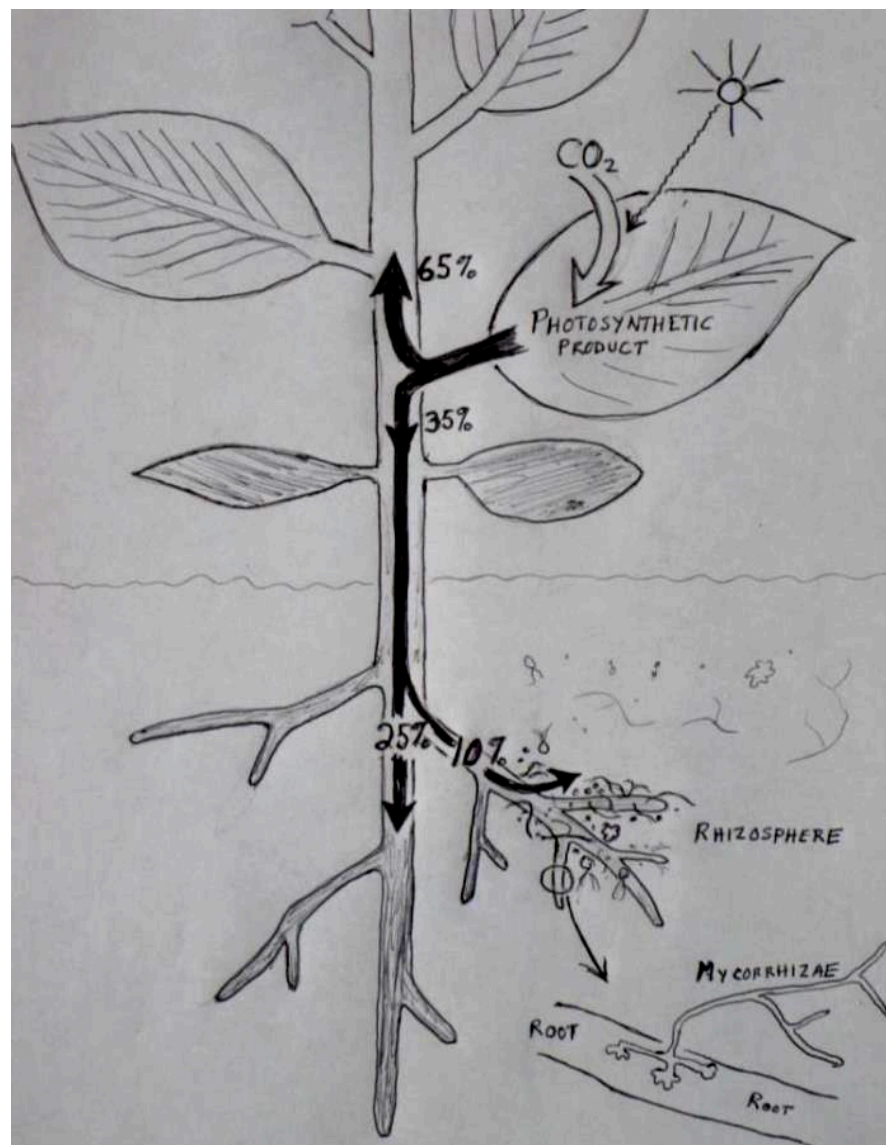
- Preventing erosion, compaction, crusting
- Adding organic matter
- Feeding the soil life
- Diverse (multi-species) cover crops enhance soil biodiversity and health



Triticale + Field Pea

What a living cover crop does for your soil

- All plants “donate” 10-15% of their photosynthetic product to the soil food web.
- High biomass cover crops generate lots of root exudates
- When soil is left bare, the soil life goes hungry.



Bare soil is hungry and is an open invitation to weeds. Plant cover crops to fill niches:

- After vegetable or other annual crop is harvested
- Over winter and before spring/summer planting
- Other breaks in rotation, e.g., hottest months
- Between wide-spaced rows until crop is established



*If you aren't sowing a cash crop, plant a cover crop now (left)
Consider cover crop between wide rows of squash (right)*

Cover Crops: the Cornerstone of Sustainable Annual Crop Production

Cover crops provide and manage nutrients by:

- Fixing N (legumes)
- Scavenging surplus N
- Making scarce P and K more available
- Not aggravating P or K excesses



Crimson Clover

Cover Crops: the Cornerstone of Sustainable Annual Crop Production

Cover crops reduce pest problems by:

- Suppressing weeds
- Breaking pest and disease life cycles
- Providing habitat for beneficial organisms



Buckwheat

Tools to Meet the Four Requirements for a Thriving Soil Food Web

- Conservation – *cover crops*. Reduce tillage. Diversify crop rotation. Put sloping land in perennials – pasture, orchard, etc.
- Soil life – *finished compost*, worm castings, compost tea, commercial soil inoculants.
- Food – *cover crops*, manure, crop residues, compost tea additives (molasses, seaweed extract, some commercial products).
- Habitat – *cover crops* (roots improve tilth), stable-carbon soil conditioners including biochar, humates *finished compost*.

WEEDS !

(Grumble, grumble, grumble ...)

The Weed Paradox

Weeds are the most costly category of pests in crop production.

Most cropland farmers consider weeds a top research priority.

Yet ...

The onions are a complete loss, but the soil is protected.



The Weed Paradox

If it weren't for weeds, the world might have already run out of fertile topsoil. *Why?*

There are no weeds here, but the soil has suffered a catastrophe.



An Ecological Understanding of Weeds

Weeds are pioneer plants whose ecological role is to occupy, protect, and restore soil exposed by disturbance.

They are adapted to emerge and grow rapidly in these open niches.

In other words, **weeds are doing an important job.**



Common dayflower covered this road cut, thus curbing soil erosion and allowing perennial shrubs and young trees to become established within a few years after this photo was taken.

How Humans Make Plants into **Weeds**

- Decide what plants are “unwanted.” (*Common lambs quarters was valued by early European settlers as a spring green eaten to prevent scurvy. Bermuda grass is still widely used as a forage*)
- Hold succession back at early stages to produce desired crops (*tillage for annual crops*).
- Create open niches (*bare soil, wide rows with nothing between*).
- Introduce exotic plants into the region. (*Examples: nutsedges, Bermuda grass, kudzu, cogon grass, Benghal dayflower, garlic mustard*)

How Cover Crops Suppress Weeds

A growing cover crop can suppress weeds by:

- Competing for light, space, water, nutrients.
- Allelopathy – releasing plant growth inhibitors.
- Altering the light environment to make weed seeds dormant.
- Altering the soil microbial community to put some weeds at a disadvantage. (*Many weeds dislike mycorrhizal fungi.*)



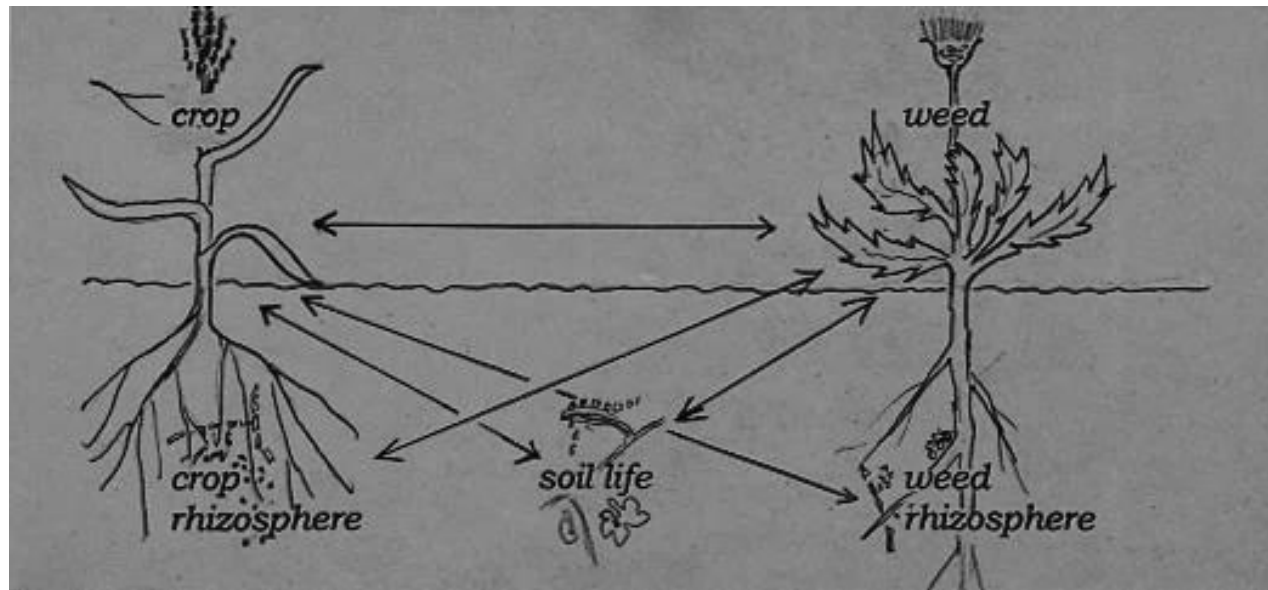
Winter rye + hairy vetch, a tried-and-true cover crop combination.

How Cover Crop Residues Suppress Weeds

After termination, cover crops can suppress weeds by:

- Physically hindering emergence of weed seedlings (if residues left on surface, e.g. roll-crimped)
- Allelopathy – products of decomposition are different from, and may be more potent than, root exudates from living cover crops.
- Supporting microbes that are pathogenic to weed seedlings.
- Tying up soluble soil N (high C residues) – a challenge and opportunity.

Allelopathy and plant-soil-microbe interactions



Every plant species gives off certain substances and fosters a particular soil microbial community, thereby affecting other plants. Learning how to utilize these complex chemical and biological interactions in designing crop rotations and selecting cover crops is a “cutting edge” in sustainable ag research.

A few warm season cover crops

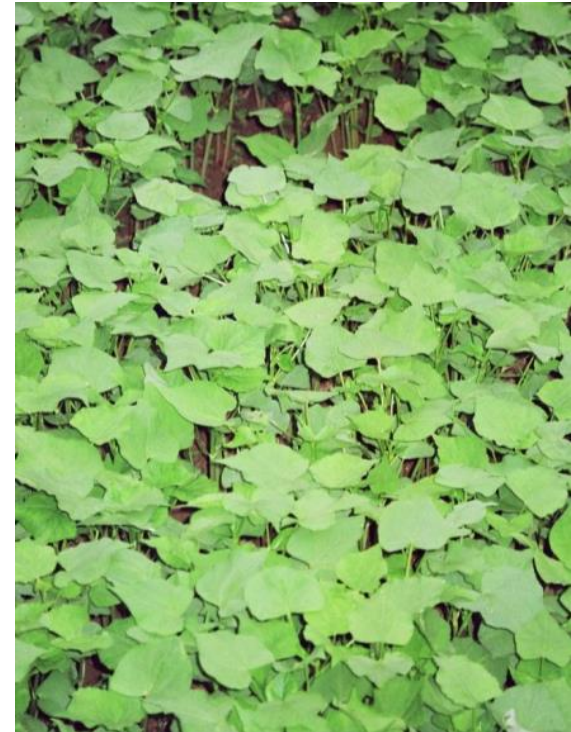
Buckwheat (*Fagopyrum esculentum*)

Strengths:

- Covers ground rapidly, shades out emerging weeds, some allelopathy
- Mobilizes soil phosphorus
- Excellent beneficial insect habitat
- Good for short (30-50 d) fallow

Weaknesses:

- Low biomass, small root mass
- Can self-seed, become weed
- Limited drought & heat tolerance



The buckwheat has nearly covered the ground by 14 DAP.

Cowpea (*Vigna unguiculata*)

Strengths:

- Good biomass, strong N fixer
- Rapidly covers ground, strong weed competitor
- Tolerates part shade – good companion with tall grasses
- Heat and drought tolerant
- Moderately deep taproot

Weaknesses:

- Requires warm soil to emerge
- Residues decompose quickly – less weed suppressive after termination



Cowpea forms a dense canopy that can smother weeds.

Forage Soybean (*Glycine max*)

Strengths:

- Covers ground fairly rapidly
- Late maturing forage types can yield high biomass and N
- Fairly weed-competitive

Weaknesses:

- Limited drought tolerance
- Early maturing varieties make little biomass
- Prone to some pests & diseases
- Non-GMO high biomass forage varieties may not be available.



'Tyrone' forage soybean forms high biomass and N

Sunnhemp (*Crotolaria juncea*)



*Sunnhemp growing
with pearl millet*

Strengths:

- Tall, high biomass, moderate N
- Extremely tolerant to drought, heat, and low soil fertility
- Tough, persistent residues
- Suppresses some pest nematodes

Weaknesses:

- Seeds are expensive and may be hard to find.
- May be so tough that it is hard to manage.

Sorghum-sudangrass

(Sorghum bicolor X sudanense)

Strengths:

- High biomass (4 – 6 tons/ac)
- Deep, fibrous root system, breaks hardpan
- Suppresses weeds through competition and allelopathy
- Heat and drought tolerant

Weaknesses:

- Requires high soil fertility, can tie up N
- Hard to kill by mowing or roll-crimping



*Sorghum-sudan
(with lablab bean)
has reached 9 ft.*

Pearl Millet (*Pennisetum glaucum*)



Benefits:

- High biomass, 4 – 5 tons/ac
- Deep, fibrous root system
- Covers ground faster than other millets.
- Tolerates lower soil fertility than sorghum-sudan, less apt to tie up N
- Easy to roll-crimp after heading

Weaknesses:

- Requires warm soil to germinate and establish quickly

Foxtail Millet (*Setaria italica*)

Strengths:

- Good biomass, 3 – 4 tons/ac in 60-70 days after planting
- Good weed suppression
- Easy to roll-crimp, forms fine mulch.

Weaknesses:

- Much shorter and lower biomass if planted after summer solstice



Foxtail millet or German millet, heading at about 60 days after planting

A few cool season cover crops

Winter Rye (*Secale cereale*)

Strengths:

- High biomass (3 – 4 t/ac)
- Scavenges soil N effectively
- Fibrous roots improve tilth
- Strong weed suppression by competition and allelopathy
- Extremely frost hardy (0 to -40°F)

Weaknesses:

- Can tie up N or suppress crops through allelopathy
- Can grow back or self seed to become weed in cool weather



Spring Oats (*Avena sativa*)

Strengths:

- Good biomass, prevents erosion
- Fibrous root system improves tilth
- Fairly strong weed competitor
- Moderate C:N, does not tie up N
- Versatile: plant fall through early spring, tolerates 15-20°F

Weaknesses:

- Not drought tolerant



Spring oats, sown in late August, forms thick cover by October.

Hairy Vetch (*Vicia villosa*)

Strengths:

- Strong N fixer, good companion for rye or wheat
- Beneficial habitat
- Helps suppress weeds by shading ground & reducing weed seed germination

Weaknesses:

- Succulent, N-rich residues break down quickly, feed weeds
- Can become weed by self seeding or if hard seed planted



Crimson Clover (*Trifolium incarnatum*)



Crimson clover in full bloom

Strengths:

- Fairly good biomass and N fixation, balanced C:N
- Beneficial insect habitat
- Moderate weed suppression
- Fairly strong, deep taproot

Weaknesses:

- Matures earlier than most rye varieties, can self seed and become weed.

Austrian Winter Pea (*Pisum sativum*)

Strengths:

- Strong N fixer
- Good ground coverage, biomass
- Beneficial habitat
- Versatile – plant late summer, fall, or spring
- Excellent marketable pea tips

Weaknesses:

- Limited weed suppression if planted alone.
- Fairly small root biomass.



*Austrian winter pea
with triticale formed
5 tons/acre biomass*

Forage and Tillage Radishes (*Raphanus sativus*)

Strengths:

- Very strong N scavenger (better than rye, and does not tie up N)
- Deep heavy taproot, breaks hardpan
- Covers and shades ground quickly
- Strong, lasting weed suppression

Weaknesses:

- Residues decay quickly, leaving soil surface exposed
- Should not be followed by brassica vegetables.



Tillage radish is a strain of daikon bred for cover cropping. It also has good eating quality.

If radish kills weeds this dead, what will it do to spring vegetables?



*Winterkilled radish leaves little residue but shows no weeds in March (left). Pearl millet + sunnhemp leave heavy residues yet allow weed growth (right). Experiment at Virginia Tech (Appalachian region).
→ Is this allelopathy? Will it harm crops?*

Radish Cover Crop for Selective Weed Control and Enhanced Spinach?



Spinach sown March 31, 2006 after winterkilled radish (left) and pearl millet + sunnhemp (right), photographed May 12. Fall radish reduced winter weeds and soilborne damping-off fungi. Research at University of Maryland showed that radish weed suppression is based on shading and light quality impacts, not allelopathy.

Multispecies cover crops for multiple, complementary benefits



Buckwheat, cowpea, pearl millet, and sorghum-sudan sown July, photo Sept (above); oats, barley, mustard, and Austrian pea sown March, photo June (right)



Green Manure versus No-Till?

Tilling a cover crop stimulates microbial activity and can:

- Release nutrients
- Develop active organic matter
- Promote crumb structure
- Release nutrients faster

However tillage can also:

- Disrupt existing soil structure
- Promote erosion
- Stimulate weed emergence



Plowing down a vetch cover crop: will it kill weed seedlings by allelopathy, or just feed them with nitrogen?

Managing High-Biomass Cover Crops at the Garden Scale



Pearl millet + sunnhemp: 7 feet, 4 tons/ac in 65 days.

Mow, scythe, or weed-whack top growth.

Using clippings as mulch or to make compost.

Till stubble as needed to prepare ground for next crop.

No-till Cover Crop Management Without Herbicides



Rolling can be done with a specially designed roller-crimper (left), or with a flail mower with the PTO off (right).

Minimum or No Tillage Without Herbicides

Reduce tillage when practical:

- No-till into rolled-down cover crops
- Strip-till – part residue, till narrow strip.
- Mulch tillage
- Ridge tillage



Demonstration of no-till vegetable transplanter in roll-crimped cereal grain cover crop at North Carolina Agriculture & Technology State U.

Organic No-Till – Will it Work?



NO! Purple nutsedge, Bermuda grass, and other invasive perennials will penetrate a rolled cover crop overnight.



YES! Organic summer squash planted no-till into rolled rye +vetch at Virginia Tech yields 15 tons/ac. Weeds were mostly summer annuals.

Challenging Soils, Tough Weeds

- Sandy soils do not hold organic matter and nutrients as effectively as heavier (loam, clay) soils.
- Warm climates accelerate organic matter (OM) breakdown
- Weeds like nutsedge and bermudagrass require repeated tillage to manage effectively.
- Tillage burns up soil organic matter, breaks up crumb structure, damages parts of soil food web.
Heavy tillage degrades soil health.



Yellow nutsedge

The Organic Farmer's Dilemma:



“How can I manage weeds adequately without tilling my soil to death?”

What do we have at this farm?

- Bermuda grass sod to begin with; yellow nutsedge in weed “seed” bank.
- Fuquay loamy sand – this particular soil has an unusually deep sandy layer before reaching the more clayey “B” horizon, which holds moisture and nutrient reserves.
- Very warm rainy climate.

Improving soil quality, developing a healthy, living soil

- An integrated approach,
 - Combining strategic or targeted tillage with high biomass cover cropping, might give better results than either one alone, since strategic tillage works against the perennial weeds, while cover crops smother annual weeds that emerge and grow in response to tillage.

Building microbial soil life

- Attending to three components – food (cover crops, etc), organisms (inoculants), and habitat (stable organic matter, biochar, humates, etc)
 - May have a synergistic effect, yielding more benefit than the sum of the effects of each one alone.

Lola's Organic Farm

SSARE Project-sharing our results

We participated and have provided our SSARE Project results during organic and sustainable ag conferences, interview with NSAC- national impact, and with local farmers and consumers during:

- (2014) Georgia Organics Conference, Jekyll Island, GA.
- (2014) SE GA Growing Local & Sustainable Conference
Tattnall County High School, Reidsville, Georgia
- We continually discuss project benefits with farmers and farming communities; during our learning FIELD DAYS:
 - Lola's Organic Farm hands-on Field Day (June 2014),
 - SSARE hands-on field day (June 2015), and etc.
- (2015) National Sustainable Agriculture Coalition (NSAC) blog interview
http://sustainableagriculture.net/blog/sare_feature_2/
- (2016) Lola's Organic Farm has been asked to participate and report project results/learning during the upcoming 2016 SSAWG Conference, Lexington, KY.

Lola's Organic Farm

SSARE Organic Field Day

What the producers learned

As we examined the on-going SSARE project:

- We, small sustainable ag organic producers, learned that there may be a need to integrate both a strong/intensive biological method with light tillage and manual weeding for best effectiveness in controlling serious invasive Bermuda grass weeds.
- Do not let the invasive weeds grow back. Each year the sustainable ag farmer needs to extend the cover cropping area around the cash crops to manage invasive weed growth successfully.
- Consider growing intensive cover crops as cash crops for the added benefit of also improving soil function and reducing weed pressure, etc.
- Another serious sustainable ag organic management examination must be made to help sustainable conventional and organic farmers increase important microbial activity, food web activity, build healthy soil, healthy crops, etc. while controlling soil erosion and invasive weed pressure.

Thank you.

Lola's Organic Farm and our Cooperators

Contact us at:

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