Fitting Cover Crops into Mixed Vegetable Operations

Focus on green manure crop management practices

--Eero Ruuttila--

Organic matter and its influence on soil biology

The crops you grow, the roots they have, their yield, the portion of crop harvested, and how you treat crop residues will affect organic matter. Soil fertility itself will influence the amount of organic residues returned, since more fertile soils grow higher yielding crops i.e. they yield more residues.

The more residues your crops leave in your field, the greater the populations of soil organisms. Conventional tillage systems are aggressive and will decrease earthworm and other soil organisms. When rotations include green manure cover crops you increase soil biological diversity.

Cover Crop // Catch Crop // Green Manure

- *Cover crops* are grown for the purpose of protecting the soil during the time of year soils would otherwise be bare.
- A *catch crop* is grown to retrieve available nutrients still in the soil following a cash crop. It keeps these nutrients from being leached during winter.
- A crop grown to maintain or build soil organic matter and to add nitrogen (N) to the soil is called a *green manure* or a green manure cover crop.

Maintaining a diverse environment

- Where many organisms coexist in the same area, there are fewer disease, insect, weed, and nematode problems. Diversity below the soil surface is as important as above ground.
- Growing cover crops and using crop rotations help maintain diversity below ground. Manures, compost, and making sure crop residues are returned to the soil are also important to promoting soil organism diversity.
- Soil organic matter hosts a universe of soil microorganisms including bacteria, fungi, algae, protozoa, nematodes and earthworms.

The special relationship of legumes to atmospheric nitrogen

- Nitrogen-fixing bacteria form symbiotic or mutually beneficial relationships with plants. Rhizobia bacteria live on nodules formed on the roots of legumes.
- Rhizobia bacteria can “fix” hundreds of pounds of available nitrogen from the atmosphere/acre/year.
- Available fixed nitrogen varies among legume species. Some vetches and alfalfa can fix as many as a couple of hundred pounds of nitrogen/acre whereas some beans and peas will only fix 40-50 pounds of nitrogen a year.

Nodules on the roots of a bell bean

DYNAMICS OF GRAIN/LEGUME COMBINATION

- Most grain crops will scavenge residual N in the root zone area & hold it over winter; legumes will fix N on legume plant root nodules. As grains shut off easily available N to legumes, the legume plant will work harder to fix additional N.
- If brought to full maturity, there will be a favorable C:N ratio for plant residue mineralization

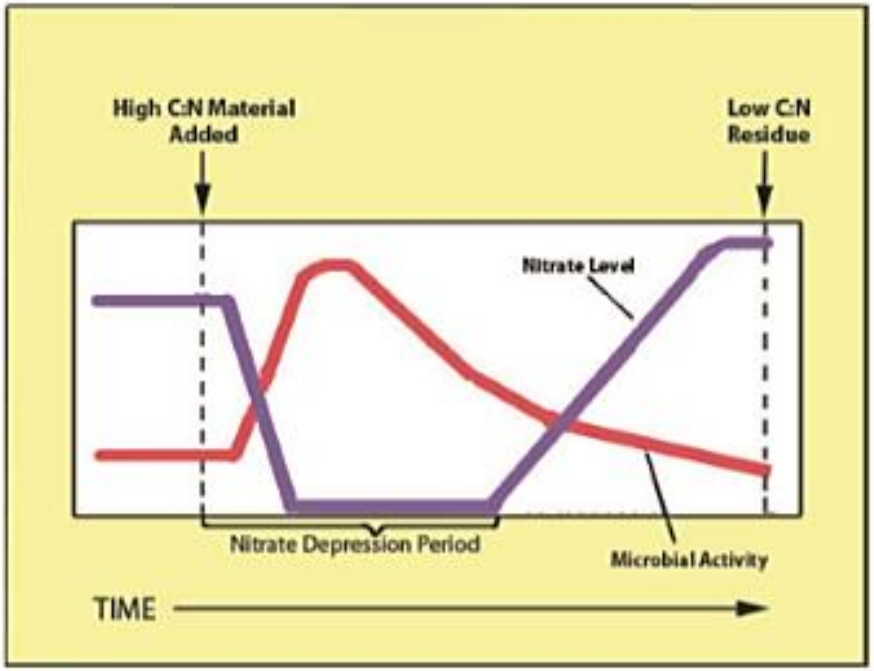


FIGURE 16
When fresh residues are added to the soil there is a rapid increase in microbial activity. If the residues have a high carbon to nitrogen ration (C:N), the microbes will take N from the soil, likely causing a deficiency. After the residues are decomposed, many of the microbes die and N is released from their bodies. This restores N to a level that is somewhat higher than it was originally, but crops could have suffered for a period.

Table 3. Typical carbon-to-nitrogen ratios of common materials.

Material	C:N
Legume hay	15-19:1
Non-legume hay	24-41:1
Corn stalks	42:1
Oat straw	70:1
Rye straw	82:1
Cow manure	8:1
Finished compost	17-20:1
Agricultural soils	10-12:1
Hardwood sawdust	500:1

Note: Straw, hay and corn stalks will have a lower C:N when green than when brown.

POSITIVE BENEFITS FROM GREEN MANURES

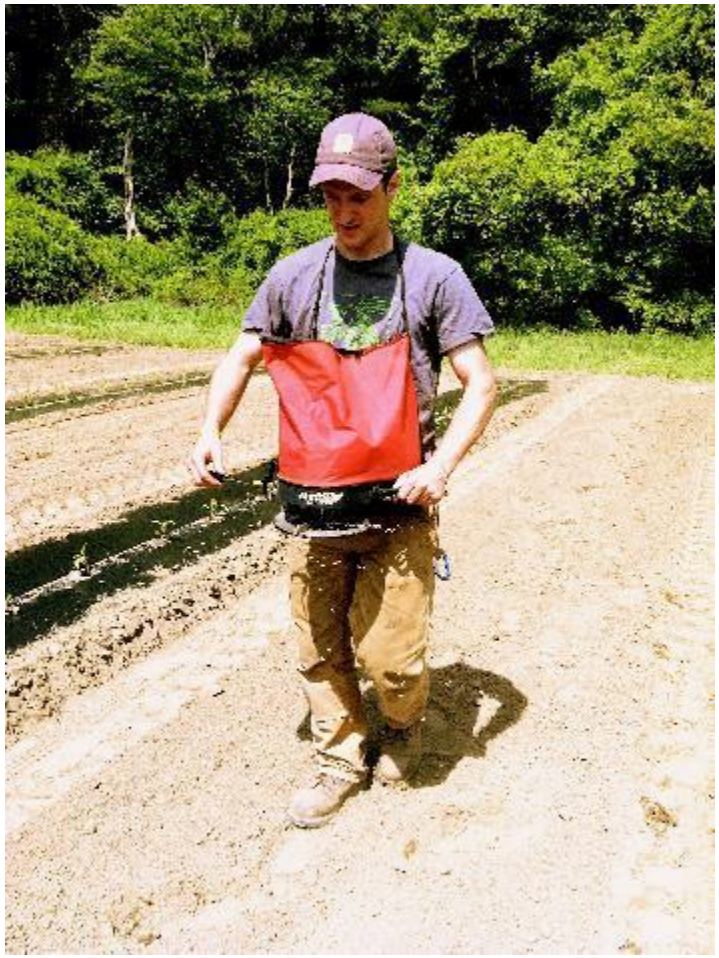
- Allelopathic effects on the weed seed bank
- Interruption of pest & disease cycles
- Elevated microbial activity in soils
- Positive effect on soil moisture conservation
- Legume family plants can fix anywhere between 50-300 lbs of N/acre
- Highly attractive to beneficial & pollinating insects

Establishing living mulch strips of medium red clover in harvest aisles of trellised tomatoes

Laying of plastic mulch on 12-foot centers

Tomatoes set into plastic mulch with transplanter

Oats spun into wide aisles between tomatoes



Covering broadcast oats with cultivating baskets & Lely tines

Medium red clover seed; inoculate with proper inoculant to insure vigorous growth of root nodules

Cultipacking broadcast clover & oats

Field view of tomato block with recently seeded living mulch strips

Established tomato transplants with living mulch aisles

Well established red clover perma-strips between rows of tomatoes (late August)

Biotello plastic mulch & tomato residue shallow- disced; winter rye seeded onto bare soil.

Full season fallow of cereal grain + legume:
field peas & oats

Field pea seed (Johnny's Maxum) + inocculant

Broadcast field pea & oat seed early spring

Pea shoots or tendrils can be harvested as soon as the stems “snap” when hand picked

Pea shoots can be continuously harvested as long as they remain tender & do not “tug” when handpicked

Field peas blossoms (late May/early June) can be sold as edible flowers

Individual pea tendril, sometimes called pea shoots in Asian stores

Once oat & field pea seed matures, mow, then incorporate into the soil. (Photo of spader tilling pea/oats residue)

Spader shovels do not pulverize soils like other more aggressive tillage implements.

Field pea & oats seed- crop residue following single spader pass.

New flush of field pea shoots & oats following tillage (late August)

Overhead irrigation is essential to establish a 2nd flush of pea shoots if mid-summer conditions dry.

A good 2nd stand of field pea/oats twice irrigated due to 2016 abnormally dry summer.

Marketable September field pea shoots from seed matured off spring-sown field pea/oats.

Mow oats before seed matures in the fall to insure no oat-seed volunteers the following spring.

Winter-killed pea/oat stubble can be easily incorporated the following spring, with light tillage to soil prep direct-seeded cash vegetable crops.

Direct seeded spring greens fertilized by N from field pea/oat fallow previous year.

Multiple cover crop uses of winter rye (& hairy vetch)

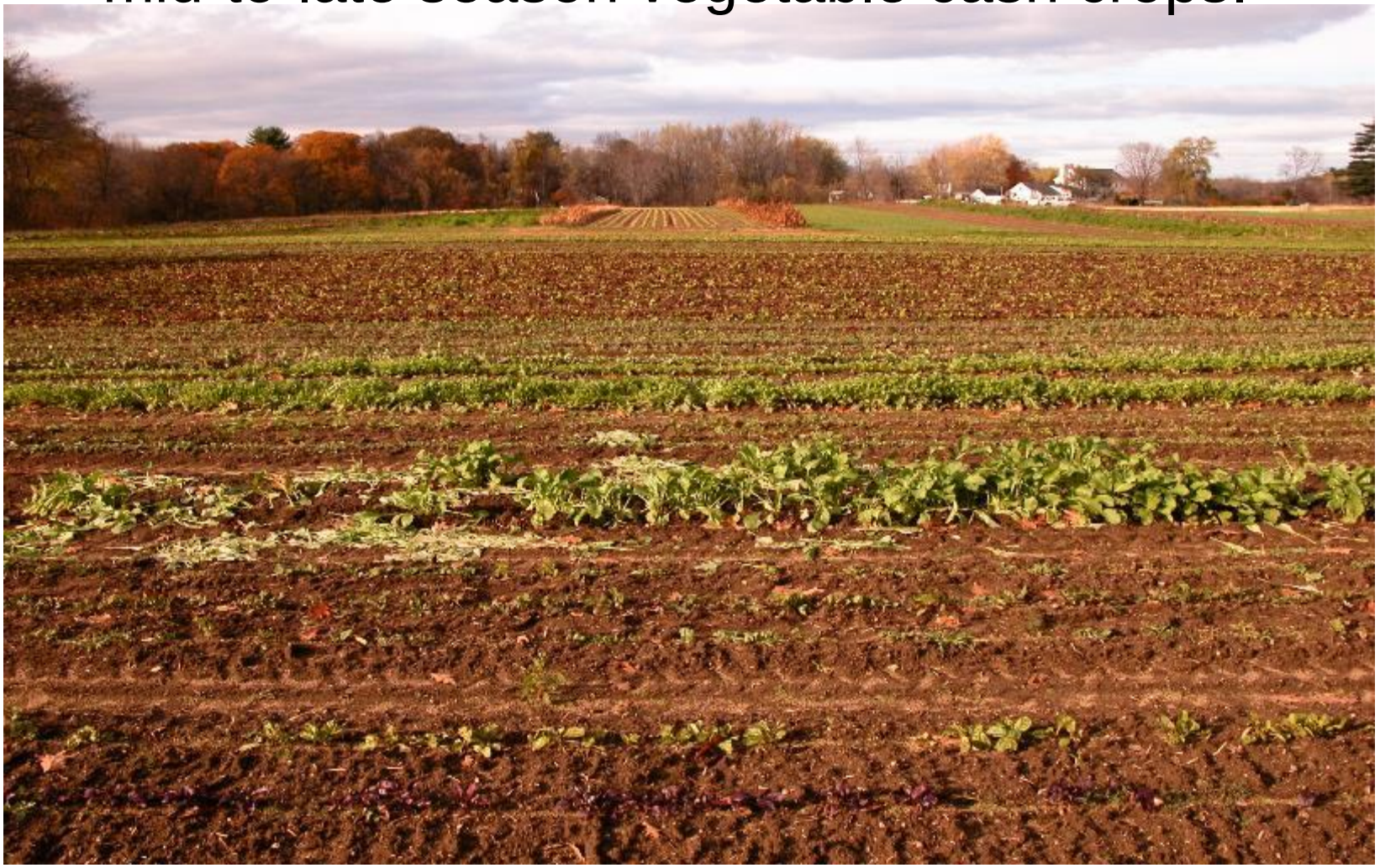
- Winter rye/hairy vetch utilized as a overwintering green manure cover crop to fertilize next summer cash crops.
- Broadcast winter rye cover in fall brassicas
- Early season winter rye to suppress spring weeds & to capture and release residue N
- Overwintered rye to provide straw mulch

Late August – early September sowing of hairy vetch with winter rye.

Overwintered rye killed by mowing at pollen stage, late May. Incorporated crop residue will mineralize to feed summer cash crops.

Winter rye at pollen stage

Late May-June incorporation of mature rye/vetch cover crops will support nutrient needs for most mid-to-late season vegetable cash crops.



Late August transplanted broccoli, under sown with winter rye mid-September

Late-September broccoli with emerging winter rye cover crop in gaps between plants

Post-harvest December broccoli plants before mowing under; winter rye cover crop well established after September broadcast of rye seed.

Quickly established early cover crop of rye (April 1st) to benefit winter squash transplants (tillage May 22nd); rye scavenges residual N + suppresses spring weeds

Field ready for winter squash transplants following minimal tillage (June 7th)

A combine cuts down on cover crop seed purchase costs

Cutting strips in overwintered rye/hairy vetch to reduce field tillage & to provide straw mulch for direct seeded winter squash

Mow strips of hairy vetch & winter rye when rye is at pollen stage & vetch flowering. Winter squash plants absorb heat in adjacent bed of bare soil.

Tractor cultivation of winter squash can both precede as well as follow rye/vetch mowing.

Establishing living mulch strips of medium red clover in winter squash.

Medium red clover seed broadcast & cultipacked when pumpkin tendrils begin to vine across field.

The clover germinates then goes dormant under the winter squash leaf canopy.

After the winter squash is harvested mow plant residue immediately in order to bring light to the clover.

The clover will migrate into all areas of the field, stimulated by light, cooler fall temperatures, & rainfall.

Migration of clover will close bare soil gaps in field with no tillage following winter squash harvest

Overwintered medium red clover in winter squash field, early June, 2nd year.

Overwintered medium red clover utilized as living mulch strips for tomatoes transplanted into bare soil (year 2).

2016 living mulch strips at Johnny's Albion Research Farm utilizing plastic mulch and/or straw mulch

Field tilled with beds prepped to establish medium red clover living mulch strips

Following the broadcast and germination of medium red clover/oats, plastic mulch is laid and crops are transplanted into alternating beds.

September, mature eggplant in plastic mulch between living mulch strips

Early October, eggplant crop mowed & plastic mulch removed, red clover migrates into former eggplant area

Establishing living mulch strips with tomatoes mulched w/straw (note cultipacker imprint for broadcast medium red clover)

Strips cut for tomato beds between new stand of red clover/oats; round bales of winter rye straw ready to mulch tomato transplants

Tomatoes transplanted into bare soil, between strips of clover and oats

Tomato transplants mulched with rye straw after tomatoes recover from transplant shock & soils are warm

Living mulch strips of clover/oats alternate with tomato plants mulched with rye straw

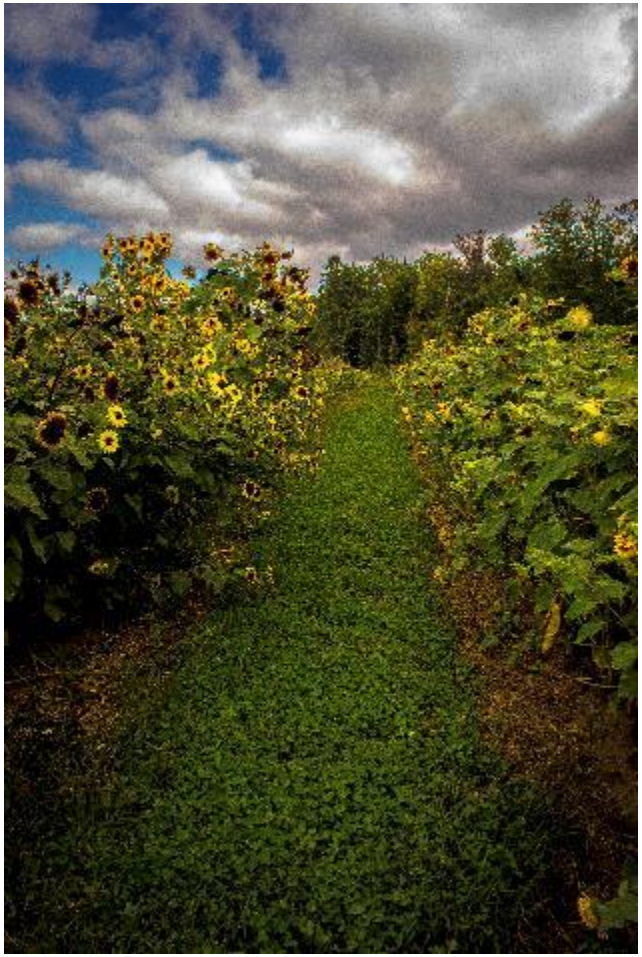
Living mulch strips managed by mowing (no cultivation or bare soil); tomatoes trellised in basket weave system

Rotary mower able to manage weeds very close to tomatoes

Tomatoes and stakes removed mid-October, red clover will migrate into straw mulch as it biodegrades

Living mulch system appropriate to other wide-spaced cash crops

Medium red clover serves as living mulch harvest aisles for cut flowers



Mowing of medium red clover will contribute to depleting field weed seed bank while also stimulating clover growth. (Utilizing cover crops to manage weeds)

Hairy galinsoga flowers bloom above medium red clover. Emerging galinsoga killed by mowing.

Hairy galinsoga unable to compete with medium red clover if persistently mowed.

Cutting strips into overwintered rye/vetch to inhibit 1st generation of Colorado potato beetles seeking young potato leaves

Colorado potato beetles are unable to find potato plants when hidden in a field of mown straw mulch.

Unsprayed new potatoes in field of overwintered rye-vetch, protected by a mown living straw mulch.

Sudan grass

for building soil organic matter &

for suppressing annual summer weeds:

Sudan grass seed

Broadcast sudangrass when soils warm, early summer. Seed thick to diminish potential for weeds in cover crop.

Mowing stimulates root mass & keeps Sudan grass residue manageable for following cash crops.

Under sowing medium red clover prior to last mowing of Sudan grass will bring a legume into fallow field.

November, excellent stand of medium red clover from over-sown August clover; frost killed Sudan grass stubble also shown without the clover.

Buckwheat, fast growing
mid-summer smother crop &
attractant to bees & other beneficial insects

Buckwheat strip planted in Brussels sprouts field

Flowering buckwheat serves as beneficial insectary strip in Brussels sprouts

Table 3. Top Cover Crop and Legume Species for Bees on CT Vegetable Farms.

Several of these plants are considered weeds in some situations, and crown vetch is listed as an invasive plant in many states.

The plant family Fabaceae used to be called Leguminoseae.

Listed in order from highest to lowest number of bees per minute of observation. Plants blooming longer may be visited by more total bees than those with high bees per minute but a short period of bloom.

Common Name	Scientific name	Primary bee category	U.S. Native or Intro-duced	Plant family	Perennial Annual, or Biennial	May	Jun	July	Aug	Sept	Oct
Buckwheat	*Fagopyrum esculentum*	HB	I	Polygonaceae	A		X	X	X	X	
Alfalfa	*Medicago sativa*	BB	I	Fabaceae	P			X			
Crimson Clover	*Trifolium incarnatum*	HB	I	Fabaceae	B	X					
Bird Vetch, Cow Vetch	*Vicia cracca*	BB	I	Fabaceae	B/P		X				
Alsike Clover	*Trifolium hybridum*	BB,HB	I	Fabaceae	P	X	X	X	X		
White Clover	*Trifolium repens*	BB,HB	I	Fabaceae	P	X	X	X	X		
Hairy Vetch	*Vicia villosa*	BB	I	Fabaceae	B/P	X	X				
Crown Vetch	*Securigera varia*	BB	I	Fabaceae	P		X	X			
Red Clover	*Trifolium pratense*	BB	I	Fabaceae	P	X	X	X	X	X	X
Birds Foot Trefoil	*Lotus corniculata*	BB,HB	I	Fabaceae	P	X	X	X	X		

- Others sampled with low bee numbers: cowpea, yellow sweet clover
- HB = honey bee, BB = bumble bee, Other = other species of native bees. "BB,HB" means roughly equal numbers of bumble bees and honey bees.
- A = annual, P = perennial, B = biennial (or winter annual), B/P = perennial but usually grown as biennial (winter annual) cover crop in CT

Smother crop par excellence

Buckwheat is easy to disc and breaks down quickly for crops sown behind it.

Tillage or oilseed radish

- Bioengineering or utilizing cover crops to breakup soil compaction. Compaction often follows utilizing farm equipment in wet soils or overuse of aggressive tillage implements like rototillers.
- Tillage or oilseed radishes are similar to daikon radishes & definitely edible. They provide opportunity for sales as a substitute to daikon.

A successful fall/winter crop requires execution of correct timing & good spacing of seed. A seed drill best implement for planting…

Tillage radishes well established prior to heavy frosts

A nurse crop w/oats or barley OK, however they will require mowing if seed-heads mature.

Really compacted soils will push roots above soil surface.

Roots acquire good size before cooler weather slows growth.

Equipment for cover crops & establishing living mulch strips:

- It’s important to match up implements to a standard bed width
- Commit to establishing good stands of cover crops with even germination of cover crop seed & low weed pressure
- Access to overhead irrigation should be part of a cover crop production plan

Implements and tractor tire widths should be consistent when laying out living mulch systems.

Tandem harrow, excellent secondary tillage implement for spacing living mulch strips

Tandem harrow establishes level seed bed for clover strips or plastic mulch

Spin spreader, good implement for broadcasting thick stands of large-seed cereal grain crops.

Seed drill, good implement to seed large and small seed cover crops simultaneously (2 seed-hoppers)

Grain drill seeded field of barley, Japanese millet, and sweet clover. (Cultipacking field post grain drill will give better germination of multi-species cover crops)

Cultipackers are important implements for aiding in the germination of tiny seed such as clover & alfalfa. They press the seed into the soil instead of burying it providing essential soil-to-seed contact.

Cultipacker with seed hopper

Cultipacker with rollers but no seed hopper

broadcast clover seed without cultipacker (left) & with cultipacker (right); hairy vetch w/cultipacker (bottom)

Cover crop candidates for high tunnels

- Fenugreek
  - rapid growth & short growth cycle from germination to maturity (30-35 days)
  - It's a legume so modest contribution of N
  - Poor weed competitor
- Caliente 199
  - Possible disease suppressive effects
  - Excellent weed suppressive properties
  - Income potential
  - Cut and cut again growth properties

Fenugreek in blossom

Fenugreek matures to seed in 35 days

Fenugreek greens are a valuable cash crop in East Indian cuisine.

Biofumigant mustards can be broadcast thick. They effectively out-compete high tunnel weeds.

Biofumigant mustards can be held for short or long intervals in high tunnels by cut & come again mowing.

The End

Resources:

- “Farmers and their Innovative Cover Cropping Techniques.”

  70-minute educational video on cover crop systems developed by vegetable growers in the Northeast, featuring 10 farms in 6 Northeastern states. Produced by: Vern Grubinger, University of Vermont Extension. With funding from: Northeast Sustainable Agriculture Research and Education (SARE), USDA. Available for purchase for $15 postpaid from the UVM Center for Sustainable Agriculture, 63 Carrigan Dr., Burlington VT 05405.

  Sample view:

  https://www.youtube.com/watch?v=Lt8f2FWTr8Y

- *Northeast Cover Crop Handbook*, Marianne Sarrantonio, Rodale Institute Soil Health Series.

- *Building Soils for Better Crops*, 2nd Edition, Fred Magdoff & Harold Van Es, Sustainable Agricultural Network.

- *Weeds of the Northeast*, Richard Uva, Joseph Neal, Joseph DiTomaso, Cornell University Press.

- Cornell Cover Crop Guide & Fact Sheet Series, Thomas Björkman, editor, www.covercrop.net.

- Certified organic & untreated Cover Crop seed:
  Johnny's Selected Seeds. Johnnyseeds.com.
  Welters Seed & Honey Co. www.welterseed.com.

- *Crop Management in the Field*, John Howell, UMass Nutrient Management Guide for New England Vegetable Production. https://ag.umass.edu/sites/ag.umass.edu/files/pdf-doc-ppt/nutrient_guide.pdf