

Fitting Cover Crops into Mixed Vegetable Operations

**Focus on green manure
crop management practices**

--Eero Ruuttila--

eruuttila@johnnyseeds.com

February 2, 1968

In the dark of the moon, in flying snow, in the
dead of winter,
war spreading, families dying, the world in
danger,
I walk the rocky hillside, sowing clover.

-- Wendell Berry --

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.

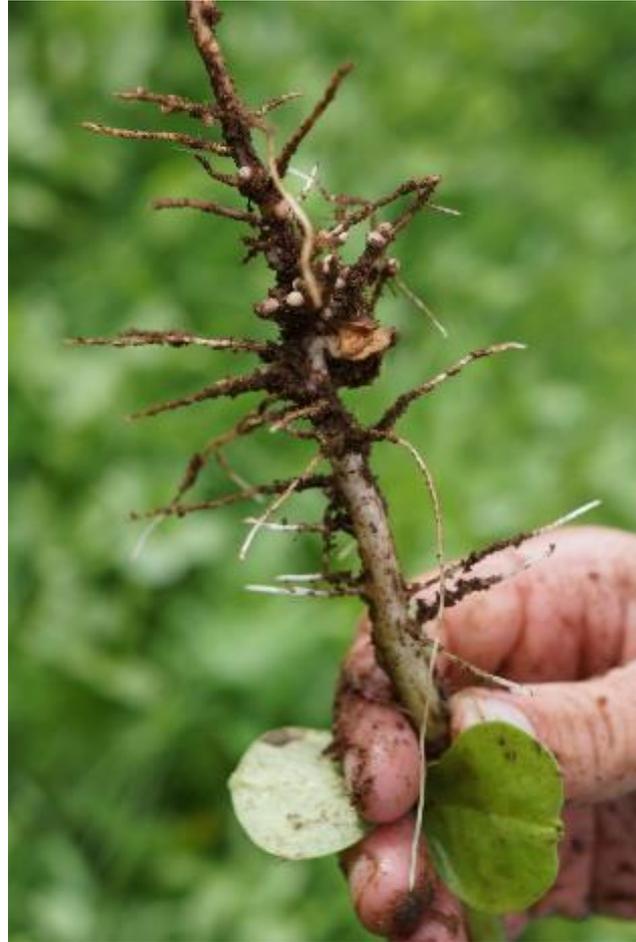
Maintaining a diverse environment

- 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 pairing cereal grains/legumes

- 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

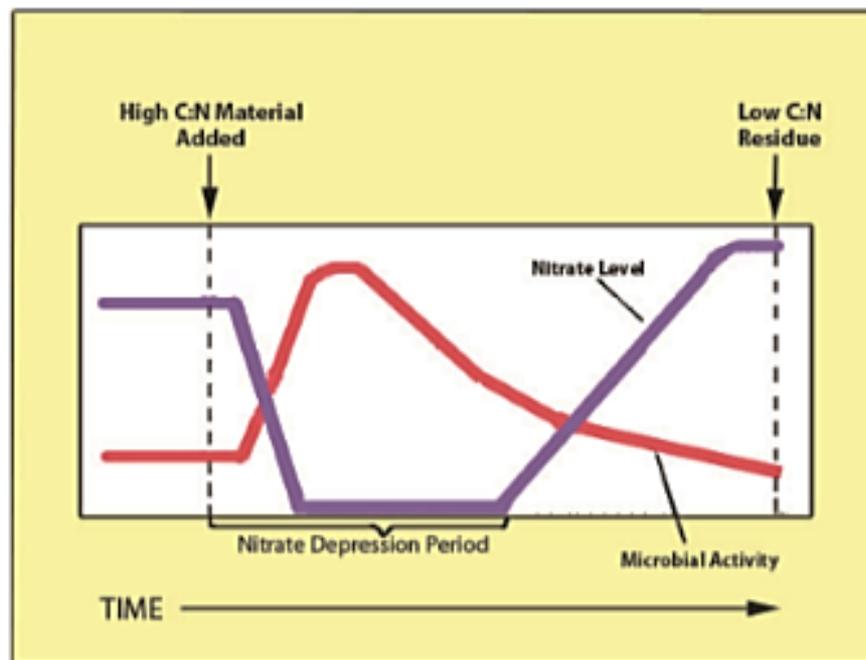


FIGURE 16

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 ratio (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**

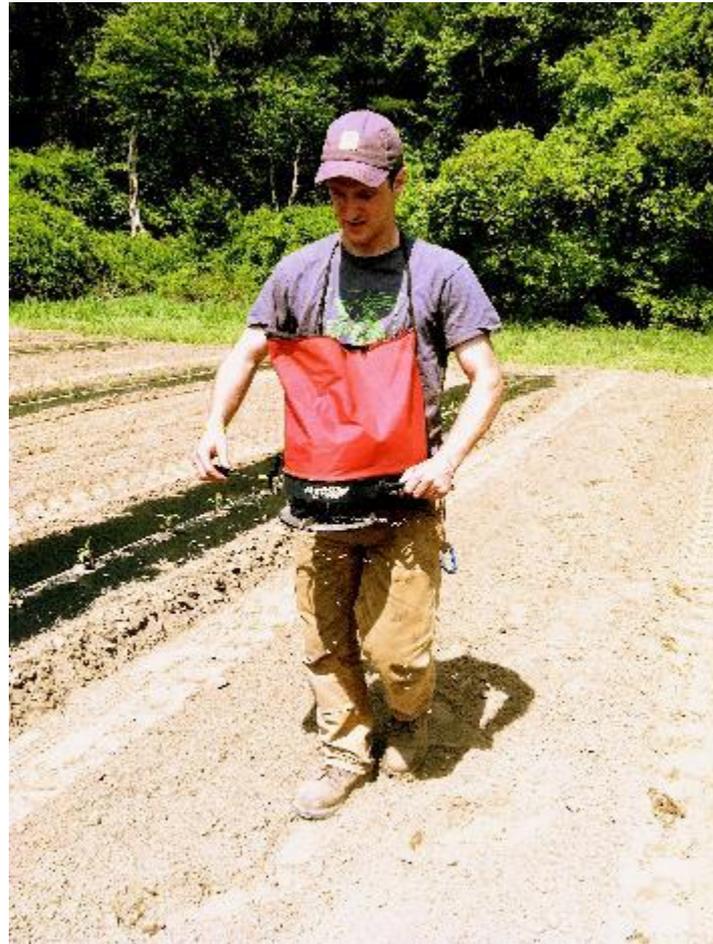
Laying of plastic mulch on 12-foot centers



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
(12-18lbs clover : 60lbs oats/A)



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-disc'd; winter rye seeded onto bare soil.



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

Field pea seed (Johnny's Maxum) + inoculant
(150 lbs peas: 60lbs oats/A)



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 picked



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 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 for direct-seeded vegetable crops.



Direct seeded spring greens fertilized 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 following 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.
(25-30 lbs vetch : 60 lbs 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



November broccoli, postharvest, before mowing;
rye cover crop well established after September
broadcast of rye seed.



Quick early cover crop of winter rye (April 1st)
set up for June winter squash transplants;
rye will scavenge residual N + suppress 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.



Utilizing cover crops to influence insect pest pressure

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.



Sudangrass

**for building soil organic matter &
for suppressing annual summer
weeds**

Sudangrass seed (45-60 lbs/A)



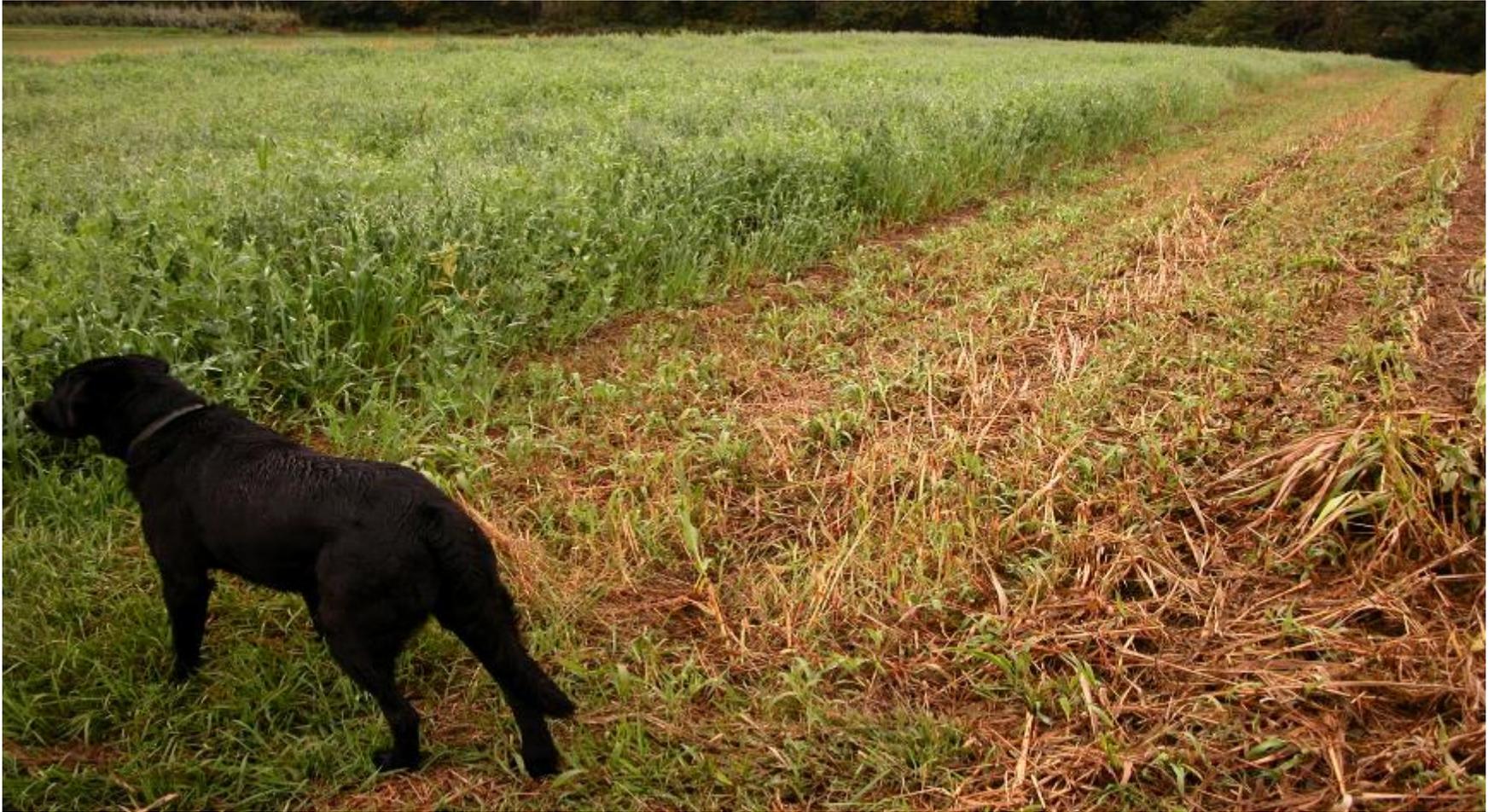
Broadcast Sudangrass when soils warm, early summer. Sow seed thick to diminish potential for weeds in cover crop.



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



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



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



Buckwheat

**fast growing mid-summer smother
crop;**

**attractant to bees & other beneficial
insects**

(80-125 lbs/A)

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 Leguminosae.

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.

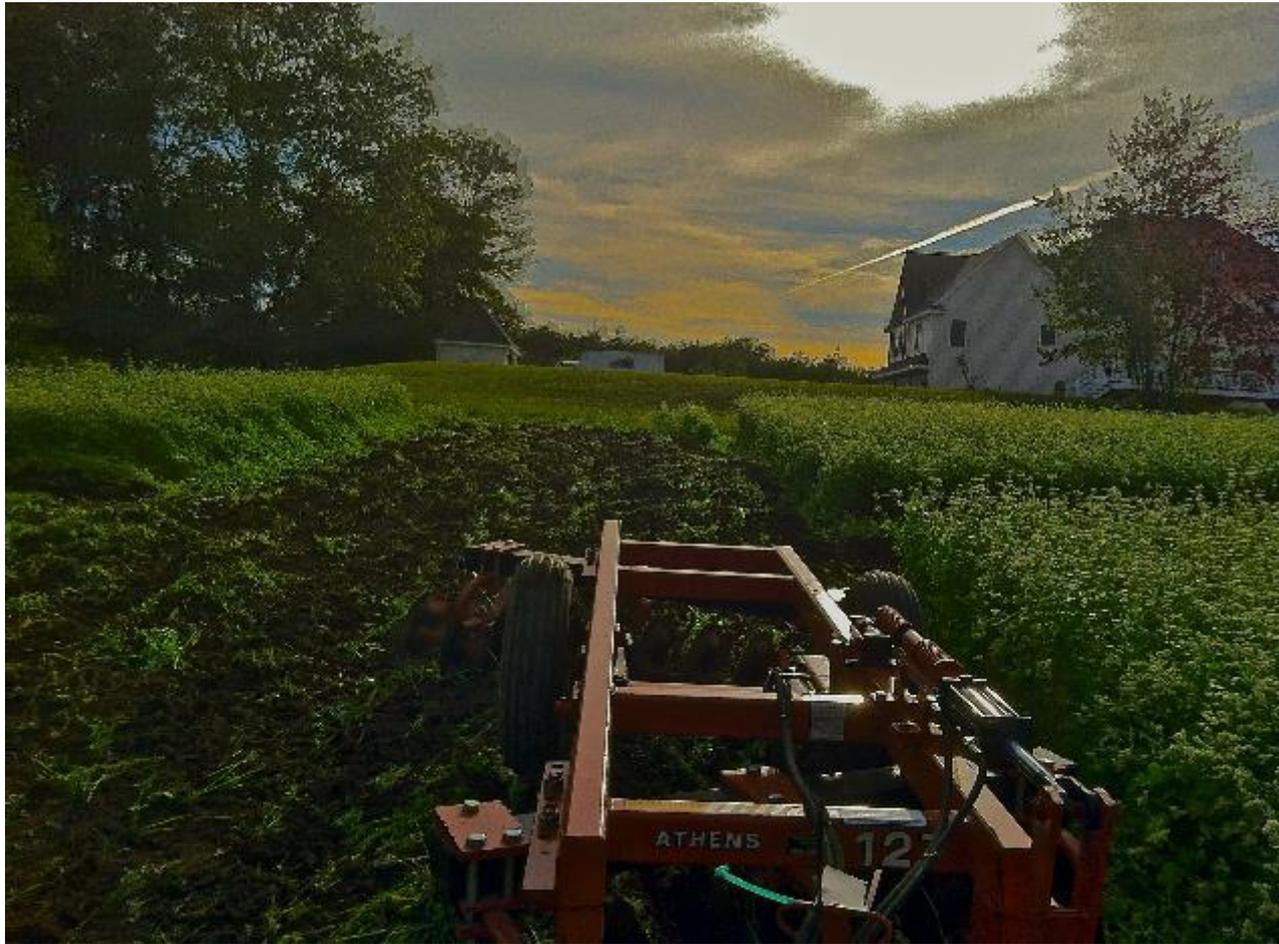
Common Name	Scientific name	Primary bee category	U.S. Native or Introduced	Plant family	Perennial Annual, or Biennial	May	Jun	July	Aug	Sept	Oct
Buckwheat	<i>Fagopyrum esculentum</i>	HB	I	Polygonaceae	A		X	X	X	X	
Alfalfa	<i>Medicago sativa</i>	BB	I	Fabaceae	P			X			
Crimson Clover	<i>Trifolium incarnatum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



Medium red clover was over-sown into flowering buckwheat prior to mowing. Clover established without field tillage. Cultipacker was used following mowing to provide good soil to seed contact for the red clover.



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. Seed drill best implement for planting oilseed radish (12-18 lbs/A)



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.



Suppressing soil diseases utilizing biofumigant cover crops

Bio-fumigant mustard (Caliente 199), April 2nd (13-18 lbs/A)



Flowering Caliente 199 mustard, early June



Bio-fumigant mustard June 19th with tandem tractor mowing, harrowing, & cultipacking initiated.



Important for plants to be chopped to rupture plant cell walls to initiate chemistry of bio-fumigant compounds, then incorporated immediately to prevent loss due to volatilization.



The soil surface should be sealed by rolling a cultipacker, followed by irrigation



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 Mustard**

- Possible disease suppressive effects
- Excellent weed suppressive properties
- Income potential
- Cut and cut again growth properties

Fenugreek in blossom



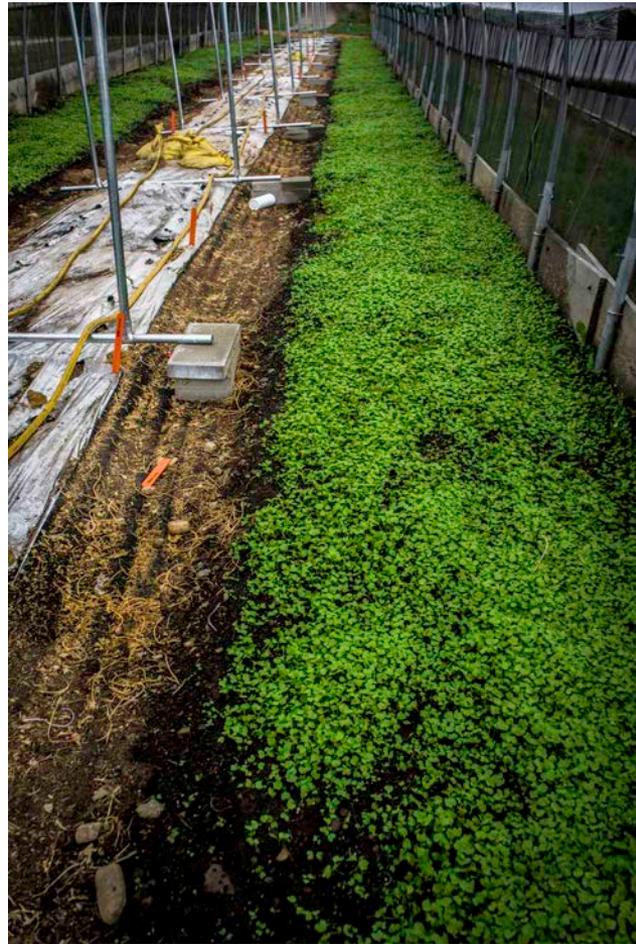
Fenugreek greens are a valuable cash crop in East Indian cuisine.



Fenugreek matures to seed in 35 days



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.



Weather conditions, geography and climate will influence cover crop choices.

Sainfoin (*Onobrychis viciifolia*) produces copious amounts of nectar & is highly attractive to pollinating insects. It is a premier legume for “monofloral” honey.



It also overwinters well and prefers dry soils.



Green manure cover crop perma-strips for arid regions?



Black medic with oats is a more resilient legume/grain combo for dry regions.



Medium red clover is more resilient to spring flood waters than winter rye and hairy vetch.



The End



Resources:

- *Farmers and their Innovative Cover Cropping Techniques.* (DVD)
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>
- *Cover Crops & Compost Crops In Your Garden, Cindy Conner, Homeplace Earth* (DVD)
- *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.
- *The Organic Grain Grower*, Small-Scale, Holistic, Grain Production for the Home and Market Producer, Jack Lazor, Chelsea Green.