Optimizing the Benefits of Hairy Vetch in Organic Production

Dr. John Teasdale, USDA-ARS

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http://www.extension.org/organic_production

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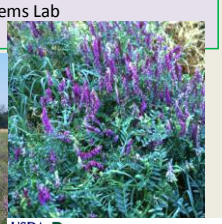

Should I use hairy vetch as a cover crop?

Objectives for cover cropping:

- **Prevent erosion**
  - maintain soil quality, prevent degradation of water quality
- **Sequester carbon**
  - improve soil quality, mitigate global warming
- **Recycle nutrients**
  - maintain fertility, prevent degradation of water quality
- **Fix nitrogen**
  - improve soil fertility, meet crop N requirements
- **Reduce weeds/pests**
  - enhance weed/pest control, reduce pesticide use
- **Reduce radiation to soil**
  - cool soil, reduce evaporation

Objective for cover cropping USING HAIRY VETCH:

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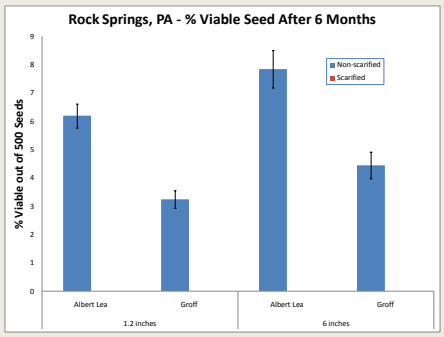
Hairy vetch (*Vicia villosa* Roth)

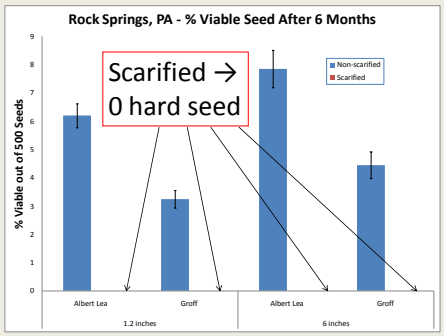
- Winter annual legume
- Produces abundant biomass
  high N content (120-160 lb/A)
  low C/N ratio (10 to 14)
- Best before high N-requiring crops
- Establishes easily
- Most winter hardy annual legume cover crop
- Widely adapted to much of U.S. except north of Zone 4
- Good spring ground cover by vines

Persistent hard seed problem, vetch can become a weed



Crockett, B. (2012) Masters Thesis, Penn State U.

Potential for scarification to eliminate hard seed



Crockett, B. (2012) Masters Thesis, Penn State U.

How should I plant hairy vetch?

How should I plant hairy vetch?

Seedbed
- Firm, good soil-seed contact
- Good drainage, poor establishment in wet areas
- Raised beds, if beds needed for succeeding crop

Planting Methods
- Drill - best
- Grass/forage seeder - good
- Broadcast – poor (unless ideal moisture conditions)

Seeding Rates
- 15-30 lb/A
- 30 lb/A recommended for high N requiring organic crops

Which "cultivar" should I use?

What is the germplasm diversity of hairy vetch?

Amplified Fragment Length Polymorphism (AFLP) analysis with the objective of characterizing the genetic relatedness among all vetch accessions in the USDA germplasm collection

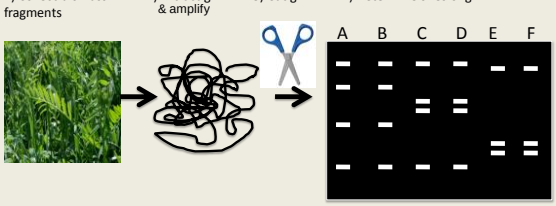
- **Jude Maul et al**, USDA-ARS Sustainable Agriculture Systems Lab, Beltsville, MD

1) Collect biomass fragments

2) Extract gDNA & amplify

3) Cut gDNA

4) Determine sizes of gDNA



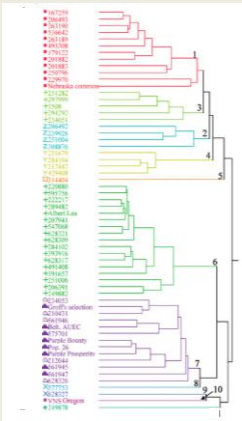
Crop Science (2011) 51:2615-2625

Global sources of the *Vicia villosa* USDA-National Plant Germplasm Collection

Table 1. Origin & number of accessions from each country

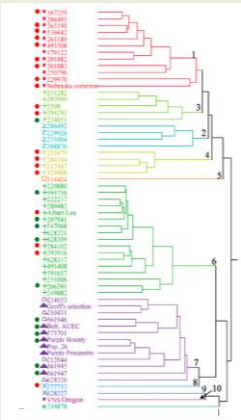
Afghanistan	3	China	2	Greece	5	Spain	2
Argentina	1	Cyprus	1	Iran	6	Syria	2
Australia	1	Denmark	1	Israel	1	Tajikistan	1
Belgium	1	Fmr. Soviet Union	2	Italy	1	Turkey	7
Bulgaria	2	France	2	Portugal	2	U.S.A.	14
Canada	1	Germany	1	Russia	2	Yugoslavia	2

Hierarchical clustering of worldwide *Vicia villosa* accessions based on amplified fragment length polymorphism (AFLP) marker analysis.



Hierarchical clustering of worldwide *Vicia villosa* accessions based on amplified fragment length polymorphism (AFLP) marker analysis.

- Late flowering
- Early flowering



Flowering date is an important trait that defines genomic variability in hairy vetch

Flowering

Winterhardiness ⟷ **Winter dormancy**

Late flowering – More winter hardy – More winter dormancy

Early flowering – Less winter hardy – Less winter dormancy

Selected "populations" of hairy vetch

Late flowering/more winter hardy
- Nebraska common (derived from Madison?)
- Albert Lea

Early flowering/less winter hardy – Auburn derived
- AU Early Cover (J. Mosjidis, Auburn AL)
- Purple Bounty (T. Devine, ARS Beltsville)
- Purple Prosperity (T. Devine, ARS Beltsville)
- Groff AUEC (S. Groff, PA farmer)

Mixed characteristics
- VNS Oregon

When should I plant hairy vetch?

When should I plant hairy vetch?

- Best when soil temperature and moisture conditions are moderate
- Permit sufficient growing degree days to obtain high biomass and nitrogen content before termination in spring
- Develop a plan for timing/method of spring vetch termination and crop planting before vetch is planted

Method and timing of hairy vetch termination for planting organic spring crops

Tillage – at vetch vegetative or flowering

No-tillage (mow or roll) – at vetch flowering only

Method and timing of hairy vetch termination for planting organic spring crops

Tillage – at vetch vegetative or flowering

- Prepare seedbed for early spring planting
- Incorporate amendments
- Facilitate N release
- Facilitate cultivation of weeds – uproot/desiccate seedling

No-tillage (mow or roll) – at vetch flowering only

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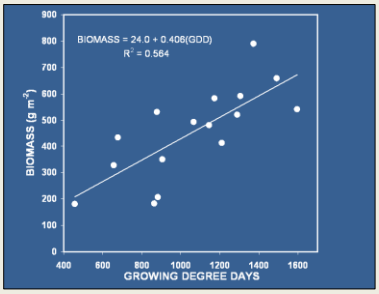
No-tillage (mow or roll) – at vetch flowering only
- Preserve soil organic matter
- Mulching benefits from surface residue
  - ✓Reduce soil and nutrient losses
  - ✓Improved rain infiltration and lower evaporation
  - ✓Weed suppression

Hairy vetch biomass accumulation is a linear function of growing degree days

265 lb/A biomass for every 100 GDD (base 39°F)



Teasdale et al. (2004) Agron. J. 96:1266–1271

Example:

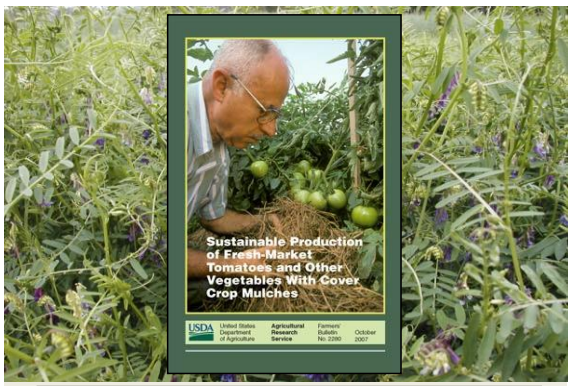
Transplant vegetable crops following a hairy vetch cover crop
Plow-till hairy vetch.
Transplant on the 90-percent frost-free date.
Require 4,000 pounds of vetch dry biomass per acre.
Compute the GDD (39°F base) requirement = 1509.
Determine fall vetch planting date.

Location	**Planting date**	90% frost-free date
Binghamton, NY	**August 24**	May 15
Peoria, IL	**September 8**	May 2
Beltsville, MD	**September 28**	May 6
Nashville, TN	**October 13**	April 19
Raleigh, NC	**October 18**	April 17

Abdul-Baki & Teasdale (2007) USDA Farmers Bulletin 2280

How should I manage crops following hairy vetch?

System for No-Till Tomatoes in Hairy Vetch



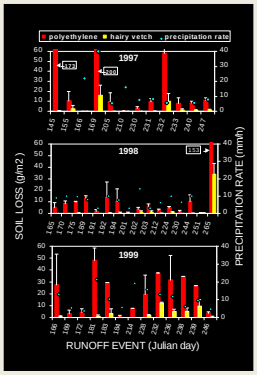
http://www.ars.usda.gov/is/np/SustainableTomatoes2007/TomatoPub.pdf

Polyethylene Mulch…versus…Hairy Vetch Mulch

Soil Erosion

- 93% of events, **runoff volume** greater in plastic than vetch
- 90% of events, **soil loss** greater in plastic than vetch

Year	Soil in Runoff Plastic g/m²	Vetch g/m²
1997	492	33
1998	247	39
1999	535	118



Rice et al. 2001. J. Environ. Qual. 30:1808-1821

Early Season Soil Temperature and Tomato Response

Mulch	Hours/day soil temp. > 20°C	Early root length (cm/dm³)	Early fruit yield (Mg/ha)	Total fruit yield (Mg/ha)
Black Poly	19	245	15	88
Bare Soil	12	203	10	77
Vetch	11	180	7	96

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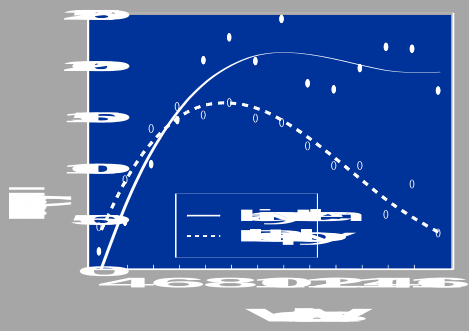
Vetch	11	180	7	96

1. No-till vegetable crops in hairy vetch require a sufficiently long season to overcome early season temperature depression.

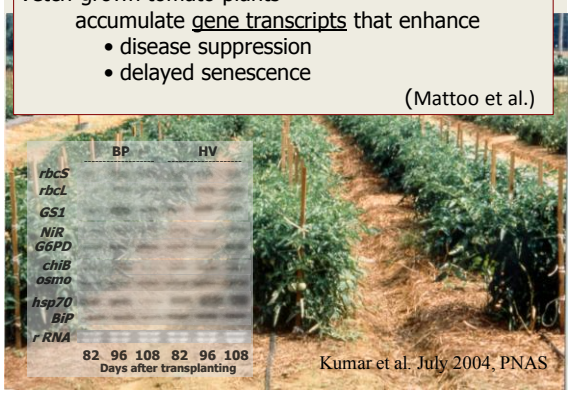
Tomato Leaf Area Response to Mulches



Teasdale and Abdul-Baki. HortScience 32:659-663 (1997)

Vetch-grown tomato plants
accumulate gene transcripts that enhance
- disease suppression
- delayed senescence

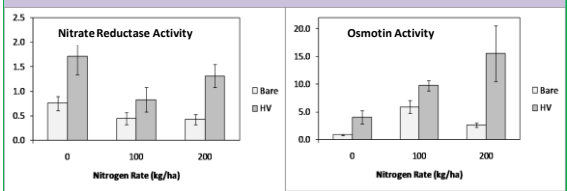
(Mattoo et al.)



Kumar et al. July 2004, PNAS

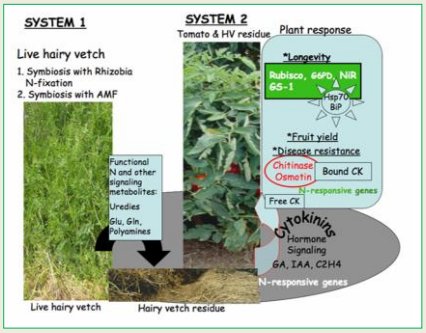
Tomato gene expression patterns differ in response to hairy vetch versus nitrogen fertilizer

Quantitative real time polymerase chain reaction (qPCR) analysis



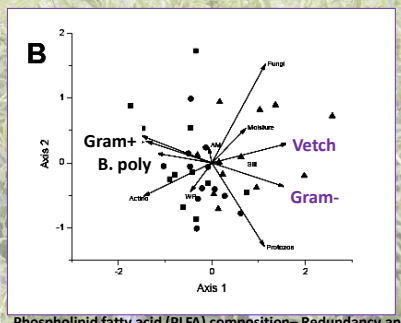
Fatima et al. (2012) Functional Plant Biology, in press

Gene Up-regulation in Response to Hairy Vetch



Mattoo and Teasdale (2010) Hort. Rev. 37:331-362

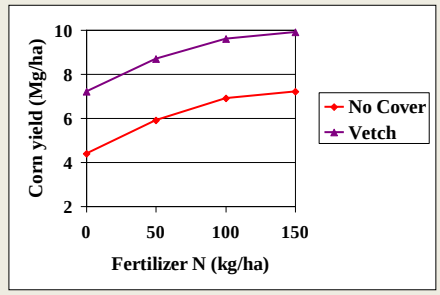
Soil microbial community structure in the tomato rhizosphere



Phospholipid fatty acid (PLFA) composition– Redundancy analysis
Buyer et al. (2010) Soil Biol. Biochem. 42:831-841

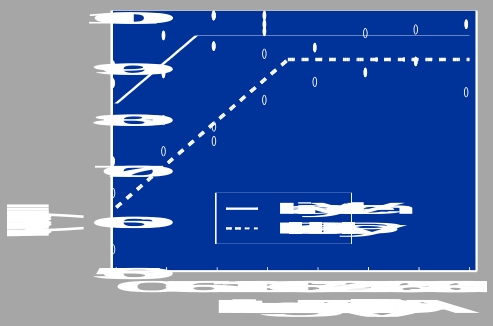
How do I manage nitrogen following a hairy vetch cover crop?

Corn response to nitrogen following hairy vetch



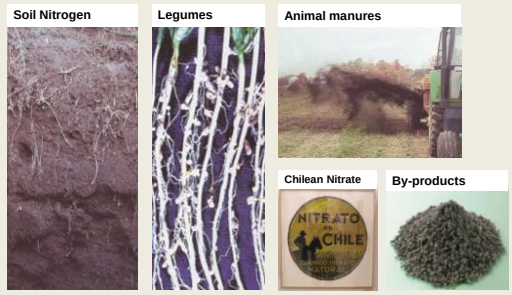
Decker et al. (1994) Agron. J. 86:126-135

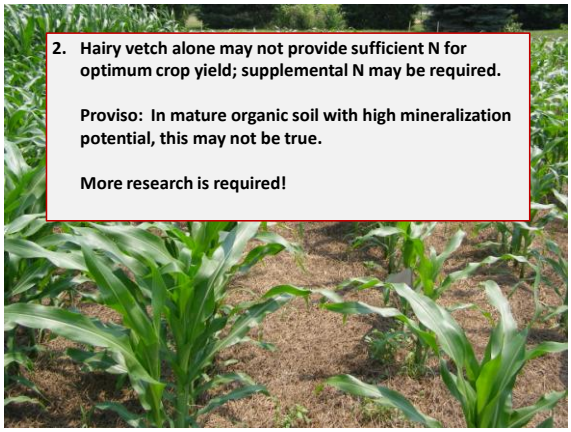
Tomato Response to Mulches and Nitrogen



Abdul-Baki et al. HortScience 32:217-221 (1997)

Sources of Nitrogen in Organic Production





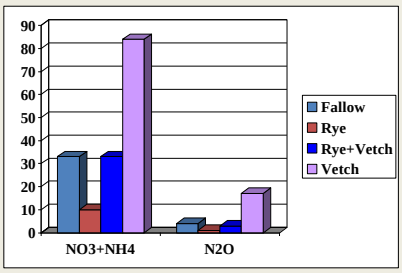
2. **Hairy vetch alone may not provide sufficient N for optimum crop yield; supplemental N may be required.**

   Proviso: In mature organic soil with high mineralization potential, this may not be true.

   More research is required!

Nitrogen release from cover crops in soil cores

cumulative N during 55 days after kill (relative scale)



Rosecrance et al. (2000) Plant and Soil 227:283-290

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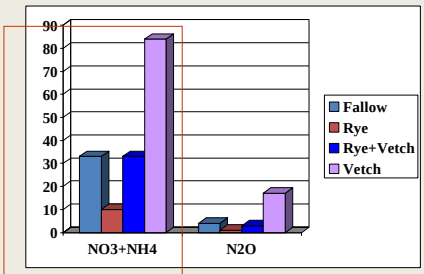

NO_3+NH_4 released for crop uptake or runoff/leaching

Rosecrance et al. (2000) Plant and Soil 227:283-290

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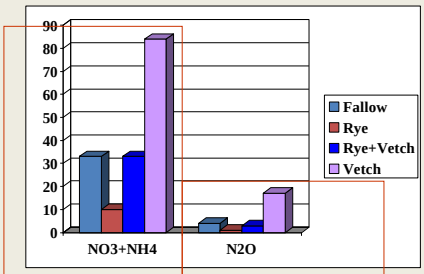


NO_3+NH_4 released for crop uptake or runoff/leaching

N_2O lost to denitrification, ↑ greenhouse gas emissions

Rosecrance et al. (2000) Plant and Soil 227:283-290

3. **Nitrogen from hairy vetch needs to be managed with similar care as is required of fertilizer N management.**
   - Avoid use on soils prone to leaching.
   - A vetch-grass mixture may mitigate potential leaching and denitrification losses from vetch.

Can organic corn be produced with a roller-crimper system?

Can organic corn be produced with a roller-crimper system?

For more details see eOrganic webinar: Curren et al. (3/22/11)
The evolution, status, and future of organic no-till in the northeast US

Reduced-Tillage Organic Corn Production in a Hairy Vetch Cover Crop

Teasdale, Mirsky, Spargo, Cavigelli, Maul (2012) Agron. J. – in press

Potentially,
roll-kill system can provide **equivalent or better yields** along with **enhanced environmental benefits** compared to a tillage-based system.

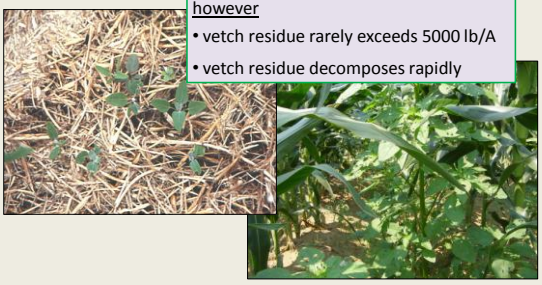
However,

- Potential for **corn stand reduction**,
- **Inadequate weed suppression** by vetch mulch,
- **Reduced cultivation efficacy.**

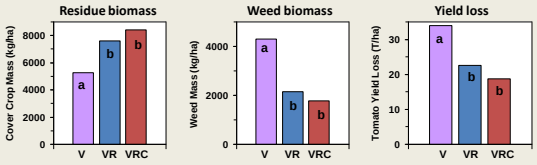
Weed suppression by hairy vetch residue is inadequate

>8000 lb/A residue biomass is typically required for good weed suppression, however

- vetch residue rarely exceeds 5000 lb/A
- vetch residue decomposes rapidly



Mixtures of hairy vetch and small grains can increase residue biomass and weed suppression

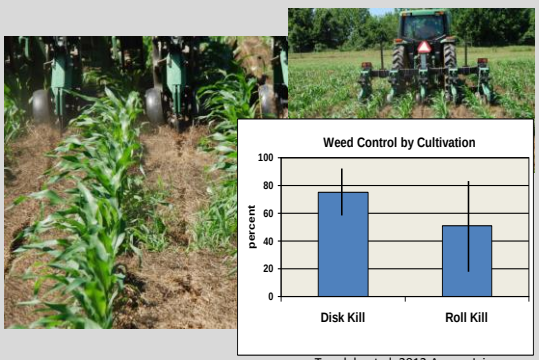


Legend
V = Hairy vetch
VR = Vetch + Rye
VRC = Vetch + Rye + Crimson clover

Teasdale & Abdul-Baki (1998) HortScience 33:1163-1166

Reduced cultivation efficacy in rolled hairy vetch

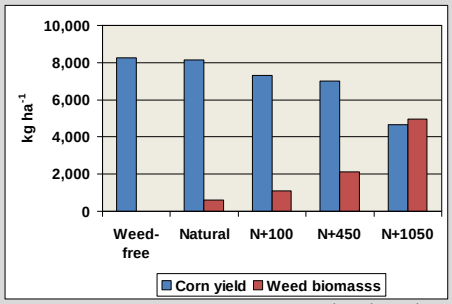
Reduced cultivation efficacy in rolled hairy vetch



Teasdale et al. 2012 Agron. J. in press

Roller-crimper system requires a low weed seed bank

Example: field with low natural seed bank = N supplemented with 100, 450, or 1050 seed/m^2



Mirsky et al. 2008 data

4. Requirements for a successful organic, reduced-tillage, vetch-based system

- Extended growing season
  - avoid cool spring soil
  - delay termination until vetch flowering
  - permit full expression of anti-senescence vetch properties
- Ample and evenly distributed rainfall to release N from vetch
- Supplemental N sources: soil reserves or amendments
- Weed management plan
  - Low weed seedbank/absence of perennial weeds
  - High residue levels (perhaps cover crop mixture)
  - Post-plant weed management strategy

Questions?

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Find the slides as a pdf handout and the recording at http://www.extension.org/pages/62753

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