

Cover Crops in Organic Systems: Improving Soil and Managing Pests

Mark Van Horn
Agricultural Sustainability Institute
Student Farm
University of California, Davis
mxvanhorn@ucdavis.edu



UCDAVIS
AGRICULTURAL SUSTAINABILITY INSTITUTE



THE STUDENT FARM

Organic Production

A production system that is managed in accordance with the Act and regulations in this part to respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity.

CFR § 205.2 (USDA NATIONAL ORGANIC PROGRAM STANDARDS)

Long term success requires optimizing natural processes on farm

Cover Crops - Potential Benefits

Organic Matter addition

Nitrogen addition &/or conservation

Soil tilth improvement

Erosion control

Water infiltration & availability

Weed suppression

Beneficial insect enhancement

Soil-borne pest reduction



Cover Crops - Potential Disincentives



Costs

Water use

Nutrient tie-up

Weed problems increase

Insect, pathogen, vertebrate
increases

Timing & other operational
challenges

Cover Crops – Questions to Ask

Why?

What?

When?

How?



Types of Cover Crops

Planted – ‘Resident Vegetation’

Legumes - Grasses - Others

Annual - Perennial

Winter - Summer

Cool Season Annual Legumes

Vetches

Common, Purple, 'Lana', Hairy
Fava/Bell Beans

Peas

Winter peas, 'Magnus', 'Miranda'

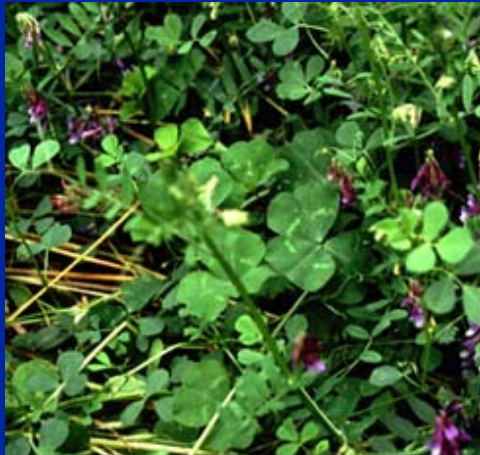
Clovers

Rose, Crimson, Sub-clovers, etc.

Medics

Bur medics (= burclover), etc.

~ 5 months, fix up to 200#N/A+



Cool Season Annuals: Grasses & Others

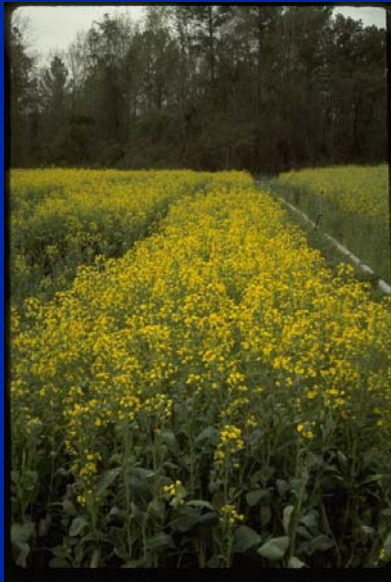
Cereal Grasses

Oats, Barley, Wheat

Forage/Pasture Grasses

Annual Ryegrass, Brome, Fescue

May Scavenge N, Tie-up N



“Other Cool Season Annuals”

Mustards, Phacelia, Buckwheat

May Scavenge, Release N easily

Warm Season Annual Legumes

“Bean types”

Blackeye beans, Hyacinth bean,

“Uprights”

Sesbania, Crotalaria

Drought tolerant

65 - 80 days

fix 100 – 150 lb N/A



Warm Season Annual Grasses

Sudan grass, Sorghum, hybrids

Large amounts of biomass

Hay, regrowth for cover

Low %N; tie up N



Perennial Cover Crops

Legumes

Strawberry & White clovers,
Birdsfoot trefoil

Grasses

California native grasses
Perennial ryegrass,
Bermudagrass



Improving Physical Properties & Erosion Control

Physical Properties:

Increased SOM from all cover crops

Grasses particularly beneficial

Management practices: large impact

Erosion control:

Perennials, annuals

Grasses particularly beneficial



Tillage and Cover Crops

Reduced/No till cover crop planting often feasible

Reduced/No till management in perennial crops or for planting of subsequent annual cash crops:

- Operational challenges
- Pest challenges
- Nitrogen behavior



Water Considerations

Water use by:

Winter Annuals

Summer Annuals

Perennials

Mulch effects

Erosion Control



Managing Nitrogen

Legumes

can **add** 100 – 200+ #N per acre
typically quickly available

Non-legumes

don't add N, but may **scavenge** N
may release or tie-up N

Mixes of legumes + non-legumes
may have advantages of both

Mineralization (or immobilization)
how much and how fast -
%N (C:N), maturity (C quality)
residues incorporated or not



Nitrogen Scavenging

Large reductions (e.g. 70%) in leaching possible

Advantages: Economic, Environmental

Challenges/Risks: N tie up post incorporation;
Residue management, timing & weather

California

Central Coast

6 Year Means

(many high N

input fields)

| | Biomass (T/A) | Nitrogen (%) | Total N (N/A) |
|-------------|------------------|-----------------|------------------|
| Legumes | 2.0 | 3.6 | 146 |
| Grasses | 3.8 | 1.7 | 131 |
| L + G mixes | 3.1 | 2.9 | 177 |

(Non-L/Non-G also good scavengers)

R. Smith, 2004

N Fixation by Legumes

Legumes can convert atmospheric N_2 into forms used by plants; this is called *nitrogen fixation*

Requires symbiosis with *Rhizobium* bacteria

form “nodules” on roots of legume

nodules should be pink/red inside

without this, no N fixation

Rhizobium inoculants used

different strains for different legumes

be sure using correct strain



Legume Inoculation

Rhizobium inoculants:

Inexpensive

Alive

Apply to seed pre-plant



Some legume seeds
can be bought pre-inoculated

How Much N is Fixed and When?

N fixed related to species and total plant growth

Cool season: more N fixed; higher % N; longer season

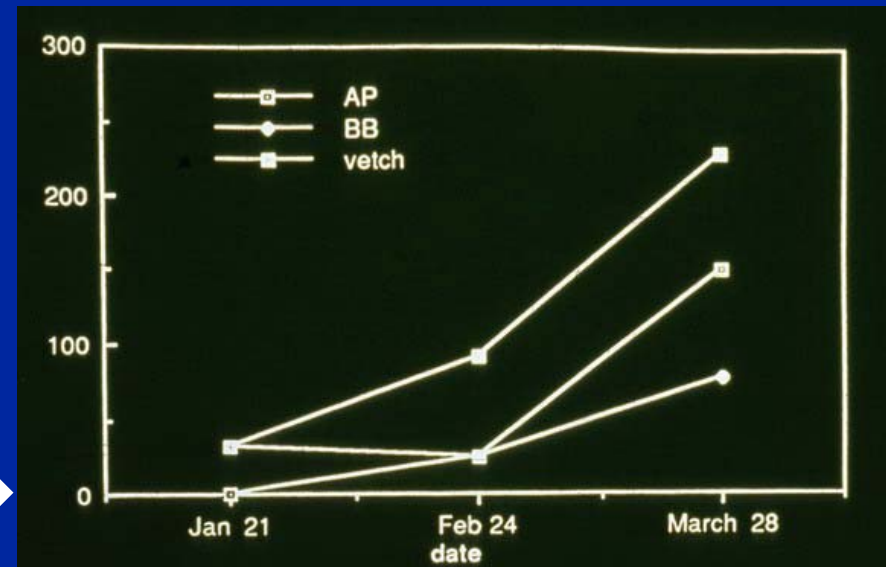
Warm season: grow faster

High soil N levels suppress

Legume-Grass mix may fix more
N than pure Legume

Most N fixed late in season

e.g., planted Oct 15 →



P.R. Miller, 1989

In-Field N Estimation

Cut cover crop from specified area (e.g. 4 ft²)

Measure fresh weight in field

Multiply by conversion factor

crop specific

valid mid-season to

mid-flowering

Repeat several times

throughout field



Nitrogen Mineralization & Release

Favored by High % tissue N (Low C:N), younger plants

Rapid release: Winter legumes, juv. mustard; $\sim 3^5 - 4^0\%N$

Mod – rapid: Summer legumes, mustards; $\sim 2^5 - 3^5\%N$

Mod – slow: Juv. grasses, heading mustard; $\sim 1^7 - 2^5\%N$

Immobilize (days-weeks), then mod-slow release:

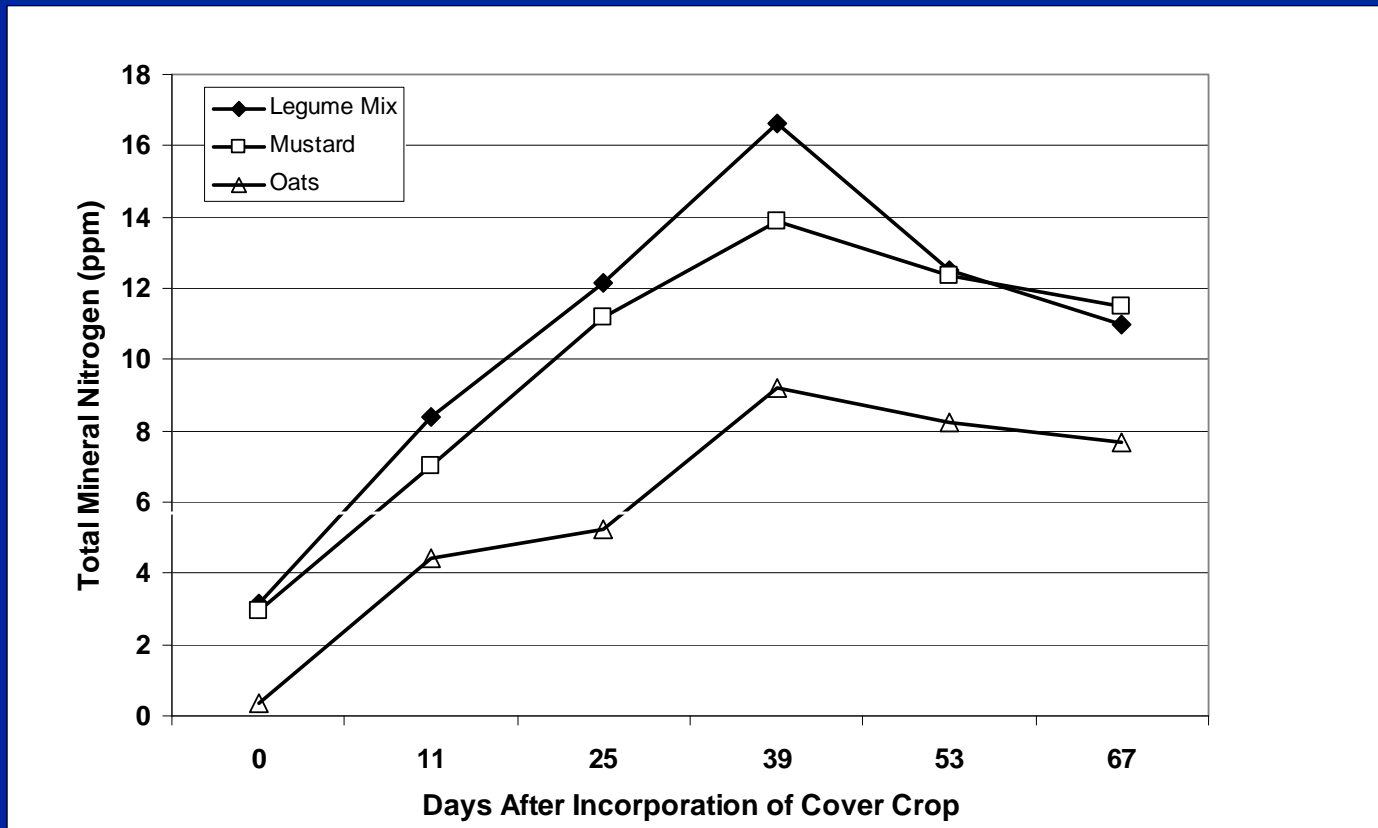
Grasses near heading; $> \sim 1^7\%N$; (decreases w/age)

Mixes (e.g., spp from 2 groups):

May have traits of both groups

Relative abundance of spp in mix is hard to control

Nitrogen Mineralization & Release



R. Smith & E. Brennan, 2003

Nitrogen Mineralization & Release

Many crops: N uptake most rapid from ~30 d.a.p. to 60 – 90 d.a.p.

Additional crop available N may be from:

Compost, Organic fertilizers, etc

How does cover crop N interact with other N sources?

Do organic & conventional crops rely on NO_3 similarly?



Strategies for Optimizing N Use by Subsequent Cash Crop

Synchronize N release with crop demand

- Plant soon after incorporation (usually)

- Try to manipulate residue C:N, C quality (cover crop age)
[via species, mix ratios, timing]

Manage water carefully to minimize N leaching

Choose other N sources with N release curves that
complement cover crop N release curve

Cover Crops & Weed Management

Annual Cropping Systems

Suppressing weeds:

- Competitive, vigorous cover crops
 - High seed density, proper timing
- “Rotation effect” in row crop rotations



Perennial Cropping Systems

Suppressing weeds
Mowing cover crops
Mulch effects

Cover Crops & Soil Born Pests

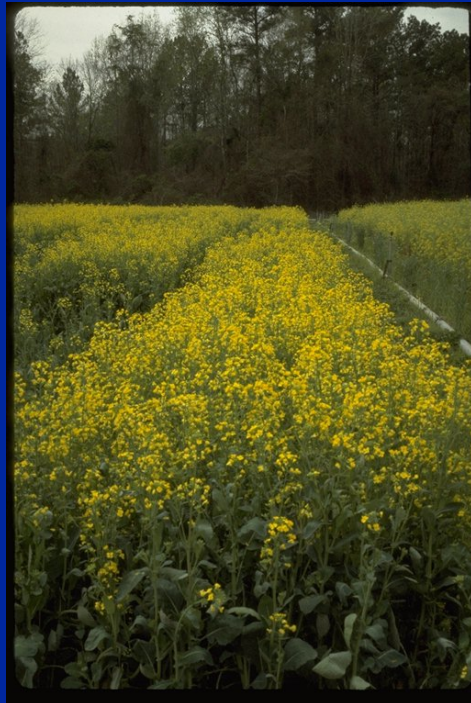
Cover Crops generally:

Increase SOM, biological activity

Improve tilth, water infiltration/drainage

- May help suppress some pathogens & diseases

Can favor gophers, etc. in perennial crops



Specific Cover Crops:

May host pathogens, nematodes

e.g., vetch & *Sclerotinia*

May reduce specific pathogens, nematodes

e.g., *Crotalaria*, grasses & some root knot nemas

e.g., “Biofumigation” by brassicas (mustards)

Cover Crops & Arthropod Management

Cover crops can “support”

Pest arthropods (and pathogens)
‘reservoir’ and/or ‘trap crop’

Natural enemies

shelter, nectar & pollen
alternate hosts/prey



‘Live’ cover crops, mulches, decaying residues

Cover Crops & Arthropod Management

Predators

- Commonly generalists

- Cover crop may provide prey, nectar, pollen

- Don't 'track' pest populations well

Parasitoids

- More host specificity

- Cover crop may provide nectar, pollen

- May 'track' pest population



Cover crops typically have many beneficials, but consistent increases in biocontrol are less common

Cover Crops Can Support Beneficials

Pollen

Grasses, legumes, mustards (flowering)

Nectar

Buckwheat, Alyssum, Dill, Cilantro, Fennel
Common vetch, Bell bean, Blackeye Bean

Alternate prey/host (e.g. aphids, thrips)

Most cover crops, 'dead or alive'

'Habitat'



*Usually, for generalist predators:
Legumes > Mustards > Grasses*

Cover Crop Conclusions - Soils

Many benefits (& challenges); important part of integrated organic systems

Can improve soil tilth, biology, water relations, etc

N fixation: often primary reason in organic systems; inoculation is important to maximize fixation; often the cheapest N source for organic farms

N available to crop: want mineralization to release N where and when cash crop needs it

Challenges: Rotational & operational, opportunity costs, uncertainty (performance, weather, etc.)

Cover Crop Conclusions - Pests

Many benefits (& challenges); important part of integrated organic systems

Net impacts depends upon cover crop selection, management

Specific biology of interactions between cover crops, pests and beneficials are important

While difficult to demonstrate consistent specific impacts, well-reasoned diversity (cover crops, rotations, crop mixes, hedgerows) seems to enhance biocontrol

Challenges include need to “rotate your cover crops” to avoid build up of soil born pests of cover crop

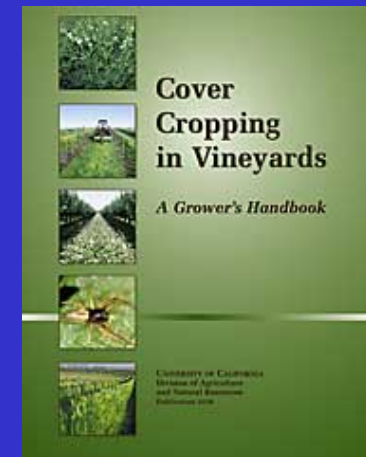
For More Information

<http://sarep.ucdavis.edu/organic/>

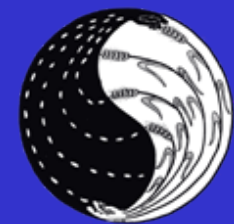
<http://sarep.ucdavis.edu/ccrop/index.htm>

Mark Van Horn

[**mxvanhorn@ucdavis.edu**](mailto:mxvanhorn@ucdavis.edu)



UCDAVIS
AGRICULTURAL SUSTAINABILITY INSTITUTE



THE STUDENT FARM