Cover Crops for Organic Vegetable Crop Production

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Monterey, Santa Cruz and San Benito Counties
Cover cropping is an age old agricultural practice that can benefit soils/crops by:

- Increasing nitrogen (N) supply to subsequent crops
- Conserve nutrients (i.e. reducing N leaching)
- Improve soil physical properties
- Reduce soilborne pest pressure
- Reduce soil erosion (water quality benefits)
If Cover Crops are So Beneficial, Why are They Not More Commonly Planted

- Direct cost ($150 to $200/A)
- Opportunity Costs
- Risk of missing planting schedules
- Dealing with cover crop residue in the spring (wet soils)
Reality Check on Cover Crops

- There is probably no more than 5% of vegetable acreage in the Salinas Valley that is cover cropped.
- High land rents are the biggest problem for greater use of cover crops.
- Organic producers generally cover crop more.
- Organic growers on the Central Coast that use cover crops average 1.5 to 2.0 crops per year vs conventional growers that can produce an average 2.0 to 2.5 crops per year.
Vegetable Cover Crop
Planting Slots

- Winter (Oct. – March)
- Summer
- Fall (Sept. to Oct.)
Cover Crop Roles

1. Nutrient input and cycling
2. Pest management impacts
3. Soil quality impacts
4. Water quality impacts (discussed yesterday)
Cereals and mustards are good at scavenging N from the soil. In the Salinas Valley, there are often high levels of residual N in the soil left over from intensive crop production.

Legumes have the ability to fix atmospheric nitrogen and make it available for plant growth.
# Productivity of Cover Crops

**Six year Average**

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Biomass (T/A)</th>
<th>Nitrogen (Lbs/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>3.8</td>
<td>131</td>
</tr>
<tr>
<td>Legumes</td>
<td>2.0</td>
<td>146</td>
</tr>
<tr>
<td>Cereal/Legume Mix</td>
<td>3.1</td>
<td>177</td>
</tr>
<tr>
<td>Mustards*</td>
<td>2.3</td>
<td>197</td>
</tr>
</tbody>
</table>

* One year’s data
Release of N from Cover Crops

• When cover crops are incorporated into the soil, microbes begin to decompose the tissue and the complex forms of nitrogen that they contain (i.e. proteins)

• Plant available forms of nitrogen (ammonium and nitrate) are released to the soil through this process
Cover Crop Proteins

Microbes

Depends upon C:N; lignin and Polyphenols

Available Mineral Nitrogen

Typically <10-30% of cover crop N is taken up by the first subsequent crop; however much more is taken up by later cash crops (i.e. 73%)
### Nitrogen release from cover crop residue based on the N content

<table>
<thead>
<tr>
<th>Nitrogen Release</th>
<th>Percent N in Cover Crop</th>
<th>Examples of Cover Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Will Tie up N</td>
<td>0.5</td>
<td>Cereal Straw</td>
</tr>
<tr>
<td>Will Tie up N</td>
<td>1.0</td>
<td>Cereal Straw</td>
</tr>
<tr>
<td>Will Tie up N</td>
<td>1.5</td>
<td>Cereal at heading</td>
</tr>
<tr>
<td>May Tie up N</td>
<td>2.0</td>
<td>Cereal pre heading</td>
</tr>
<tr>
<td>May Tie up N</td>
<td>2.5</td>
<td>Mustards at heading and Imm. cereal</td>
</tr>
<tr>
<td>Will Release N</td>
<td>3.0</td>
<td>Mustards, legumes and juvenile cereal</td>
</tr>
<tr>
<td>Will Release N</td>
<td>3.5</td>
<td>Legumes and immature mustards</td>
</tr>
<tr>
<td>Will Release N</td>
<td>4.0</td>
<td>Legumes</td>
</tr>
</tbody>
</table>
N Release Pattern from Cover Crops

Days After Incorporation of Cover Crop

Total Mineral Nitrogen (ppm)

Legume Mix
Mustard
Oats

Smith and Brennan 2003
Cereal Residue                        Legume Residue
High C:N                             Lower C:N
Cereal Residue                        Legume Residue
High C:N                             Lower C:N
Release of N from Cover Crops

• The ideal scenario would be that the release of N from cover crop residue would match the N demand by crops (i.e. fast enough to match crop demand, but not so fast to leach)
The cover crop plots produced 3.2 tons of biomass and contained 195 lbs N/A.
The cover crop was incorporated February 14.
12 inches of rain fell between incorporation of the cover crop and transplanting broccoli on April 20.
Rain Events Between Cover Crop Incorporation and Transplanting Broccoli

![Graph showing rainfall events and cumulative rainfall between 14 February to 18 April.](image-url)
Harvest – Numb of Heads
Number/A

<table>
<thead>
<tr>
<th>Number/A</th>
<th>0</th>
<th>75</th>
<th>150</th>
<th>225</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5000</td>
<td>10000</td>
<td>15000</td>
<td>20000</td>
</tr>
<tr>
<td></td>
<td>25000</td>
<td>30000</td>
<td>35000</td>
<td>40000</td>
</tr>
<tr>
<td></td>
<td>45000</td>
<td>50000</td>
<td></td>
<td></td>
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</table>

- **No Cover Crop**
- **Cover Crop**
N availability from cover crops

- Legume cover crops contained 195 lbs of N/A
- A portion of the nitrogen contained in the cover crop was initially lost to leaching prior to planting the broccoli
N availability from cover crops

• In spite of these conditions, there was an increase of 25 lbs of N/A in the biomass of broccoli in cover cropped plots vs non-cover cropped plots at the end of the growing season.

• In a similar trial conducted at UCSC, Joji Muramoto observed 75 lbs of N in the broccoli from the cover crop (no rain fell on the cover crop residue)
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Organic Matter</th>
<th>Nitrogen Storage*</th>
<th>Nitrogen Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short Rotation Conventional</td>
<td>1.10</td>
<td>0</td>
<td>452</td>
</tr>
<tr>
<td>(Low Biomass)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic</td>
<td>1.46</td>
<td>901</td>
<td>90</td>
</tr>
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Poudel et al. 2001
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Poudel et al. 2001
Cover Crop Nitrogen Synchrony

- Achieving synchrony between crop uptake and N supplied by mineralization from cover crops, soil organic matter, and fertilizers is the challenge for managing N fertility of vegetables in organic systems
# Impacts of Soil Building on Nitrogen Storage in the Soil

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Management</th>
<th>N storage Lbs/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay Loam</td>
<td>Organic</td>
<td>3400</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>Conventional</td>
<td>2800</td>
</tr>
<tr>
<td>Loam</td>
<td>Organic</td>
<td>2800</td>
</tr>
<tr>
<td>Loam</td>
<td>Conventional</td>
<td>2200</td>
</tr>
<tr>
<td>Fine Sandy Loam</td>
<td>Organic</td>
<td>2400</td>
</tr>
<tr>
<td>Fine Sandy Loam</td>
<td>Conventional</td>
<td>1200</td>
</tr>
</tbody>
</table>
Nitrogen Release from Soil Organic Matter

Relative Rate of N Mineralization

Available Nitrate (ppm)

Soil organic matter mineralization

Relative Rate of N Mineralization
Nitrogen Release Characteristics from Cover Crop

- Relative Rate of N Mineralization
- Available Nitrate (ppm)

Cover Crop Incorporation

Cover Crop Mineralization

Soil organic matter mineralization

Relative Rate of N Mineralization

Available Nitrate (ppm)
Nitrogen Release Characteristics

Fertilizer Application

Relative Rate of N Mineralization

Available Nitrate (ppm)

Cover Crop Incorporation

Fertilizer Mineralization

Cover Crop Mineralization

Soil organic matter mineralization

Relative Rate of N Mineralization
Nitrogen Release Characteristics of N From All Sources

*Ideal Scenario*

<table>
<thead>
<tr>
<th>Relative Rate of N Mineralization</th>
<th>Available Nitrate (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil organic matter mineralization</td>
<td>5</td>
</tr>
<tr>
<td>Cover Crop Incorporation</td>
<td>10</td>
</tr>
<tr>
<td>Cover Crop Mineralization</td>
<td>15</td>
</tr>
<tr>
<td>Fertilizer Mineralization</td>
<td>20</td>
</tr>
<tr>
<td>Crop Demand</td>
<td>- - -</td>
</tr>
</tbody>
</table>

Relative Rate of N Mineralization
Nitrogen Release Characteristics of N From All Sources
Suboptimal – mineralization too early

Available Nitrate (ppm)

Cover Crop Incorporation
Fertilizer Mineralization
Cover Crop Mineralization
Soil organic matter mineralization

Relative Rate of N Mineralization

Crop Demand
Nitrogen Release Characteristics of N From All Sources

Adjusting fertilization for lack of synchrony from cover crop N release

![Graph showing the relative rate of N mineralization](image)

- Soil Organic Matter Mineralization
- Cover Crop Mineralization
- Fertilizer Mineralization
- Crop Demand

Available Nitrate (ppm) vs. Relative Rate of N Mineralization
Summary of Nitrogen Impacts of Cover Crops on Crop Production

• Cover crops mineralize useful amounts of nitrogen that can be an important source for subsequent crops
• For high yield and quality, supplemental applications of N are needed for long-season crops
• Over a period of years, as the soil organic matter levels build up from the use of cover crops and compost, the amounts of supplemental nitrogen fertilizer needed for high yields may decline
2. Pest Management Impacts of Cover Crops

- Insects
- Disease
- Weeds
Soilborne Disease Impacts

- Mustards
Why Mustard Cover Crops

• Produce a class of chemicals known as *glucosinolates*

• These materials break down enzymatically to *isothiocyanates*, *thiocyanates*, *nitriles* and *isonitriles* in the soil which are toxic to nematodes, fungi and weed seeds – biofumigation

• There may also be soil microbiological effects as well
Mustard Cover Crop Trials
Percent Infection by *S. minor* on Summer Lettuce Crop, 2005
(after two cover crop cycles and 4 lettuce cycles)

* Did not grow normally
Cover Crop Impacts on Disease

• Biofumigation by cover crops has been a disappointment for disease control.
• However, positive impacts have been demonstrated for nematode control.
• Benefits from cover crops for disease control may be due to impact of adding organic matter and its affect on stimulating beneficial microorganisms.
Weed Impacts

• During the cover crop growth cycle they can allow weeds to grow and set seed undetected

• In a sense, cover crops can act as a nurse crop to weeds
Weed Growth In the Cover Crop

Legume  Oats  Rye  Mustard Mix
# Weed Seed Production While Cover Crop Was Growing

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Percent ground cover 28 days after planting</th>
<th>Burning Nettle Seed production Viable seeds per square meter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Year 1</td>
</tr>
<tr>
<td>Legume/oats Mix</td>
<td>18</td>
<td>13,622</td>
</tr>
<tr>
<td>Mustard Blend</td>
<td>78</td>
<td>1,283</td>
</tr>
<tr>
<td>‘Cayuse’ Oats</td>
<td>30</td>
<td>6,010</td>
</tr>
<tr>
<td>‘Merced’ Rye</td>
<td>46</td>
<td>-----</td>
</tr>
</tbody>
</table>

Brennan and Smith 2005
Weed Impacts

• The negative impacts of slow growing legume mixes on weeds can be offset by higher seeding rates (i.e. 200 lbs/A)
Rotary Hoe Which Can Kill Weeds in Cover Crops

Used when weeds are at the white thread stage
Impact of Rotary Hoe on Weed Seed Production

Boyd and Brennan, 2006
3. Soil Quality Impacts of Cover Crops

• Additions of organic amendments to agricultural soils is important because they are key to improving the quality of soils for crop production

• Cover crops are an economical method of adding organic matter to soils
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<tr>
<td>Clay Loam</td>
<td>Organic</td>
<td>2.24</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>Conventional</td>
<td>1.78</td>
</tr>
<tr>
<td>Loam</td>
<td>Organic</td>
<td>1.74</td>
</tr>
<tr>
<td>Loam</td>
<td>Conventional</td>
<td>1.37</td>
</tr>
<tr>
<td>Fine Sandy Loam</td>
<td>Organic</td>
<td>1.31</td>
</tr>
<tr>
<td>Fine Sandy Loam</td>
<td>Conventional</td>
<td>0.66</td>
</tr>
</tbody>
</table>
Soil Quality Impacts of Cover Crops

- **Cover crops** are important in providing a rotation for cash crops
- Improve soil tilth and aggregate stability
- Increase water infiltration
- Provides the basic food for the soil food web
  - Increases the health of soil
  - May suppress soilborne diseases and nematodes
Cover crops have many benefits in vegetable production systems

• We have to figure out ways to include them on high value vegetable ground
Resources

- **Soil Fertility Management for Organic Crops (UCDANR 7249)**
  - Google CEMonterey and go to publications then free publications

- **Weed ‘em and Reap (Part 2)**
  - Available from www.weedemandreap.org