Cover Crop Contributions to Nitrogen Fertility

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Cover Crops: Background

- Cover crops are an important agricultural production practice
- In modern agriculture their use is common in permanent crops but is more problematic in annual crops
- They are mostly grown in the winter, but can “get in the way” of preparing the ground for early spring planting if wet weather prevents soil incorporation
Cover Crops: Background

• Cover crops can be a source of nitrogen for subsequent cash crops

• However, regarding N availability, there are important agronomic details that need to be discussed to better understand the role that cover crops can play in providing nitrogen to subsequent crops
Legumes: Fix N from the air and provide a net input of N to the soil

Cereals, Mustards, Others: Scavenge & recycle residual N from soil
Legume have the ability to obtain the N they need by N fixation.

- **Sweet Clover**
- **Oats**

Low Nitrogen Scenario: Oat are N Stressed (yellowed)
Legumes can leak some of their nitrogen to plants growing in their immediate vicinity.

Compare the color of these two oat plants.
Legume and cereal mixes take advantage of the N fixing ability of legumes and the N scavenging ability of cereals.
How Much N do Cover Crops Contain?
Nitrogen Content of Cover Crops
Organic Farm in San Benito County – moderate N
Six year Average

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Lbs N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>131.5</td>
</tr>
<tr>
<td>Legumes</td>
<td>145.7*</td>
</tr>
<tr>
<td>Cereal/Legume Mix</td>
<td>177.1</td>
</tr>
</tbody>
</table>

* How much is net fixation is not known
# Scavenging of Nitrogen by Cover Crops Following Conventional Lettuce Production – high N

Chualar, 2003

<table>
<thead>
<tr>
<th>Cover Crops</th>
<th>Biomass T/A</th>
<th>% N in Tops</th>
<th>Ibs N/acre in Tops</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Mustard</td>
<td>2.5</td>
<td>3.9</td>
<td>194.8</td>
</tr>
<tr>
<td>Indian Mustard</td>
<td>2.2</td>
<td>4.5</td>
<td>199.7</td>
</tr>
<tr>
<td>Cereal Rye</td>
<td>3.1</td>
<td>3.3</td>
<td>203.7</td>
</tr>
</tbody>
</table>
What rate is the nitrogen contained in cover crops made available to the subsequent cash crop?

• The release of nitrogen by cover crops is dependent on soil moisture and temperature

• The nitrogen concentration of the cover crop is important
N Release Pattern from Cover Crops

Days After Incorporation of Cover Crop

Total Mineral Nitrogen (ppm)

- Legume Mix
- Mustard
- Oats

Smith & Brennan, 2003
Various legume, and non-legume, cover crops, Hartz, unpublished
# 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>
Cereal Residue
High C:N

Legume Residue
Lower C:N
Cover Crop Proteins

Microbes
Need carbon and nitrogen for their growth

Available Mineral Nitrogen
(Nitrate & Ammonium)

Rate of mineralization depends mostly on nitrogen concentration of the tissue
Nitrogen Release by Cover Crops

• The amount of N provided by the cover crop is important
• The nitrogen demand by the cash crop is also important to understand
Biomass Accumulation and Nitrogen Demand of Lettuce

- Rapid growth from 30 to 60 days following planting
- High Peak Demand for N

4-5 lbs Nitrogen/Acre/day
Peak Uptake Demand
Field Trial on Nitrogen Release and Crop Response

- A field study conducted by Rick Miller (1987-1988), conducted on the UCD farm, illustrates an optimal situation of a cover crop providing adequate amounts of N in synchrony with crop demand.
Nitrogen Content of Cover Crop Tops
Two Year Average (1987/1988)

Miller, 1989
Nitrogen Uptake in Grain lbs/A
Two Year Average (1987/1988)

Miller, 1989
Grain Yield lbs/A
Two Year Average (1987/1988)

Miller, 1989
Conclusions of this Study

• The release of N from the cover crop and the uptake demand of corn synchronized well

• This is an example of optimal use of nitrogen from the cover crop by the subsequent cash crop
### 2006 & 2007 Cover Crop & Fertilizer Trial - Salinas

<table>
<thead>
<tr>
<th>Year</th>
<th>Biomass T/A</th>
<th>N in Tops Percent</th>
<th>N in Tops lbs/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>3.21</td>
<td>3.1</td>
<td>194.5</td>
</tr>
<tr>
<td>2007</td>
<td>3.71</td>
<td>2.1</td>
<td>153.4</td>
</tr>
</tbody>
</table>

Smith and Muramoto, 2007
2006 Soil Mineral Nitrogen
Cover Crop Incorporation to Planting Broccoli

![Graph showing the comparison of Total Mineral N (mg/kg +/- SEM) between with and without cover crop over time from 21-Feb to 20-Apr. The blue line represents 'With cover crop' and the red line represents 'No cover crop.' The graph indicates variations in mineral nitrogen levels throughout the specified period.]
2007 Soil Mineral Nitrogen
Cover Crop Incorporation to Planting Broccoli
2006 Nitrogen in Broccoli Biomass lbs/A
At Harvest

![Graph showing the nitrogen content in broccoli biomass at harvest in 2006. The graph compares the biomass nitrogen for treatments with and without a cover crop, plotted against organic fertilizer application rates in lbs N/A. The graph indicates a positive correlation between nitrogen content and fertilizer application.]
2006 Nitrogen in Broccoli Biomass lbs/A At Harvest

- No cover crop
- With cover crop

63 lbs Fertilizer N
2007 Nitrogen in Broccoli Biomass lbs/A
At Harvest

![Graph showing nitrogen in broccoli biomass vs organic fertilizer application rate with data points for no cover crop and with cover crop.]
Broccoli Yield
2006 Trial

Bar graph showing broccoli yield (Tons/A) SEM with and without cover crop at different organic fertilizer application rates (0, 75, 150, 225 lbs N/A).
Broccoli Yield
2007 Trial

![Graph showing broccoli yield with and without cover crop at different organic fertilizer application rates.](image)
Summary of Cover Crop and Nitrogen Fertility Trial

When the nitrogen concentration in the cover crop was >3%, the cover crop provided the equivalent of 63 lbs of fertilizer N to the broccoli.

Cover crop N boosted the yield of broccoli at all fertilization rates.
Summary of Cover Crop and Nitrogen Fertility Trial

When the nitrogen concentration in the cover crop was 2%, the cover crop tied up nitrogen and it took 225 lbs of fertilizer N to overcome this effect.

The nitrogen concentration in the cover crop greatly affected N release to the subsequent cash crop.
Composition of Cover Crop Mixes

- Planting Date, weather conditions and soil fertility can affect the composition of cover crop mixes and can impact their nitrogen concentration at incorporation.
Comparison of Cover Crop Composition on Two Soil Types

black = cereal; gray = legume

Hollister Year 2

Salinas Year 2

Sandy loam, low fertility

Clay loam, high soil fertility

Brennan et al, in press
How Much Cover Crop N is Made Available for Crop Growth

- Cover crops can contain 100 – 200 lbs N but typically less than half of this is made available to the subsequent crop.
Mineralization of Mineral Nitrogen from Cover Crops

- Cover crops also play a larger role in soil building and provide a long-term source of N that contributes to total soil nitrogen content and that behaves the same as soil organic matter.
## Impacts of Organic Soil Building on Nitrogen Storage in Soil

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<tr>
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<th>Management</th>
<th>Total Soil N %</th>
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<tr>
<td>Clay Loam</td>
<td>Organic</td>
<td>0.17</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>Conventional</td>
<td>0.14</td>
</tr>
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<td>0.14</td>
</tr>
<tr>
<td>Loam</td>
<td>Conventional</td>
<td>0.11</td>
</tr>
<tr>
<td>Fine Sandy Loam</td>
<td>Organic</td>
<td>0.12</td>
</tr>
<tr>
<td>Fine Sandy Loam</td>
<td>Conventional</td>
<td>0.06</td>
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Smith, 2003
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Smith, 2003
Summary of Nitrogen Fertilization of Organic Horticultural Crops

• Some crops may be able to achieve economically acceptable yield from nitrogen from cover crop decomposition.

• Many crops (e.g. lettuce) generally need greater quantities of available mineral nitrogen to achieve economically viable yields.
Nitrogen Fertilization of Organic Horticultural Crops

- The key is for organic sources of N to mineralize in sufficient quantities and quick enough to meet crop demand
- Synchrony of supply and demand
Effective Synchrony Between Mineralization from the Various Sources and Crop Demand
Management of Cover Crops to Provide Nitrogen to Subsequent Cash Crops

- Cover crops should be incorporated in a juvenile enough stage to prevent immobilization of N:
  - Nitrogen content of the tops > 2.5%
    - Legumes at flowering or before
    - Cereals well before heading
Management of Cover Crops to Provide Nitrogen to Subsequent Cash Crops

- Allow sufficient time for the cover crops to decompose and release nitrate and ammonium.
- Manage water carefully to not leach available N below the root zone.
Thank you for your attention