Understanding nutrient release from cover crops

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The spectrum of agro-ecosystem services based on cover crop biomass

- **Biomass (Quantity and Quality)**
  - Water Quality
  - Soil Health
  - Nitrogen
  - Weeds
  - Water Infiltration
  - Erosion
  - SOM
  - Maximum agro-ecosystem services provisioned
Cover crop management drives performance
Cover crop management drives performance

Performance: (biomass quality and quantity)

- Intrinsic (climate and soil)
- Management
Legumes

- Fix nitrogen
- High tissue N concentration (3-4% N)
  - C:N ratio < 20
- Rapid N mineralization during decomposition
- Not very good at reducing N leaching
Legumes

When compared to:

1. Mineral fertilizers
   - Slower release rates
   - Lower energy use
   - Renewable resource

2. Animal Waste
   - No new P
   - No transport costs
   - Low volatility
Intrinsic (climate and soil) and management
(USDA hardiness zone: 5a to 8a)

University of Massachusetts
Masoud Hashemi

Cornell
Matt Ryan

Penn State
Bill Curran and John Spargo

USDA-ARS Beltsville, MD
Steven Mirsky

North Carolina State University
Chris Reberg-Horton
Hairy vetch biomass biomass across a seeding rate, latitude, and planting date gradient

North to South

<table>
<thead>
<tr>
<th></th>
<th>MA</th>
<th>NY</th>
<th>PA</th>
<th>MD</th>
<th>NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass (lb ac$^{-1}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seeding rate (kg ha$^{-1}$)</td>
<td>0</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
</tr>
</tbody>
</table>

Seeding date
- Optimal
- Late
Hairy vetch biomass biomass across a seeding rate, latitude, and planting date gradient

North to South

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Seeding rate (kg ha\(^{-1}\))

Biomass (lb ac\(^{-1}\))

Seeding date
- Optimal
- Late

2011-2012

2012-2013

93-156 lb PAN ac\(^{-1}\)
56-93 lb PAN ac\(^{-1}\)
18-31 lb PAN ac\(^{-1}\)
Grasses

- Tremendous N scavenging
- Erosion control
- Weed suppression as a mulch
- Growth limited by soil N
- Lower tissue N concentration (1-2%)
  - C:N ratio > 25
- Possible N immobilization during decomposition
- Excellent at reducing N leaching
# Cover Crop Biomass and Nitrogen Content at Select Growth Stages

<table>
<thead>
<tr>
<th>Species</th>
<th>Cover Crop Biomass (lb ac⁻¹)</th>
<th>C:N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(low range)</td>
<td>(mid range)</td>
</tr>
<tr>
<td>Grasses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tillering</td>
<td>300-700</td>
<td>700-1100</td>
</tr>
<tr>
<td>Stem elongation</td>
<td>1000-1600</td>
<td>1600-2400</td>
</tr>
<tr>
<td>Boot</td>
<td>1500-2500</td>
<td>2500-3500</td>
</tr>
<tr>
<td>Anthesis</td>
<td>2000-4250</td>
<td>4250-6750</td>
</tr>
<tr>
<td>Legumes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early termination</td>
<td>1000-2000</td>
<td>2000-3000</td>
</tr>
<tr>
<td>Mid termination</td>
<td>3000-4000</td>
<td>4000-5000</td>
</tr>
<tr>
<td>Late Termination</td>
<td>4000-5000</td>
<td>5000-6000</td>
</tr>
</tbody>
</table>

*Grasses include wheat, rye, barley, and triticale; Legumes is hairy vetch and some averaging from clovers*
Cereal rye (*Secale cereale*)

**Early Termination**
- Low C/N ratio (~27:1)
  - Mineralization
- Grown ~7 months
- Terminated early spring

**Late Termination**
- High C/N ratio (~48:1)
  - Immobilization
- Grown ~8 months
- 2.5x more biomass
- Terminated late spring
Late-March

Bare Ground

Total: 44 lb N ac\(^{-1}\)

Early Cover Crop Termination

Total: 30 lb N ac\(^{-1}\)

Late Cover Crop Termination

Total: 32 lb N ac\(^{-1}\)
Late-March

Bare Ground

Early Cover Crop Termination

Late Cover Crop Termination

Soil inorganic N (lb ac\(^{-1}\))

Depth (cm)

Total: 44 lb N ac\(^{-1}\)

Total: 30 lb N ac\(^{-1}\)

Total: 32 lb N ac\(^{-1}\)

1 Foot
Late kill (3000 lb/ac)

Early kill (750 lb/ac)
Nitrogen release over time
Nitrogen release over time

No-till

- Pure hairy
- 50/50 mix
- Pure rye

Tillage

- Pure hairy vetch
- 50/50 mix v
- Pure rye

Time (days)

N released (lb ac\(^{-1}\))

0 28 52 70 90 109 131
Decomposition of grass:legume cover crop mixtures

- Pure legume (hairy vetch)
- Pure cereal rye (grass)
- Broadcast Poultry litter

Proportion of mass remaining vs. Growing degree days and Days after termination.
Decision support tools for adaptive nitrogen management

Adapt-N & N Availability Calculator
Water and Nitrogen Dynamics on mid-Atlantic and Southeastern Farms
Water and Nitrogen Dynamics on mid-Atlantic and Southeastern Farms
C:N ratios:
- Hairy vetch (16:1); Cereal rye (83:1)
- 50:50 = 25

N immobilization/mineralization threshold of hairy vetch monocultures and mixtures
### Calculator Outputs

**COVER CROP NITROGEN AVAILABILITY CALCULATOR**

If you need instructions, click the **Instructions** tab above. Please answer the questions below and click "Next Page" when complete.

#### Background

Was the cover crop residue analyzed by the Agricultural and Environmental Services Labs?

- If so, please enter the Lab Number.
- IF NOT, leave blank and enter data from another laboratory in the section below.

<table>
<thead>
<tr>
<th>Please enter the field name</th>
<th>Front Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter the sample ID</td>
<td>1</td>
</tr>
<tr>
<td>To choose the closest weather station, what county is your farm located in? (OR Choose from interactive map.)</td>
<td>Clarke</td>
</tr>
<tr>
<td>Using weather station at:</td>
<td>Horticulture Research Farm</td>
</tr>
<tr>
<td>What is the CASH crop?</td>
<td>Select a crop: Broccoli</td>
</tr>
<tr>
<td>What is your target nitrogen fertilizer rate?</td>
<td>150 lbs N/acre</td>
</tr>
<tr>
<td>What is the planting date?</td>
<td>08/24/2015</td>
</tr>
<tr>
<td>What is the COVER CROP?</td>
<td>Select one or more cover crops: Cowpeas</td>
</tr>
<tr>
<td>When was the cover crop killed or incorporated?</td>
<td>08/01/2015</td>
</tr>
</tbody>
</table>
The cover crop is predicted to release 72 lbs of N per acre from the aboveground biomass over three months. This is a N credit.

The cover crop is predicted to release:
- 29 lbs of N per acre in the first two weeks after termination.
- 59 lbs of N per acre in the first four weeks after termination.

Your target nitrogen fertilizer rate was 150 lbs N/ac.

Your recommended N after the cover crop is 78 lbs N/ac.

The available N reported above from the cover crop decompositions is considered a N credit if positive or a debit if negative. The amount of N fertilizer recommended may be reduced by a credit or increased by a debit. Here are examples:

<table>
<thead>
<tr>
<th>N Credit Example:</th>
<th>N Debit Example:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended or Target N = 150 lbs N/ac</td>
<td>Recommended or Target N = 150 lbs N/ac</td>
</tr>
<tr>
<td>Predicted Cover Crop N = 50 lbs N/ac</td>
<td>Predicted Cover Crop N = - 20 lbs N/ac</td>
</tr>
<tr>
<td>Recommended N after Credit = 150 - 50 = 100 lbs N/ac</td>
<td>Recommended N after Debit = 150 - (-20) = 150 +20 = 170 lbs N/ac</td>
</tr>
</tbody>
</table>