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
- Maximum agro-ecosystem services provisioned

- Erosion
- Water Infiltration
- SOM
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>State</th>
<th>Plot 1</th>
<th>Plot 2</th>
<th>Plot 3</th>
<th>Plot 4</th>
<th>Plot 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
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<td>NY</td>
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<td>PA</td>
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<td>NC</td>
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</tbody>
</table>

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

Seeding date
- Optimal
- Late

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

Years:
- 2011-2012
- 2012-2013
- 2013-2014
Hairy vetch biomass biomass across a seeding rate, latitude, and planting date gradient

North to South

Seeding date
- Optimal
- Late

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

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

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><strong>Grasses</strong></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><strong>Legumes</strong></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 \((\textit{Secale cereale})\)

**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

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
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
Soil inorganic N (lb ac⁻¹)
Cereal rye decomposition in field corn

Proportion Mass Remaining vs Growing Degree Days

Late kill (3000 lb/ac)

Early kill (750 lb/ac)
Cereal rye decomposition

Cereal rye shoot biomass (lb/acre)

Days after planting
Nitrogen release over time
Decomposition of grass:legume cover crop mixtures

Proportion of mass remaining

Growing degree days

Days after termination

Pure cereal rye (grass)

Pure legume (hairy vetch)

Broadcast Poultry litter

Pure legume (hairy vetch)
Decision support tools for adaptive nitrogen management
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 - 30:1;

N immobilization/mineralization threshold 

C:N ratio 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**

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was the cover crop residue analyzed by the Agricultural and Environmental Services Labs?</td>
<td><img src="image" alt="Lab No." /> Lab No.</td>
</tr>
<tr>
<td>• If so, please enter the Lab Number.</td>
<td></td>
</tr>
<tr>
<td>• IF NOT, leave blank and enter data from another laboratory in the section below.</td>
<td></td>
</tr>
<tr>
<td>Please enter the field name</td>
<td>Front Field</td>
</tr>
<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?</td>
<td>Clarke</td>
</tr>
<tr>
<td>(OR Choose from <a href="#">interactive map</a>).</td>
<td></td>
</tr>
<tr>
<td>Using weather station at:</td>
<td>Horticulture Research Farm</td>
</tr>
<tr>
<td>What is the CASH crop?</td>
<td>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 mm/dd/yyyy</td>
</tr>
<tr>
<td>What is the COVER CROP?</td>
<td>Cowpeas</td>
</tr>
<tr>
<td>When was the cover crop killed or incorporated?</td>
<td>08/01/2015 mm/dd/yyyy</td>
</tr>
</tbody>
</table>
## Calculator Outputs

### COVER CROP NITROGEN AVAILABILITY CALCULATOR

**RESULTS:** Wide Bottom Farm — Front Field - 1

Your cover crop **Cowpeas** was terminated on **08/01/2015**.

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 = <strong>100</strong> lbs N/ac</td>
<td>Recommended N after Debit = 150 - (-20) = 150 +20 = <strong>170</strong> lbs N/ac</td>
</tr>
</tbody>
</table>
Questions