Understanding nutrient release from cover crops

Steven Mirsky
USDA-ARS, Beltsville, MD
The spectrum of agro-ecosystem services based on cover crop biomass

- Water Quality
- Soil Health
- Nitrogen
- Maximum agro-ecosystem services provisioned

- Biomass (Quantity and Quality)
- Erosion
- Water Infiltration
- SOM
- Weeds
Cover crop management drives performance

- Cover Crops
  - Planting Methods
  - Site-specific Mgmt.
  - Nutrient Inputs
  - Genetics
  - Species Composition
  - Weediness
  - Seed Costs
  - Methods of Termination
  - Seeding Rate
  - Timing of Mgmt.
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>Seeding rate (kg ha(^{-1}))</th>
<th>Biomass (lb ac(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>NY</td>
</tr>
<tr>
<td>0</td>
<td>2000</td>
</tr>
<tr>
<td>2000</td>
<td>4000</td>
</tr>
<tr>
<td>4000</td>
<td>6000</td>
</tr>
<tr>
<td>6000</td>
<td>8000</td>
</tr>
<tr>
<td>8000</td>
<td>10000</td>
</tr>
</tbody>
</table>

Seeding date
- Optimal
- Late

2011-2012

2012-2013

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

North to South

<table>
<thead>
<tr>
<th>State</th>
<th>Seeding rate (kg ha$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>93-156 lb PAN ac$^{-1}$</td>
</tr>
<tr>
<td>NY</td>
<td>56-93 lb PAN ac$^{-1}$</td>
</tr>
<tr>
<td>PA</td>
<td>18-31 lb PAN ac$^{-1}$</td>
</tr>
<tr>
<td>MD</td>
<td></td>
</tr>
<tr>
<td>NC</td>
<td></td>
</tr>
</tbody>
</table>

Seeding date
- Optimal
- Late

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

Seeding rate (kg ha$^{-1}$)
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 (*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
Total: 44 lb N ac\(^{-1}\)

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

Total: 32 lb N ac\(^{-1}\)
Total: 44 lb N ac\(^{-1}\)

Late-March

Bare Ground

Early Cover Crop Termination

Late Cover Crop Termination

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

Depth (cm)

1 Foot
Early-May

Bare Ground

Early Cover Crop Termination

Late Cover Crop Termination

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

Depth (cm)

Total: 33 lb N ac\(^{-1}\)

Total: 25 lb N ac\(^{-1}\)

Total: 11 lb N ac\(^{-1}\)
Late kill (3000 lb/ac)

Cereal rye decomposition in field corn

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

Tillage

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

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

Time (days)

0 28 52 70 90 109 131

0 50 100 150 200 250 300
Nitrogen release over time

No-till

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>28</th>
<th>52</th>
<th>70</th>
<th>90</th>
<th>109</th>
<th>131</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure hairy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50/50 mix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pure rye</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tillage

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>28</th>
<th>52</th>
<th>70</th>
<th>90</th>
<th>109</th>
<th>131</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure hairy vetch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50/50 mix v</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pure rye</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Decomposition of grass:legume cover crop mixtures
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 - 30:1;

N immobilization/mineralization threshold C:N ratio of hairy vetch monocultures and mixtures
### 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>Lab No.</th>
<th>1567</th>
</tr>
</thead>
</table>

**Please enter the field name**
- Front Field

**Enter the sample ID**
- 1

**To choose the closest weather station, what county is your farm located in?**
- Clarke

**Using weather station at:**
- Horticulture Research Farm

**What is the CASH crop?**
- Broccoli

**What is your target nitrogen fertilizer rate?**
- 150 lbs N/acre

**What is the planting date?**
- 08/24/2015 mm/dd/yyyy

**What is the COVER CROP?**
- Cowpeas

**When was the cover crop killed or incorporated?**
- 08/01/2015 mm/dd/yyyy
**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 **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