Function and benefit of green manures

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Grasses

Winter rye (or cereal rye)
Annual ryegrass
Oat
Barley
Triticale

• Establish and grow quickly
• Scavenge soil nitrogen
• High C:N ratio
Brassicas

Radish
Mustard
Turnip

- Slower to establish
- Scavenge soil nitrogen (even more than the grasses if given enough time)
- Medium C:N ratio
Legumes

- Red Clover
- Berseem Clover
- Crimson Clover
- Hairy Vetch

- Slower to establish
- Fix N from atmosphere
- Low C:N ratio
Why the C:N ratio matters

Soil microorganisms degrade plant material.

They need nitrogen to do this.

If plant material has a high C:N ratio (>30), then the soil microbes use the N in the soil.

If the plant material has a low C:N ratio (<20), then there plant material can supply more than enough N for the microbes and a lot of N is left over after the plant decomposes.
Nitrogen credits are determined as the difference between argonomically optimum N rates.
Yield response from Janesville in 2010 shows a 41 to 82 lb-N/ac N credit from red clover (plus yield gains).
Study locations in Wisconsin

- Red clover
- Berseem clover
- Crimson clover
- Radish
Frost-seeded red clover study at Arlington ARS

Funded by Wisconsin Fertilizer Research Council

2015

- April 1 – apply urea to wheat
- April 16 – interseed red clover and potash
- July 27 – harvest winter wheat grain
- Sept 8 – clipped clover to 4-6”
- October 26 – terminate red clover
  - 1 qt glyphosate and 1 qt 2,4 D

2016

- May 5 – plant corn
- June 13 (V4-6) – apply N, broadcast urea with Agrotain®
- Oct 25 – harvest corn
100 lb-N/ac in AGB
C:N = 14
Nitrogen credits were also measured at Arlington in 2016, although 16 bu/ac yield reductions

![Graph showing corn yield vs. nitrogen rate with regression results and nitrogen credit values.]

**Regression** | **N credit (lb-N/ac)**
--- | ---
Q | 32
LP | 57
QP* | 92

Legend:
- None
- Red Clover
Use of red clover reduced soil nitrate in the fall and increase soil nitrate at sidedress.

<table>
<thead>
<tr>
<th></th>
<th>Fall (0-1’)</th>
<th>Fall (1-2’)</th>
<th>PSNT (0-1’)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate-N (ppm)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>No cover</td>
<td>2.4</td>
<td>1.0</td>
<td>10.4</td>
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<tr>
<td>Red clover</td>
<td>0&lt;.1</td>
<td>&lt;0.1</td>
<td>20.5</td>
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</tbody>
</table>

0 lb-N/ac N credit

100 lb-N/ac N credit
Sheboygan County berseem and crimson clover study in 2015

- August 15, 2014 – covers planted
  - Berseem clover, 15 lb/ac
  - Crimson clover, 15 lb/ac
  - None

2015
- April 30 – Corn planting
- May 7 – Nitrogen fertilizer, broadcast urea with Agrotain®
  - 8 N rates (0, 40, 80, 120, 160, 200, 240, 280 lb/ac)
- Nov. 9 – Corn harvest
Crimson clover had 47 lb-N/ac in above ground biomass (C:N = 16)
Berseem clover had 75 lb-N/ac in above ground biomass (C:N=14)
Crimson Clover—Spring Residue

April 23, 2014
Crimson clover provides an N credit, both crimson and berseem clover provide yield benefits

<table>
<thead>
<tr>
<th>Regression</th>
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<tbody>
<tr>
<td>Q</td>
<td>88</td>
</tr>
<tr>
<td>LP</td>
<td>9</td>
</tr>
<tr>
<td>QP*</td>
<td>168</td>
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</tbody>
</table>

Corn Yield (bu/ac) vs Nitrogen Rate (lb-N/ac)
Crimson clover provides an N credit, both crimson and berseem clover provide yield benefits.
But no N credit based on PSNT

<table>
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<tr>
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<td>Nitrate-N (ppm)</td>
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<tr>
<td>No cover</td>
<td>3.5</td>
<td>3.3</td>
<td>8.6</td>
</tr>
<tr>
<td>Crimson</td>
<td>3.7</td>
<td>2.6</td>
<td>5.3</td>
</tr>
<tr>
<td>Berseem</td>
<td>3.7</td>
<td>3.2</td>
<td>8.7</td>
</tr>
</tbody>
</table>
Soil – Kewaunee Silt Loam

2015
- August 12 – Clovers planted (15 lb/ac)
- Sept. 4 – TSP and KCl
- Nov. 5 – Clover biomass sampling (end of growth)

2016
- May 8 – Corn planting
- June 20 – N fertilizer application, broadcast urea w/ Agrotain®
- Nov. 15 – Grain harvest
81 lb-N/ac in AGB  
C:N 11

70 lb-N/ac in AGB  
C:N 13
Crimson had the clearer N credit, Berseem had the clearer yield benefit.
There was plenty of nitrogen in the soil, no N credit of legumes relative to the no cover crop plots

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<tr>
<td>No cover</td>
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<tr>
<td>Crimson</td>
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<td>3.4</td>
<td>22.4</td>
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<tr>
<td>Berseem</td>
<td>7.8</td>
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<tr>
<td>Cover crop</td>
<td>Nitrogen credit</td>
<td>Yield difference</td>
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<tr>
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<td>-----------------</td>
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<tr>
<td></td>
<td>lb-N/ac</td>
<td>bu/ac</td>
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<tr>
<td>Red clover</td>
<td>46</td>
<td>27</td>
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<tr>
<td>Red clover</td>
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<tr>
<td>Crimson</td>
<td>46</td>
<td>2</td>
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</tr>
<tr>
<td>Berseem</td>
<td>40</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Berseem</td>
<td>15</td>
<td>13</td>
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<tr>
<td>Average</td>
<td>68</td>
<td>8</td>
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</tbody>
</table>
Review of Corn Yield Response under Winter Cover Cropping Systems Using Meta-Analytic Methods

Fernando E. Miguez and Germán A. Bollero*

68 observations (US & CA)

2005 publication

82 observations (US & CA)
Fig. 3. The cover crop biomass characteristics and soil NO$_3^-$-N concentrations used to calibrate Eq. [3] to predict corn yield response, averaged by cover crop treatment across all experiments. Cover crop treatments included in the data set are listed on the y-axis, with species codes used from Table 1. In the first and second columns are the cover crop biomass N content ($N_{cc}$) and C/N ratio ([C/N]$_{cc}$) for winterkilled and winter-hardy components of each treatment. In the third column are soil NO$_3^-$-N concentrations measured in the 0- to 20-cm depth segment at the time of cover crop termination in spring. In the fourth column, blue bars are the model prediction for the corn yield response ($\Delta Y$) and black dots are the measured $\Delta Y$ bounded by a 95% confidence interval of the mean. The $\Delta Y$ was calculated as the difference between the corn yield after a cover crop and the corn yield after no cover crop. Cover crop treatments are sorted in ascending order of $\Delta Y$ as predicted by the model.
The magnitude of the N credit of a legume will vary from year to year and site to site.

- Environmental factors like moisture and temperature are the drivers of decomposition and mineralization.
- Some sort of predictive model based on these factors would be necessary to fine-tune N recommendations when N is applied at sidedress.
- There are current efforts, both university and industry, to develop these models.
- In my opinion, this is the biggest gap in predictive model development – accurately predicting the release of N from organic sources (cover crops and manure).
Summary

- Clear N credit of red and crimson clover
- Yield benefits with most clovers
- No green manure N credit for radish

- Use of clovers in rotations with small grains enhance the benefit of the diversified rotation
Questions?
Comments?
Concerns?