Session 4: Estimating Nitrogen Credits
Outline

• Factors effecting nitrogen content of cover crop
• Factors effecting cover crop nitrogen availability to cash crop
• Major steps to estimating nitrogen credits
  • Biomass sampling of area of known sq. ft.
  • Assessment of biomass nitrogen content
  • Estimate of nitrogen release and availability to cash crop
Biological Nitrogen Fixation

Mineralization

Soil microbes mineralize organic nitrogen held in plant matter into plant available forms.

N\textsubscript{2}

How Legume Cover Crops Supply Nitrogen to Cash Crops

Summer cowpea cover crop

Fall broccoli cash crop

Nitrogen Uptake

Plant matter added to the soil

Mineralization

Soil microbes mineralize organic nitrogen held in plant matter into plant available forms.

Image: Amanda McWhirt
Legume Cover Crop Require Inoculants

- Ensure good seed coverage
- Can be added to the seed dry, some recommend a sticking agent
- Contain live organisms so avoid temperature extremes

<table>
<thead>
<tr>
<th>Legume</th>
<th>Recommended Inoculant Group(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowpeas, Lespedeza</td>
<td>Cowpeas or Lespedeza</td>
</tr>
<tr>
<td>Crimson clover, Berseem clover</td>
<td>Crimson or Berseem</td>
</tr>
<tr>
<td>Field peas, Hairy vetch, Lentil</td>
<td>Pea or Vetch</td>
</tr>
<tr>
<td>Red clover</td>
<td>Red clover or White clover</td>
</tr>
<tr>
<td>White clover</td>
<td></td>
</tr>
<tr>
<td>Subterranean clover</td>
<td>Subterranean clover or Clover or Rose clover</td>
</tr>
<tr>
<td>Sunn hemp</td>
<td>Cowpea EL (based on Abdul-Baki et al., 2001)</td>
</tr>
<tr>
<td>Velvetbean</td>
<td>Cowpea EL (based on Piper and Morse, 1928)</td>
</tr>
</tbody>
</table>
## How much nitrogen can cover crops fix?

<table>
<thead>
<tr>
<th>Legume</th>
<th>Total Nitrogen Content of the Cover Crop Biomass $^{1}$ (Total lbs. /acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austrian pea</td>
<td>90-150</td>
</tr>
<tr>
<td>Crimson Clover</td>
<td>70-130</td>
</tr>
<tr>
<td>Vetch</td>
<td>90-200</td>
</tr>
<tr>
<td>Cowpea</td>
<td>50-150</td>
</tr>
<tr>
<td>Soybean</td>
<td>50-150</td>
</tr>
</tbody>
</table>

For reference: Tomato nitrogen requirements range from 90-200 lbs. of Nitrogen. (Total season)$^{10}$
Factors Affecting Nitrogen Content of Cover Crop

- **Cover crop mixes**
  - Mixes with higher proportions of legumes will have higher N content
- **Inoculation**
  - Legumes must have active rhizobia and root nodules to fix Nitrogen.
  - May require an inoculant
- **Different legumes species fix different amounts of N and have different biomass potentials.**
  - Consider seed costs and potential lbs. N/ acre fixed.
- **Cover crop stand**
  - Amount of N is dependent on the amount of biomass produced
- **Available soil N**
  - High soil N will inhibit legume reliance on biological nitrogen fixation
- **Cover crop age**
  - Established legumes fix more N than young seedlings.
  - Peak nitrogen content in green *aboveground* tissue generally occurs at or just before bloom.
Estimating Nitrogen Credits from Cover Crops

Assess biomass
- Known dry weight per known area
- Estimate Total Nitrogen
  - From established ranges
  - Send material to be tested at lab
- Estimate Available Nitrogen
  - Estimate how much of the total nitrogen will be available to the cash crop
    - 50% is a good rule of thumb

- This method does not include nitrogen in the plant roots in the estimation, the amount of below ground N is variable but release tends to be very quick after termination

\[^{13}\]
Example Estimating Nitrogen Credits from Cover Crops

Example:

Biomass (lb.)/Acre = (Total weight of dried samples (lb.)/ # square feet sampled) \( \times \) (43,560 sq. ft./Acre)

Then multiply by percent nitrogen in the plant tissue

– General Estimates: Annual legumes 3.5-4.0% N in their aboveground parts prior to FLOWERING and 3.0-3.5% percent at flowering. \(^1\)

Example: 37 grams = 37/454 g per lb. = 0.081 lb
(0.081 lbs./ 2.25 sq. ft. sampling square= 0.036) \( \times \) (43,560/1) = 1,577 lbs. of biomass per acre \( \times \) 3% N = 47.33 lbs. of Total Nitrogen
Factors Affecting Nitrogen Return to Cash Crop

• Crop biomass incorporated or on soil surface
  – Some sources estimate up to 25% less Nitrogen from the cover crop will be returned to the cash crop if the residue is left on the soil surface rather than incorporated; other estimates suggest no difference between surface application and soil incorporation for the Southeast.¹
  – Nitrogen can be lost from cover crop residues due to microbial activity.¹

• Soil temperature ²
  – Influences soil biological activity

• Soil moisture ²
  – Influences soil biological activity

• C:N ratio of biomass²
  – Immobilization (tie up) >30:1
  – Mobilization (release) <15:1

• Time
  – General rule of thumb has suggested much of the plant available Nitrogen (50-75%) supplied by the cover crop is released 4-6 weeks after incorporation or termination
    • So if the nitrogen credit was estimated to be 60lbs; 30-45 lbs. of that will have become available in the first 4-6 weeks after termination
C:N Ratio of Cover Crops Residues and N Mineralization / Immobilization

- **High N content**: 5:1 Clovers, 10:1 Peas, 15:1 Radish
- **Neutral**: 20:1 Canola, Cereal rye, triticale, Annual ryegrass
- **Low N content**: 30:1, 40:1 Oats

N mineralization: Microbes release excess N to soil
N Immobilization: Microbes tie up N from soil

(C. White, 2014. Penn State Univ.)
Timing of Cover Crop Nitrogen Release and Cash Crop Demand

Figure 1. Timing of nitrogen mineralization from soil organic matter, cover crop residue, and organic fertilizer in relation to crop nitrogen uptake.

Source: Gaskell and Smith, 2007
# Nutrient Inputs from Legume Cover Crops and Cover Crop Mixes

Estimates of Lbs./ Acre of **Plant Available**\(^1\) N, Total P\(_2\)O\(_5\), K\(_2\)O and C:N Ratios of Summer Cover Crop Mixes

<table>
<thead>
<tr>
<th>Cover Crop Mix</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>C:N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>21.6</td>
<td>4.7</td>
<td>46.0</td>
<td>25:1</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>21.0</td>
<td>5.2</td>
<td>54.0</td>
<td>28:1</td>
</tr>
<tr>
<td>Buckwheat + Millet</td>
<td>15.8</td>
<td>8.3</td>
<td>53.1</td>
<td>36:1</td>
</tr>
<tr>
<td>Buckwheat + Sudan</td>
<td>18.2</td>
<td>5.1</td>
<td>45.1</td>
<td>38:1</td>
</tr>
<tr>
<td>Cowpea</td>
<td>51.1</td>
<td>6.6</td>
<td>59.3</td>
<td>17:1</td>
</tr>
<tr>
<td>Cowpea + Millet</td>
<td>28.3</td>
<td>6.2</td>
<td>58.1</td>
<td>35:1</td>
</tr>
<tr>
<td>Cowpea + Sudan</td>
<td>31.3</td>
<td>6.1</td>
<td>34.7</td>
<td>32:1</td>
</tr>
</tbody>
</table>

\(^1\)Based off an estimate that 50% of the total Nitrogen would be available to the cash crop

*Based off results from of two site locations in Arkansas in 2016*
Calculators: Cover Crop Nitrogen Credits

• Combine estimated nitrogen contents of the cover crop with temperature or weather data to estimate nitrogen release patterns.

– Georgia:

http://aesl.ces.uga.edu/mineralization/

***Relies on local weather stations in Georgia***
# Costs of Cover Crop Nitrogen

## Estimates of Cover Crop Seeding Costs per Acre

<table>
<thead>
<tr>
<th></th>
<th>Broadcast Seeding Rate, lbs/acre</th>
<th>Seed Cost, $/50lbs</th>
<th>Seed Cost, $/lb</th>
<th>Seed Cost, $/acre</th>
<th>Average Dry Biomass, lbs/acre</th>
<th>Average Dry Weed Biomass, lbs/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Black Oats</strong></td>
<td>100</td>
<td>25.00</td>
<td>0.50</td>
<td>50.00</td>
<td>52.25</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Cereal rye</strong></td>
<td>100</td>
<td>22.00</td>
<td>0.44</td>
<td>44.00</td>
<td>50.39</td>
<td>0.09</td>
</tr>
<tr>
<td><strong>Winter Wheat</strong></td>
<td>90</td>
<td>25.00</td>
<td>0.50</td>
<td>45.00</td>
<td>61.6</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>Austrian Pea</strong></td>
<td>50</td>
<td>40.00</td>
<td>0.80</td>
<td>40.00</td>
<td>14.15</td>
<td>5.58</td>
</tr>
<tr>
<td><strong>Crimson Clover</strong></td>
<td>12</td>
<td>60.00</td>
<td>1.20</td>
<td>14.40</td>
<td>16.06</td>
<td>2.76</td>
</tr>
<tr>
<td><strong>Mustard</strong></td>
<td>10</td>
<td>120.00</td>
<td>2.40</td>
<td>24.00</td>
<td>32.12</td>
<td>3.44</td>
</tr>
<tr>
<td><strong>Sodbuster Radish</strong></td>
<td>10</td>
<td>80.00</td>
<td>1.60</td>
<td>16.00</td>
<td>45.84</td>
<td>16.39</td>
</tr>
<tr>
<td><strong>Hairy Vetch</strong></td>
<td>20</td>
<td>110.00</td>
<td>2.20</td>
<td>44.00</td>
<td>114.34</td>
<td>0.64</td>
</tr>
<tr>
<td><strong>Sorghum Sudan</strong></td>
<td>40</td>
<td>80.00</td>
<td>1.60</td>
<td>64.00</td>
<td>$0.44</td>
<td>0.27 per lb of N</td>
</tr>
<tr>
<td><strong>Pearl Millet</strong></td>
<td>30</td>
<td>80.00</td>
<td>1.60</td>
<td>48.00</td>
<td>$0.20</td>
<td>0.11 per lb of N</td>
</tr>
<tr>
<td><strong>Japanese Millet</strong></td>
<td>30</td>
<td>40.00</td>
<td>0.80</td>
<td>24.00</td>
<td>$0.48</td>
<td>0.22 per lb of N</td>
</tr>
<tr>
<td><strong>Cowpea</strong></td>
<td>80</td>
<td>40.00</td>
<td>0.80</td>
<td>64.00</td>
<td>$1.28</td>
<td>0.42 per lb of N</td>
</tr>
<tr>
<td><strong>Soybean</strong></td>
<td>90</td>
<td>40.00</td>
<td>0.80</td>
<td>72.00</td>
<td>$1.44</td>
<td>0.48 per lb of N</td>
</tr>
<tr>
<td><strong>Velvet Bean</strong></td>
<td>40</td>
<td>175.00</td>
<td>3.50</td>
<td>140.00</td>
<td>$0.44</td>
<td>0.27 per lb of N</td>
</tr>
<tr>
<td><strong>Lablab</strong></td>
<td>40</td>
<td>250.00</td>
<td>5.00</td>
<td>200.00</td>
<td>$0.20</td>
<td>0.11 per lb of N</td>
</tr>
<tr>
<td><strong>Buckwheat</strong></td>
<td>60</td>
<td>50.00</td>
<td>1.00</td>
<td>60.00</td>
<td>$0.48</td>
<td>0.22 per lb of N</td>
</tr>
<tr>
<td><strong>Sunflower</strong></td>
<td>15</td>
<td>45.00</td>
<td>0.90</td>
<td>13.50</td>
<td>$1.28</td>
<td>0.42 per lb of N</td>
</tr>
<tr>
<td><strong>Chinese Red Pea</strong></td>
<td>20</td>
<td>50.00</td>
<td>1.00</td>
<td>20.00</td>
<td>$0.20</td>
<td>0.11 per lb of N</td>
</tr>
</tbody>
</table>

*These are only rough estimates. Seeding rates and local conditions will influence the potential nitrogen credit obtained by various legumes and seed prices vary by region and year. Estimates obtained based off of two years of data.*
Take Home Message

• Legume cover crops can supply large quantities of nitrogen to subsequent cash crops

• We can make estimates of how much of that nitrogen will become plant available
  — These are generally only well educated estimates due to the reliance on biological processes to release the nitrogen into plant available forms that are impacted by temperature and moisture
Authors and Acknowledgements

This presentation was prepared by Dr. Amanda McWhirt, Matt Fryer and Dr. Jackie Lee with support from a Southern SARE Professional Development Program Grant (RD309-137 / S001419 – ES17-135) and are provided by the USDA-SARE program to educators and producers for outreach and educational purposes. These presentations were further reviewed by Dr. Trent Roberts and Dr. Bill Robertson.
Resources and Sources


2. Virginia NRCS Cover Crop Planning Manual 1.0


10. Southeastern vegetable crop handbook https://content.ces.ncsu.edu/southeastern-us-vegetable-crop-handbook

