Using Green Manure Crops for Nitrogen Management

National Alliance of Independent Crop Consultants
2009 Annual Meeting
Memphis TN
January 28-31

Donald J. Boquet
Professor of Agronomy
LSU AgCenter
Crimson clover in Missouri in early May

Self reseeding crimson clover in Missouri in October

Hairy vetch in early April in Louisiana

Crimson clover in Alabama in early March
Contributors to this presentation

Jac Varco, Mississippi State Univ.
Charles Burmester, Auburn Univ.
Charles Mitchell, Auburn Univ.
Gene Stevens, Univ. of Missouri
Glen Harris, Univ. of Georgia
Rick Mascagni, LSU AgCenter
Robert Hutchinson, LSU AgCenter
M.G. Wagger, N.C. State
Seth Dabney, USDA
Eddie Millhollon, LSU AgCenter
W. L. Hargrove, Univ. of Georgia
Three-part presentation

1. Introduction

2. Legume crops and potential N - Establish the expectations for biomass production and N contribution.

3. Crop yield responses to legumes.

photo courtesy of Gene Stevens, Univ. of Missouri
Questions from farmers and county agents last fall

Which legume should I plant?
How much N will I get from the cover crop and when will it be available?
What is the procedure for measuring the N content in the legume?
Will I still have to apply some fertilizer N?

Cotton planted in hairy vetch residue

Cotton planted in Austrian winter pea residue
Winter legumes’ biomass contain from 100 to 150 lb N/acre in early spring.

Up to 80% of this N can be available for the following summer crop.

Based on past research, the best overall legume is hairy vetch followed by several of the clover species and by winter peas.

Cotton planted in hairy vetch residue

Cotton planted in Austrian winter pea residue
Legumes should be chosen for early growth, total N and tolerance to cold.

The largest impediment to effective use of winter cover crops for N is the conflict with maximum N fixation time (early spring) and planting of the following summer crop.

Cotton planted in hairy vetch residue
Cotton planted in Austrian winter pea residue
<table>
<thead>
<tr>
<th>Legume crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Vetches (hairy, common, big flower)</td>
</tr>
<tr>
<td>- Winter peas (Austrian, Caly, Roughpea, Singletary)</td>
</tr>
<tr>
<td>- Clovers - Crimson, Berseem, Arrowleaf, Bur, Sub, Red, White, many others)</td>
</tr>
<tr>
<td>- Medics – Barrel medic, annual lucerne</td>
</tr>
<tr>
<td>- Lupines – White, blue and yellow</td>
</tr>
</tbody>
</table>
Why plant legume crops?

- Relative cost of other N sources
  - Inorganic fertilizers
  - Organic (poultry litter, gin trash, composts)
- Soil organic matter increase
- Soil quality improvement
- Winter ground cover for BMPs
- Intangibles (improved soil tilth & biology)
Why not plant legume crops?

- Relative cost of other N sources
- Uncertainty of production
- Time management – fall planting; possible delay with spring planting preparation and planting itself.
- The unknowns – Depletion of soil water; increase nematode numbers? diseases?; termination timing and cost.
A little history of crop responses to specific legumes
Cotton yield following legume crops, LSU AgCenter Northeast Research Station, 22 years, 1929-51.

Data from C.B. Haddon from 36 species evaluated
1. Expectations for biomass and available legume N?

Specific legumes

*Results will differ for locations due to specific varieties, weather, and harvest timing.*
Cover crop biomass yield with time of harvest (termination) in Louisiana.

Harvest or termination date

- Crimson
- Berseem
- Arrowleaf
- Sub
- BF vetch

lb/acre

20 Mar 10 Apr 1 May 22 May
Nitrogen content of legume crops with time of harvest in Louisiana.

- Crimson
- Berseem
- Arrowleaf
- SubBF vetch

Harvest or termination date:
- 20 Mar
- 10 Apr
- 1 May
- 22 May

Lb N/acre
Nitrogen content of legume crops at two harvest dates in North Carolina.

Data from M.G. Wagger, N.C. State
Above ground biomass yield and N content of legume cover crops in LA, 5 yr. avg., 1986-90.

<table>
<thead>
<tr>
<th>Biomass</th>
<th>N content</th>
</tr>
</thead>
<tbody>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Hairy vetch</td>
<td>3402</td>
</tr>
<tr>
<td>Crimson clv. (Chief)</td>
<td>5535</td>
</tr>
<tr>
<td>Bigflower vetch</td>
<td>3238</td>
</tr>
<tr>
<td>Austrian winter pea</td>
<td>2902</td>
</tr>
<tr>
<td>Roughpea (Caley)</td>
<td>3364</td>
</tr>
<tr>
<td>Berseem clv.</td>
<td>4624</td>
</tr>
</tbody>
</table>

Data from Seth Dabney, formerly LSU AgCenter, now USDA
Above ground biomass yield and N content of legume cover crops in LA, 5 yr. avg., 1986-90.

<table>
<thead>
<tr>
<th>Cover Crop Type</th>
<th>Yield</th>
<th>N Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrowleaf clv. ‘Amclo’</td>
<td>4746</td>
<td>135</td>
</tr>
<tr>
<td>Subterranean clv.</td>
<td>3844</td>
<td>118</td>
</tr>
<tr>
<td>Bur clv. ‘Serena’</td>
<td>5119</td>
<td>150</td>
</tr>
<tr>
<td>Lupin ‘Tifblue 78’</td>
<td>5342</td>
<td>143</td>
</tr>
<tr>
<td>Barrel medic ‘Paraggio’</td>
<td>4254</td>
<td>124</td>
</tr>
<tr>
<td>Common vetch</td>
<td>3549</td>
<td>105</td>
</tr>
<tr>
<td>‘Cahaba White’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data from Seth Dabney, formerly LSU AgCenter, now USDA
Above ground biomass yield and N content of legume cover crops in Mississippi, 4 yr. avg.

<table>
<thead>
<tr>
<th></th>
<th>Biomass</th>
<th>N content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hairy vetch</td>
<td>4130</td>
<td>117</td>
</tr>
<tr>
<td>Crimson clv. ‘Chief’</td>
<td>6060</td>
<td>131</td>
</tr>
<tr>
<td>Bigflower vetch</td>
<td>3480</td>
<td>88</td>
</tr>
<tr>
<td>Austrian winter pea</td>
<td>3050</td>
<td>81</td>
</tr>
<tr>
<td>Berseem clv. ‘Bigbee’</td>
<td>4820</td>
<td>93</td>
</tr>
<tr>
<td>Arrowleaf clv. ‘Amclo’</td>
<td>2980</td>
<td>56</td>
</tr>
<tr>
<td>Subterranean clv. ‘Mt. Barker’</td>
<td>1230</td>
<td>21</td>
</tr>
</tbody>
</table>

*Data from Jac Varco, Mississippi State*
Nitrogen content of legume crops in Louisiana and Mississippi research

Data from Jac Varco, Mississippi State and Seth Dabey, USDA
Above ground biomass yield and N content of legume cover crops in Alabama, 2 yr. avg.

<table>
<thead>
<tr>
<th></th>
<th>Biomass</th>
<th>N content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>--------</td>
<td>-----------</td>
</tr>
<tr>
<td>Hairy vetch</td>
<td>3440</td>
<td>133</td>
</tr>
<tr>
<td>Crimson clv. ‘Tibbee’</td>
<td>3900</td>
<td>91</td>
</tr>
<tr>
<td>Common vetch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Cahaba white’</td>
<td>3480</td>
<td>105</td>
</tr>
<tr>
<td>Common vetch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘AU Early Cover’</td>
<td>3050</td>
<td>139</td>
</tr>
</tbody>
</table>

Data from Charles Mitchell, Auburn
# Winter survival of legume cover crops in Louisiana across 5 years

<table>
<thead>
<tr>
<th>Cover Crop Type</th>
<th>Total Trials</th>
<th>Lost Trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hairy vetch</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Crimson clv. ‘Tibbee’</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Bigflower vetch</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Austrian winter pea</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Berseem clv.</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Rough (Caley) pea</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Subterranean clv.</td>
<td>17</td>
<td>0</td>
</tr>
</tbody>
</table>

*Data from Seth Dabney, formerly LSU AgCenter, now USDA*
## Winter survival of legume cover crops in Louisiana across 5 years

<table>
<thead>
<tr>
<th>Species</th>
<th>Total trials</th>
<th>No. lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrowleaf clv. ‘Amclo’</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>Ball clv. ‘Segrest’</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Barrel medic ‘Paraggio’</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Common vetch</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>‘Cahaba White’</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lupin ‘Tifblue 78’</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Sour clv.</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Bur clv. ‘Serena’</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Red clv. ‘Chesapeake’</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>

*Data from Seth Dabney, formerly LSU AgCenter, now USDA*
3. Yield responses following legume cover crops?

Are responses related to: N, crop residue, other nutrients, other factors?
Nitrogen release curve for legume residue

Days after crop termination

Percent N mineralized
Cotton lint yield response to N rate and cover crop on silt loam, 5 yr. avg.

- **Native veg**
  - $R^2 = 0.39$

- **H. vetch**
  - $R^2 = 0.99$
Cotton lint yield response to N rate and cover crop on Sharkey clay, 2-yr avg.

- A graph showing the relationship between Lint yield (lb/a) and Fertilizer N rate (lb/a) for Vetch and Native veg.

Vetch:
- R² = 0.87
- Lint yield ranges from 600 to 1200 lb/a

Native veg:
- R² = 0.99
- Lint yield ranges from 200 to 1400 lb/a
Cotton yield following legume crops, LSU AgCenter Red River Research Station, 50 year avg., 1955-2008.

Data from Eddie Millhollon, LSU AgCenter
Corn grain yield response to N rate and cover crop on Sharkey clay in Louisiana, 3-yr avg.

Data from H.J. Mascagni, LSU AgCenter
Corn grain yield response to N rate and cover crop on Sharkey clay in Kentucky, 5-yr avg.

Data from S.J. Ebelhar, Univ. of Kentucky
Cotton lint yield response to N rate and cover crop on Tiptonville sandy loam, in Missouri, 4-yr avg.

From Gene Stevens, Univ. of MO
Cotton lint yield (rainfed) response to tillage and cover crop in Alabama, “Old Rotation” 10-year avg.

<table>
<thead>
<tr>
<th>Cover crop</th>
<th>Lint yield</th>
<th>Corn yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>390c</td>
<td>------</td>
</tr>
<tr>
<td>Crimson clv.</td>
<td>1060b</td>
<td>------</td>
</tr>
<tr>
<td>120 lb N/ac</td>
<td>1170b</td>
<td>------</td>
</tr>
</tbody>
</table>

Data from Charles Mitchell, Auburn
Cotton lint yields following legume cover crops in Alabama.

<table>
<thead>
<tr>
<th>Legume crop</th>
<th>Lint yield (lb/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hairy vetch</td>
<td>1290</td>
</tr>
<tr>
<td>Crimson clv. ‘Tibbee’</td>
<td>1430</td>
</tr>
<tr>
<td>100 lb N/ac</td>
<td>1450</td>
</tr>
<tr>
<td>No fertilizer N</td>
<td>760</td>
</tr>
</tbody>
</table>

Data from Charles Mitchell, Auburn
Grain sorghum grain yield response to N rate and cover crop on sandy loam in Georgia, 3-yr avg.

Data from W.L. Hargrove, Univ. of Georgia
Annual net returns for winter cover crop and cotton cropping sequences in a BMP study – 2007-2008.  (FAL, winter fallow; WGM, wheat green manure; COT, cotton)

Economic analysis by Dr. Kenneth Paxton
Wrap up - and general comments
Advantages for hairy vetch as green manure cover crop

- Total Biomass not excessive, but high in N. Residue does not interfere with planting
- N release from residue up to 80% within four months, fastest of all legumes.
- Terminates fairly easily with correct herbicides.
- Most consistent among tested legumes in N supplied. Very cold tolerant.
Disadvantages for hairy vetch as green manure cover crop

- Slow to establish ground cover.
- Susceptible to nematodes when soil temperature above 70 degrees.
- Needs those last two weeks of spring growth for maximum N fixation, so there may be a conflict with planting the summer crop.
Advantages for crimson clover as green manure cover crop

- Rapid and complete winter ground cover. (Total biomass can actually be excessive.)
- Terminates fairly easily with correct herbicides.
- Consistent among tested legumes in N supplied. Very cold tolerant.
Disadvantages for crimson clover as green manure cover crop

- Needs to be planted in September for best results. Conflicts with harvest.
- N release is slower than vetch.
- Yield responses of cotton and corn have not been consistent.
Advantages for winter peas as green manure cover crop

- Good early growth.
- Terminates easily with correct herbicides.
- Very cold tolerant.
- Caly pea (Roughpea) better than Austrian for N fixation.
Disadvantages for winter peas as green manure cover crop

- Ground cover usually not extensive.
- Susceptible to nematodes when soil temperature above 70 degrees.
- Has not consistently produced large amounts of N.
Status of lupin(e)s as green manure
cover crop

- Excellent potential for biomass and N fixation but needs genetic improvement.
- Very tolerant to low soil pH.
- Not as cold tolerant as vetch or clovers.
- Very Susceptible to nematodes and root rots.
Cultural practices for legumes

- Plant on raised beds for drainage.
- Drilling is best but clovers can be broadcast (after cotton defoliate is applied).
- Inoculate with correct inoculants. Each legume has their own special strains of inoculants.
Cultural practices for legumes

- Plan termination for as late as possible to allow for growth and N fixation in late winter/early spring (especially important with vetches). Two weeks delay will double the biomass and increase N content by 40%.

- Tillage not necessary but will increase N release rate. Benefits of no-till should be considered.
Future for legumes

- Use will increase at some point depending mostly on prices for fertilizer N.

- Will likely be great funding opportunities for research to improve varieties that are earlier and more effective.

- Opportunity for placing a ceiling on fertilizer N prices. Legume N can be produced for less when fertilizer N prices are high.
Alternatives to winter legumes

- Summer or tropical legumes planted in August after corn or grain sorghum harvest.

- Sun Hemp or soybean — These have a high N fixation capacity compared with winter legumes.
Thank You

Questions?

Crimson clover in Missouri in early May.

Hairy vetch in early April in Louisiana.