Managing Nitrogen with Cover Crops

Steven Mirsky
USDA-ARS, Beltsville, MD
Legumes

- Growth not limited by soil N
- 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
Hairy vetch (*Vicia villosa*)

- Winter annual legume
- Seed at 20-30 lb/ac; 0.5-1.5” deep
- High biomass producer (4000-7000 lb/ac)
  - Produce more than 150 lb N/ac
    - Good weed control
- Disease suppression in vegetables
Crimson clover *(Trifolium incarnatum)*

- Winter annual legume
- Seed at 8-15 lb/ac; 0.25-0.5” deep
  - Biomass (1000-3500 lb/ac)
- Produce more than 130 lb N/ac
  - Improves soil structure
Austrian winter peas (*Pisum sativum*)

- Winter and spring annual
- Seed at 50-80 lb/ac; 1-2” deep
- Biomass (1000-3500 lb/ac)
- Produce more than 130 lb N/ac
- Improves soil structure/reduces compaction
Total above ground plant available nitrogen from hairy vetch (lb PAN ac\(^{-1}\))

<table>
<thead>
<tr>
<th>Location</th>
<th>Biomass (kg ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA</td>
<td>18-31 lb PAN ac(^{-1})</td>
</tr>
<tr>
<td>NY</td>
<td>56-93 lb PAN ac(^{-1})</td>
</tr>
<tr>
<td>PA</td>
<td>56-93 lb PAN ac(^{-1})</td>
</tr>
<tr>
<td>MD</td>
<td>93-156 lb PAN ac(^{-1})</td>
</tr>
<tr>
<td>NC_Gold</td>
<td>93-156 lb PAN ac(^{-1})</td>
</tr>
<tr>
<td>NC_Sali</td>
<td>93-156 lb PAN ac(^{-1})</td>
</tr>
<tr>
<td>NC_Kin</td>
<td>93-156 lb PAN ac(^{-1})</td>
</tr>
</tbody>
</table>
Need covers for multiple functions

- No-till has soil conservation benefits
- Successful due to herbicides/herbicide resistant crops
Nutrient supply vs. weed control

- Grasses: High weed suppression, low N supply
  - Cereal rye (*Secale cereale* L.)

- Legumes: Low weed suppression, high N supply
  - Hairy vetch (*Vicia villosa* Roth)
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
Cereal rye nitrogen content across a fall fertilizer gradient

Fall nitrogen application rate (kg ha$^{-1}$)
Cover crop biomass across mixture proportions

North Farm 2012

Biomass, Mg ha\(^{-1}\)

Hairy vetch/Cereal rye seeding rate (proportion of monoculture)
Cover crop biomass across mixture proportions

North Farm 2012

Biomass, Mg ha\(^{-1}\)

Hairy vetch/Cereal rye seeding rate (proportion of monoculture)
Cover crop biomass across mixture proportions

North Farm 2012

Biomass, Mg ha⁻¹

0  10  15

Cereal rye monoculture

Total

Rye

Vetch

Hairy vetch monoculture

Hairy vetch/Cereal rye seeding rate (proportion of monoculture)
Cover crop biomass across mixture proportions

Meta-analysis (Poffenbarger et al. 2014)
Mixture vs. monocultures

- > biomass
- = 50% legume content equivalent to pure legume
- Drivers for over yielding: proportion, seed applied, and GDD
C:N ratio of hairy vetch monocultures and mixtures

C:N ratios:
- Hairy vetch (16:1)
- Cereal rye (83:1)

50:50 = 25-30:1;
N immobilization/mineralization threshold
C:N ratios:
Hairy vetch (16:1);
Cereal rye (83:1)

50:50 = 25-30:1;
N immobilization/mineralization threshold
Cereal rye and hairy vetch monoculture and mixture N content
Cereal rye and hairy vetch monoculture and mixture N content

North Farm 2012

South Farm 2012

North Farm 2013

South Farm 2013
Nutrient management

Determine the right: rate, source, time, and placement

• Focus is on reducing potential for losses:
  – Leaching
  – Erosion
  – Volatilization

• Increasing use efficiency
  – lowers cost of production and conserves natural resources

Penn State Extension
Improving nitrogen mgmt. in corn

V6: Period of greatest N uptake

University of Illinois
Cover crop decomposition and N release
Nitrogen release over time

Tillage

Pure hairy vetch

50/50 mix

Pure rye

N released (lb ac⁻¹)

Time (days)
Nitrogen release over time

No-till

- Pure hairy
- 50/50 mix
- Pure rye

Tillage

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

N released (lb ac⁻¹)

Time (days)
Moving beyond C:N ratios to quality
(decision support tools for growers; water and nitrogen)

Call for farmers to participate
Effects of hairy vetch and mineral fertilizer on corn yield

![Graph showing the effects of hairy vetch and mineral fertilizer on corn yield. The graph plots corn grain yield (Mg ha⁻¹) against fertilizer N (kg ha⁻¹). The dashed line represents 'With vetch' and the solid line represents 'No hairy vetch'. The graph indicates that 'With vetch' consistently yields more corn grain compared to 'No hairy vetch' across different fertilizer N levels.]
Managing N in cereal covers

(may need to adjust split application rates)
Balancing N needs with P concerns

- legume cover crops + organic amendments
- apply amendments at P removal rates
- soil reserves as “buffer”
Poultry litter nutrient properties

<table>
<thead>
<tr>
<th>Nutrient pool</th>
<th>lbs/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N</td>
<td>60</td>
</tr>
<tr>
<td>NH4-N</td>
<td>14</td>
</tr>
<tr>
<td>Org-N</td>
<td>46</td>
</tr>
<tr>
<td>PAN</td>
<td>42</td>
</tr>
<tr>
<td>P2O5</td>
<td>58</td>
</tr>
<tr>
<td>K2O</td>
<td>52</td>
</tr>
</tbody>
</table>


• N-based rate: Need ~3 tons/acre to supply 140 lbs PAN/acre
  • 174 lbs P2O5/acre
  • 156 lbs K2O/acre

• P-based rate: Need ~1.5 tons/acre to supply 85 lbs P2O5/acre
  • 63 lbs PAN/acre
  • 78 lbs K2O/acre
Poultry litter N availability over time

Total ammonium and nitrate; g N kg\(^{-1}\) amendment

- PL
- PPL
- PFMB
- FM

Time, d
• N losses to atmosphere (~50% of NH$_4$-N lost)
• Nutrient losses in run-off
Manure subsurface band applicator
Soil inorganic N in grass/legume cover crops over time

<table>
<thead>
<tr>
<th>Corn growth stage</th>
<th>Cereal rye</th>
<th>Mixture</th>
<th>Hairy vetch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fifth-leaf</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maturity</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Tillage: No-till**

**Grain growth stage:**
- V7
- V
- T
- R6

**N released (lb ac⁻¹):**
- 0 28 52 70 90 109 131
- 0 50 100 150 200 250 300

**Depth (cm):**
- 0 10 20 30

**Color scale:**
- 640 mg/kg
- 320 mg/kg
- 160 mg/kg
- 80 mg/kg
- 0 mg/kg
Effect of cover crop and poultry litter application method on corn yield

![Graph showing the effect of cover crop and poultry litter application method on corn yield. The graph displays the grain yield (bushels acre⁻¹) as a function of the hairy vetch/cereal rye sown proportion. The graph is divided into two sections: Organic and Intensive. The application methods include Broadcast, Incorporated, and SSB. The data points and error bars are shown for each application method and proportion.]
Effect of cover crop and poultry litter application method on corn yield.

Weeds

Hairy vetch/Cereal rye sown proportion
Integrated fertility management in field corn

Grain yield (bushels acre$^{-1}$)

N source and application method
- Surface UAN
- SSB PL

Hairy Vetch
Cereal Rye

Bare Ground

Biomass proportion

0.0

1.0
Questions