Re-emergence of Cover Crop Adoption

Nationally: 133% increase in cover crop acres nationally since 2011 in the U.S.

Nutrient Loss Reduction

<5% of row crop acres receives cover crops
Planting Corn

Cover Crop Residue

How much N did I conserve in the biomass?

How much CC biomass Carbon did I generate?

How much CC N will be of use to my corn crop and when?

Should I expect N immobilization and can I adjust management?
No Question about Cover Crops and Water Quality
Water Quality Impacts: 4R + Cover Crops

- Interseeded Cereal Rye/Radish Mix (Mid Sept.)
- Average cover crop biomass: **1,200 lbs/A**
- Average shoot N uptake was **59 lbs/A**
- Terminated **2 weeks** before planting

Cereal Rye/Radish in Standing Corn

Radish/Oats in Soybean Residue

Cereal Rye/Radish in Corn Residue
Watershed Impact of Mass Cover Crop Adoption

Tile Water Nitrate-N Concentration (mg L⁻¹)

- CC
- None CC

Dates:
- 5/26/2015
- 10/23/2015
- 3/21/2016
- 8/18/2016
- 1/15/2017
- 6/14/2017
- 11/11/2017
- 4/10/2018
- 9/7/2018
- 2/4/2019
- 7/4/2019
- 12/1/2019
Watershed Impact of Mass Cover Crop Adoption

- 18% reduction in Nitrate (lb per 1000 gallons per day) from 2017 to 2019
- 33% reduction in Nitrate from 2018 to 2019
- 36% overall reduction in Nitrate from 2017 to 2019

Comparison between Treatment (Cover Crop) and Reference (control)
Cereal Rye Impacts on Cash Crop Yield
Soybean Yield

2016 Soybean

Soybean Yield (Mg ha\(^{-1}\))

- Fall
- Fall Cover Crop
- Spring
- Spring Cover Crop
- Zero Control
Corn Yield

*Corn following cereal rye with no starter N applied
Regional CR-Cash Crop Yield Study

- **773 Total Paired Observations** from **24 different Experimental Sites**
  - **430 Corn Paired** observations from **20 Experimental sites**
  - **343 Soybean Paired** observations from **18 Experimental Sites**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Treatment</th>
<th>Yield Mg ha⁻¹ (SE)</th>
<th>Average Δ Yield Control – Cereal Rye</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>Control</td>
<td>9.6 (0.183)</td>
<td>6% (10 bu/A)</td>
<td>&lt;0.00001</td>
</tr>
<tr>
<td>N= 430 pairs</td>
<td>Cereal Rye</td>
<td>9.0 (0.162)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>Control</td>
<td>3.1 (0.049)</td>
<td>6% (3 bu/A)</td>
<td>&lt;0.00001</td>
</tr>
<tr>
<td>N= 343 pairs</td>
<td>Cereal Rye</td>
<td>2.9 (0.035)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Intensive Corn Plant Sampling at Key Growth Stages

Cereal Rye Impact on Corn N Uptake

Corn N Uptake (kg ha$^{-1}$)

0
50
100
150
200
250
300

Non-Cover Crop
Cover Crop

60-75 days after CR termination

Corn Growth Stage
V6 V12 VT R6

Corn N Uptake (kg ha$^{-1}$)

0
50
100
150
200
250
300

Non-Cover Crop
Cover Crop

60-75 days after CR termination
Soil N demand synchrony between the soil microbiome and corn that occurs approximately 53-65 days after cover crop termination.

Nevins et al. (2018) Soil Biology and Biochemistry
Research Objectives:

- Use 15N techniques to measure the amount of cover crop residue N that is utilized by the subsequent corn and soybean crop.
- Use 15N techniques to quantify the fate of cover crop N.
Cereal Residue Nitrogen Tracking N Study

Soil and fertilizer N is taken up by cereal rye cover crop in fall and spring. After termination of cereal rye, N returns to the soil. By the end of vegetative growth, both corn and soybean took up 6.5 - 7.6% of cereal rye biomass N. At harvest 10.6 - 12.2% of cereal rye N is taken up by the following cash crop. Cereal rye N that is not removed with the grain harvest is returned to the soil, where it can promote soil health, organic matter accumulation, and N cycling.
Cereal Rye (CR) Nitrogen Recovery in Corn and Soybean

Percent CR N Recovery (%)

<table>
<thead>
<tr>
<th></th>
<th>Corn</th>
<th>Soybean</th>
</tr>
</thead>
<tbody>
<tr>
<td>V6</td>
<td>7.8%</td>
<td>5.4%</td>
</tr>
<tr>
<td>Vt - R1</td>
<td>10.1%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Harvest</td>
<td>1.9%</td>
<td>7.3%</td>
</tr>
</tbody>
</table>
Partitioning of Cereal Rye Biomass N Recovery

Corn:
- Further Research: 89.9%
- Corn Stover: 2.9%
- Corn Grain: 7.2%

Soybean:
- Further Research: 92.7%
- Projected Soil: 0.9%
The major release of CR residue N comes during the reproductive growth of corn.

At R6, only 14% of CR residue N is released.

At R6, the largest pool of CR N was in the organic form of N.
Changes in Nitrogen Availability During the Life Cycle of Cereal Rye

![Bar chart showing nitrogen availability and loss between non-cover crop, cover crop theory, and cover crop reality. The chart indicates that cover crop reality shows a lower nitrogen loss compared to non-cover crop and cover crop theory.]
Optimization of Starter N Fertilizer for Corn following Cereal Rye

Houston Miller, Shalamar Armstrong, James Camberato, and Robert Nielsen.
Objectives

Determine the optimal starter fertilizer N rate for corn following CR adoption to achieve competitive yield.
Cereal Rye Season

- Soil Sampling at planting. 30 cm depth.

- CR combustion analyzed for total biomass, carbon, and nitrogen (N).

09/26/2017 - 10/18/2017
CR planted at 67 kg ha\(^{-1}\)

4/13/2018 - 5/7/2018
CR sampling
- Two 1/4m\(^2\) squares from each plot.

CR termination
- Chemical termination combination of glyphosate and saflufenacil.

79,072 seeds ha\(^{-1}\)
Corn Season

Population, Growth Stage (# of leaf collars), and N uptake.

- V3
- V6
- V7
- V11
- R1-R2

- V2
  - Disease
  - Population
  - Growth Stage
  - N uptake

Sidedress application Injection.

NRE calculation.
NRE = ((NUF) - (NUC) / R) * 100
(Kovacs et al., 2015)

- R6
  - Nitrogen Recovery Efficiency (NRE)
  - N uptake
  - Grain Yield

Field-scale equipment Harvest Monitor used for yield analysis.

Corn residue combustion analyzed to determine total corn N uptake. Using Flash 2000.
<table>
<thead>
<tr>
<th>Site</th>
<th>Biomass (kg ha(^{-1}))</th>
<th>N uptake (kg ha(^{-1}))</th>
<th>C uptake (kg ha(^{-1}))</th>
<th>C:N ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1075.58</td>
<td>B</td>
<td>22.97</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>1083.41</td>
<td>B</td>
<td>19.77</td>
<td>B</td>
</tr>
<tr>
<td>3</td>
<td>1453.61</td>
<td>A</td>
<td>33.65</td>
<td>A</td>
</tr>
</tbody>
</table>

N- Nitrogen  
C- Carbon  
C:N- Carbon to Nitrogen ratio.  

*significance between sites are indicated by a different capital letter.  
Average CR biomass = 1200 (kg ha\(^{-1}\))
### Spring Soil Inorganic N at Corn Planting

<table>
<thead>
<tr>
<th>Site</th>
<th>CR</th>
<th>Non-CR</th>
<th>CR</th>
<th>Non-CR</th>
<th>CR</th>
<th>Non-CR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>25.6</td>
<td>35.5*</td>
<td>30.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site 2</td>
<td></td>
<td></td>
<td></td>
<td>53.1*</td>
<td>21.1</td>
<td>23.3*</td>
</tr>
</tbody>
</table>

*Significant differences at the 0.05 level.
Site 1 Nitrogen Uptake CR vs. non-CR

- **Corn N uptake (kg N ha⁻¹)**
  - V2
  - V3
  - V6
  - V7
  - V11
  - R1-R2
  - R6

- **Growth Stage**
  - CR vs. non-CR
  - CR vs. non-CR *
  - Sidedress

- **Comparison**
  - CR ON
  - Non-CR ON
Site 1 Nitrogen Uptake in CR Plots

Corn N uptake (kg N ha⁻¹)

Growth Stage

CR 0N
CR 28N
CR 56N
CR 56NP
CR 84N
Non-CR 0N

Sidedress
Site 3 Nitrogen Uptake CR vs. non-CR

Nitrogen Sufficient
Site 3 Nitrogen Uptake in CR plots

Corn N uptake (kg N ha$^{-1}$)

- **Growth Stage**
  - V2
  - V4
  - V5
  - V7
  - V8
  - R1-R2
  - R6

- **Nitrogen Sufficient**

- **Nitrogen Sufficient**

- Sidedress

- CR 0N
- CR 28N
- CR 56N
- CR 56NP
- CR 84N
- Non-CR 0N

Nitrogen Sufficient
Starter N Closing the Corn Yield Gap

- At 1 of 3 sites, CR significantly reduced corn yield (2.4 - 9.2% reduction).

- Within CR treatments, at 3 of 3 sites, adding 56 and 84 kg N ha\(^{-1}\) starter resulted in significantly greater yield (1.3 - 13.4% greater).

- At 2 of 3 sites, adding 56 kg N ha\(^{-1}\) (50 lbs/A) resulted in equal or greater corn yield relative to the non-CR control and non-CR control with starter N.
Cover Crop Selection - Soybean/Corn Yields

Cereal Rye: 100% CR
HV/CR: 80% CR
Big Mix: 10% CR
Rotation: 0% CR
HV: 0% CR
Summary

• There is no question, the inclusion of a cereal rye base mixture increases water quality
• Cereal rye cover crop scavenges N and give it back slowly, where only 7-10% of cereal rye residue N is recovered in the subsequent crop.
• Potential adaptive N management for corn following cereal rye is adding 50-75 lbs of starter N at planting.
• Cover crop selection and rotation with cash crop is another option get achieve competitive corn yields following cover crops.
Thank You

Questions?

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https://ag.purdue.edu/agry/armstrong-sendlab/