CONTRIBUTIONS OF INFIELD CONSERVATION TO SUSTAINABILITY INTENSIFIED AGRICULTURAL SYSTEMS

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1

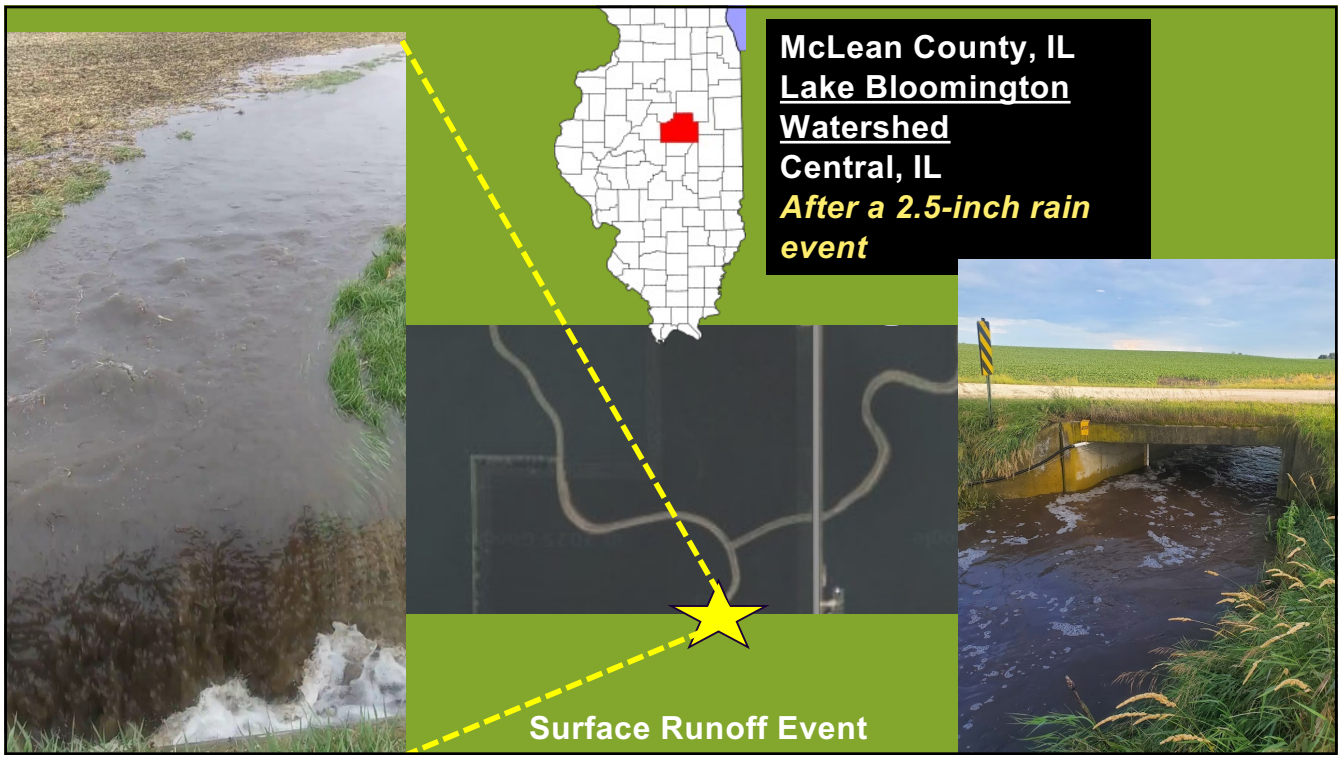
Is There a Need for Sustainably Intensified Agriculture (SIA)?

Sustainable intensification agriculture includes inputs, practices, and the integration of multiple technologies to ***enhance the productivity and resilience of agricultural production systems, while conserving the natural resource base***. (Kassie et al, 2015)

2


Maximize Production and Profit
Environmental Ecosystem Services
Sustainably Intensified Agriculture

3


McLean County, IL
Lake Bloomington Watershed
Central, IL
After a 2.5-inch rain event
Surface Runoff Event

4

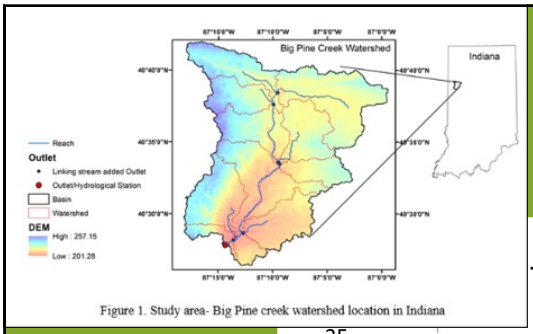
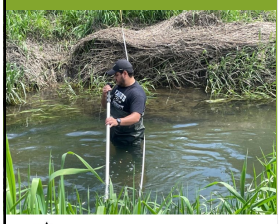


Figure 1. Study area- Big Pine creek watershed location in Indiana

Big Pine Creek Watershed Northwest, Indiana



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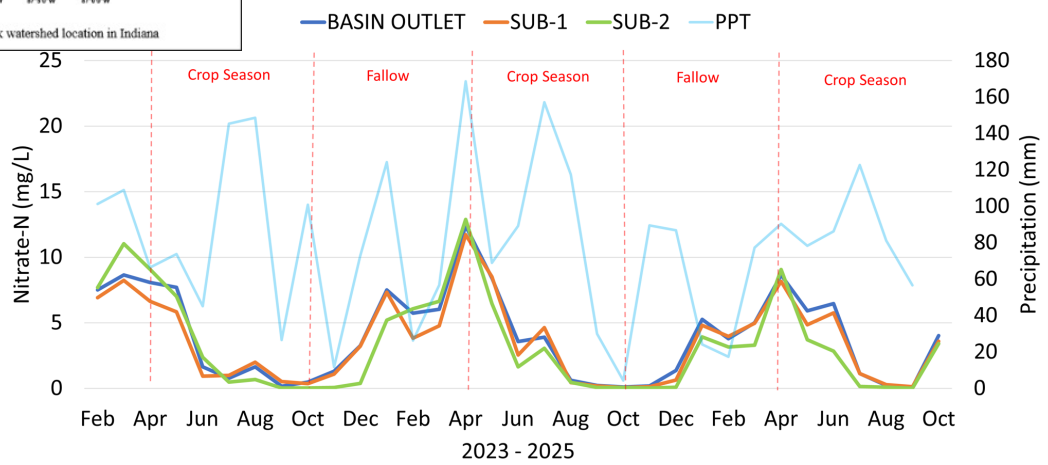
Nitrate-N (mg/L) for Sub-watersheds



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What is an INFIELD Conservation Practice (ICP)

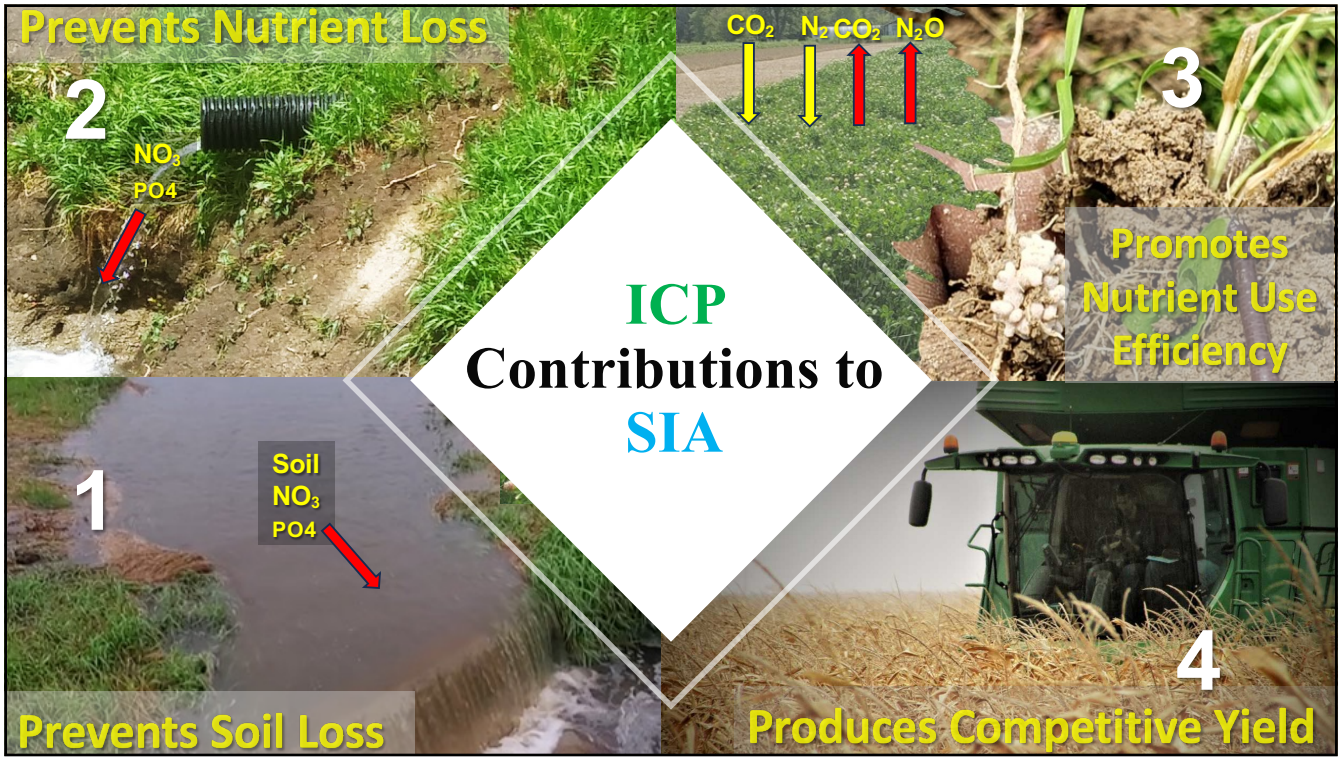
Conservation practices that are employed between the crop rows.

Conservation Tillage

4R Nutrient Management

Cover Crops

6



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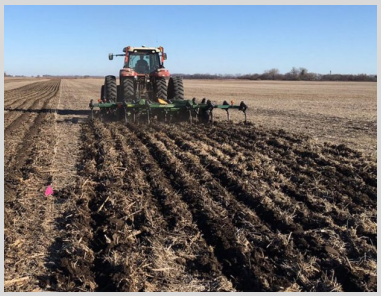
SIA Begins with **Conservation Tillage**

Moldboard Plow



Chisel Plow

No-tillage

Reducing Tillage Intensity

8

Location: Long-term Tillage Plots

Purdue University Agronomy Center for Research and Education (ACRE) at West Lafayette, IN

-Established in 1975 (46 years of management)

Crop Rotation	Tillage Intensity
a. Continuous Corn (C-C)	1. No tillage (NT)
b. Corn-Soybean (C-B)	2. Chisel plow (CP)
c. Continuous Soybean (B-B)	3. Mold board plow (MBP)

Objectives

- To compare the long-term effects of tillage intensity and crop rotations on SOC and TN distribution and storage.
- To assess soil sampling depth consideration for SOC and TN measurement.

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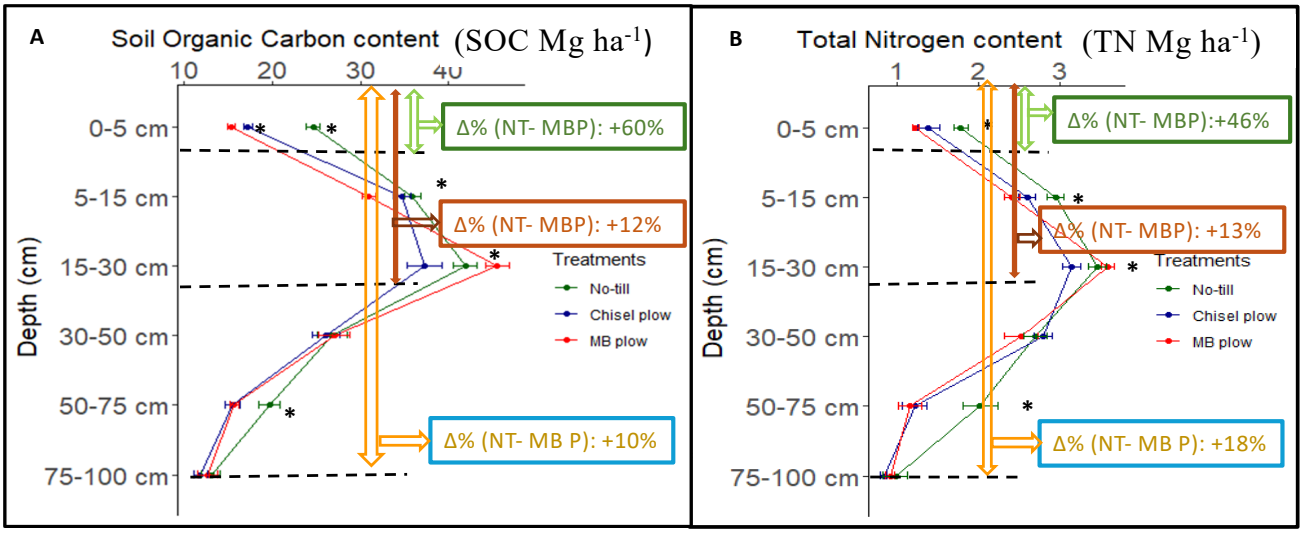

*indicated that the treatments are significantly different at 5 % level of significance

(Gautum et al., 2025)
Soil & Tillage Journal

- Crop Rotation had no significant Impact on SOC.
- NT increased SOC and TN by 10 and 18%, respectively, relative to MBP
- MBP and CP were similar in SOC storage.

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Cover Crop and Nitrogen Management Experimental Site

Est. 2014-Present

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NORTH CENTRAL SARE Sustainable Agriculture Research & Education

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Objective

Quantify the long-term impact of cover crops on discharge, NO_3-N and N_2O losses within a sub-surface drained system.

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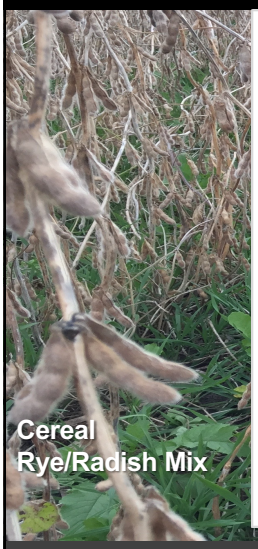
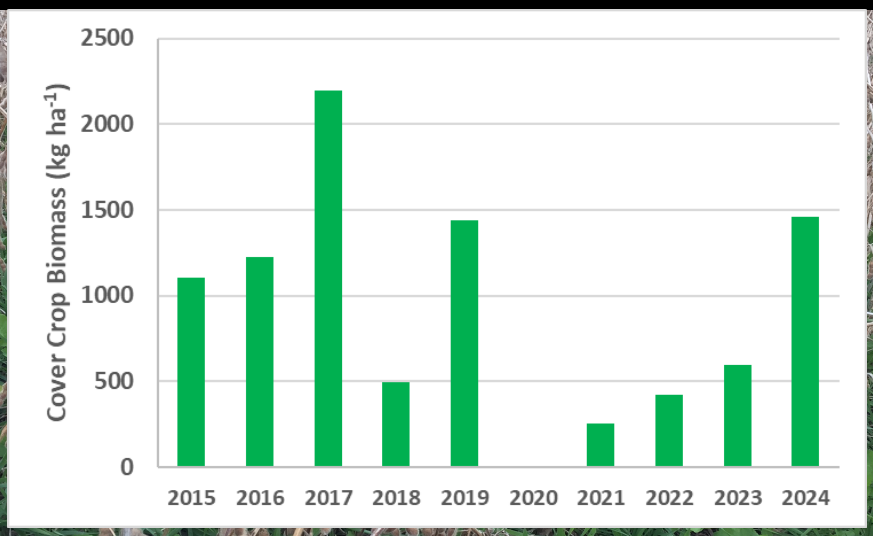
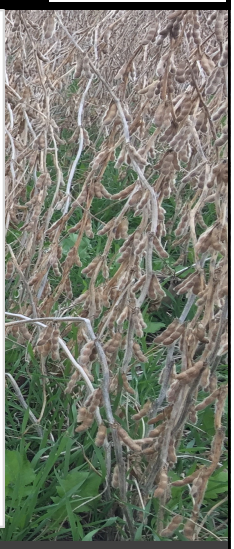
Cover Crop Performance







Average Cover Crop Biomass = 1021 kg ha^{-1} ; range = 254-2,195 kg ha^{-1}
Average Cover Crop N uptake = 46 kg ha^{-1} ; range = 17-79 kg ha^{-1}

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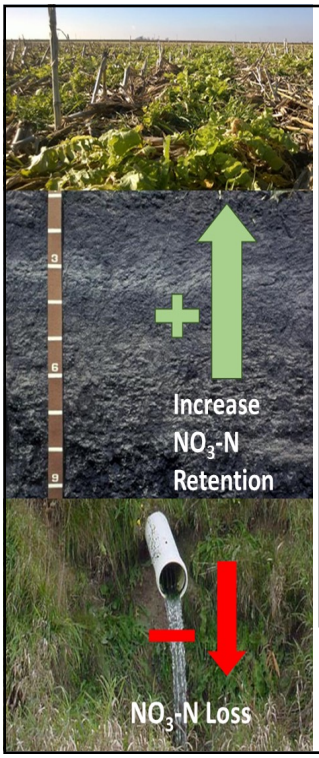
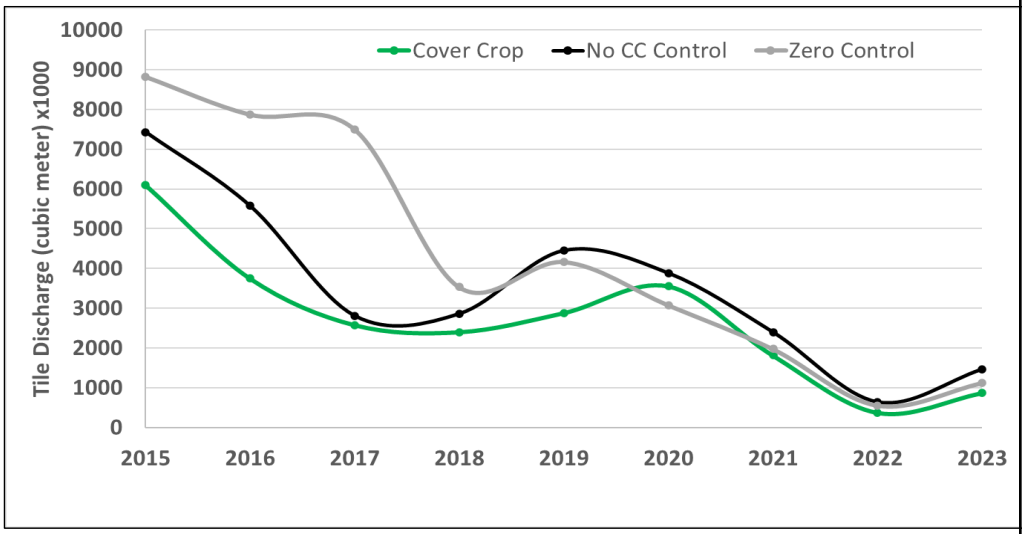


Water Quantity Impacts of Cover Crops



Cover crops reduced Discharge by 23-37% relative the fertilized and unfertilized controls, respectively.

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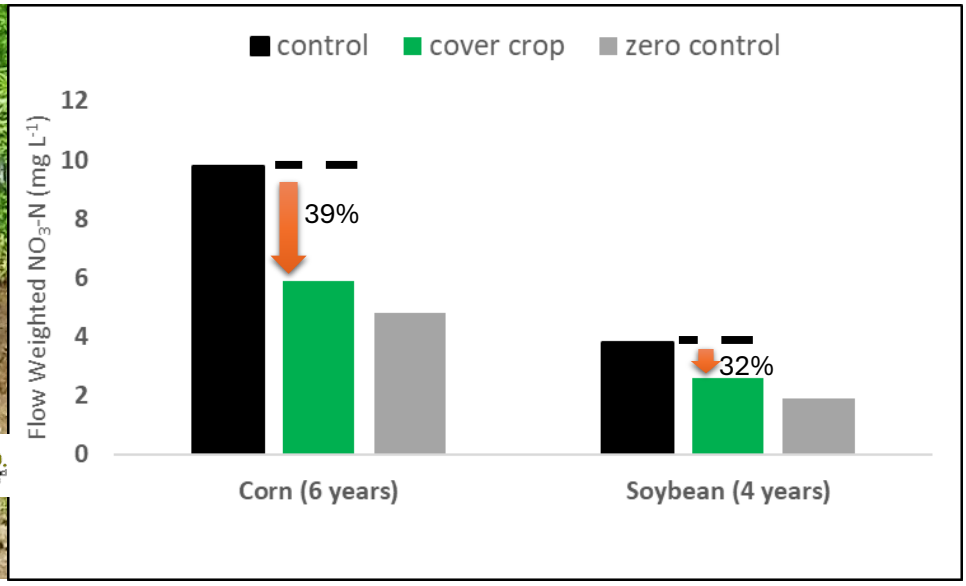
Flow Weighted NO_3-N (2014-2024)



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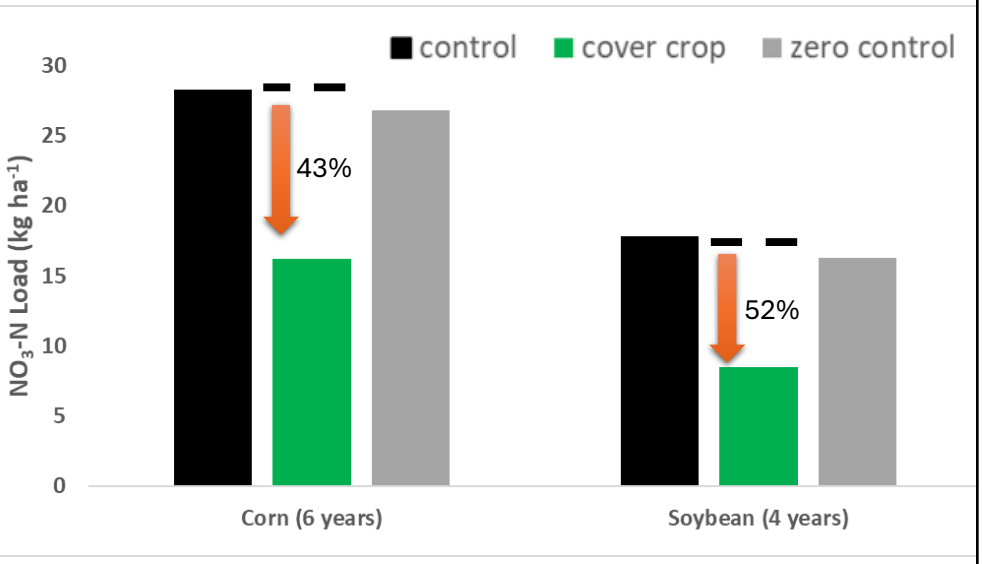
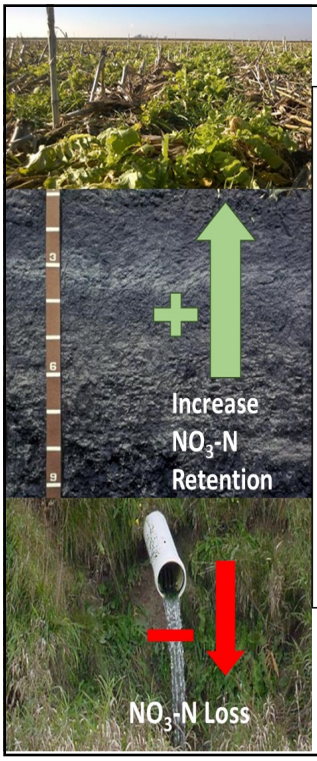
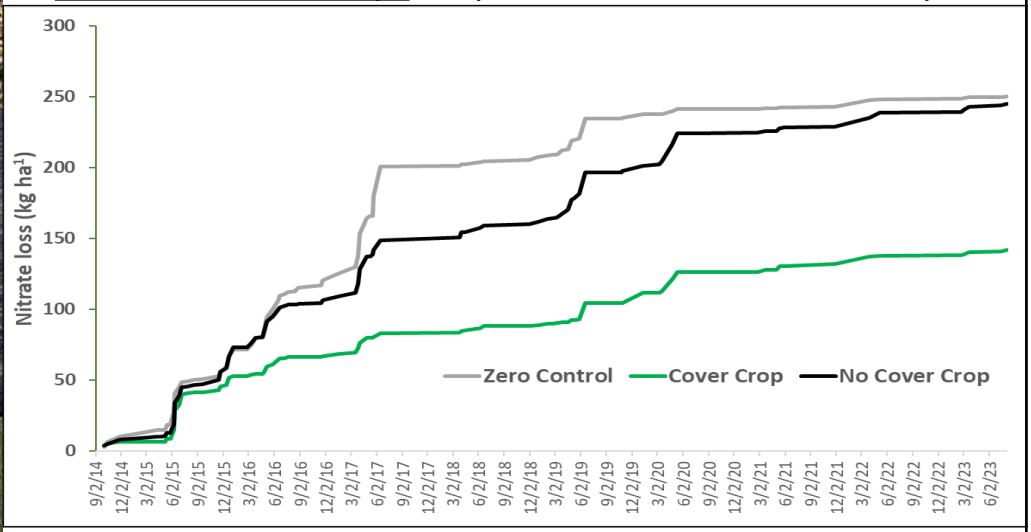
NO_3-N Load (2014-2024)



16



Water Quality Impacts of Cover Crops



Cover Crops reduced cumulative NO^3-N load by *42% (2015-2023)*

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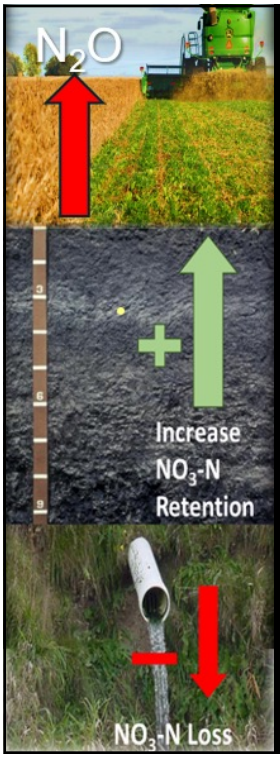
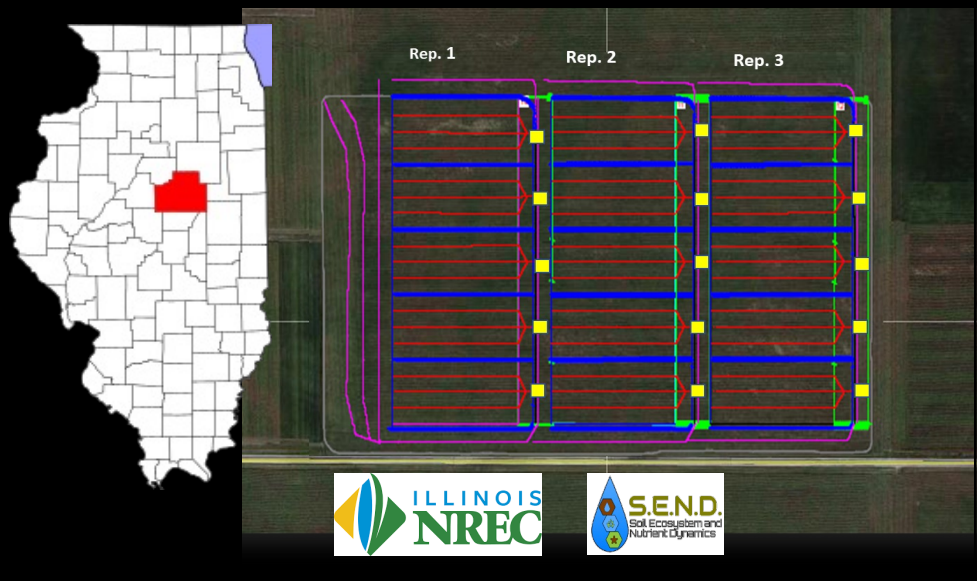


Impact of Cover Crops on N_2O Emissions



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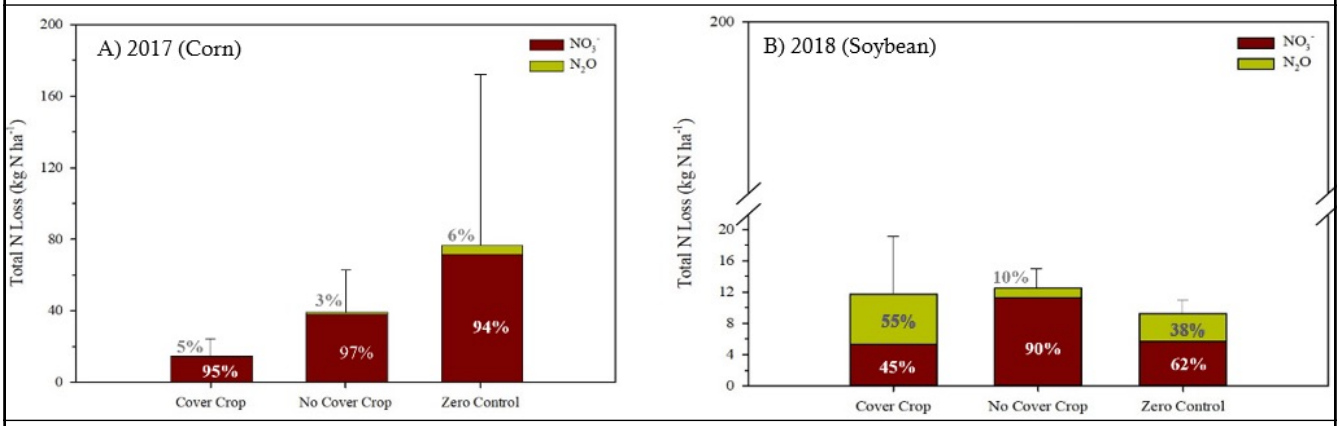
Impact of Cover Crops on N_2O and NO_3 Losses (2017 corn-2018 soybean)



Delayed CC residue decomposition and N_20 emissions.

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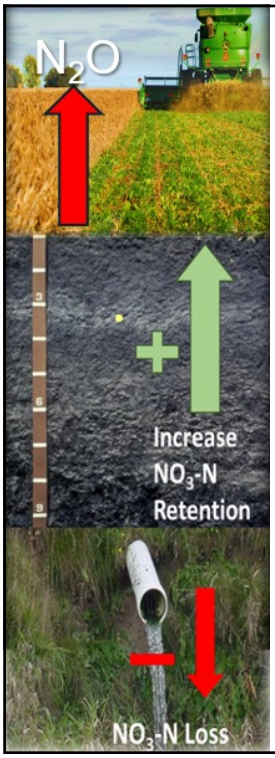
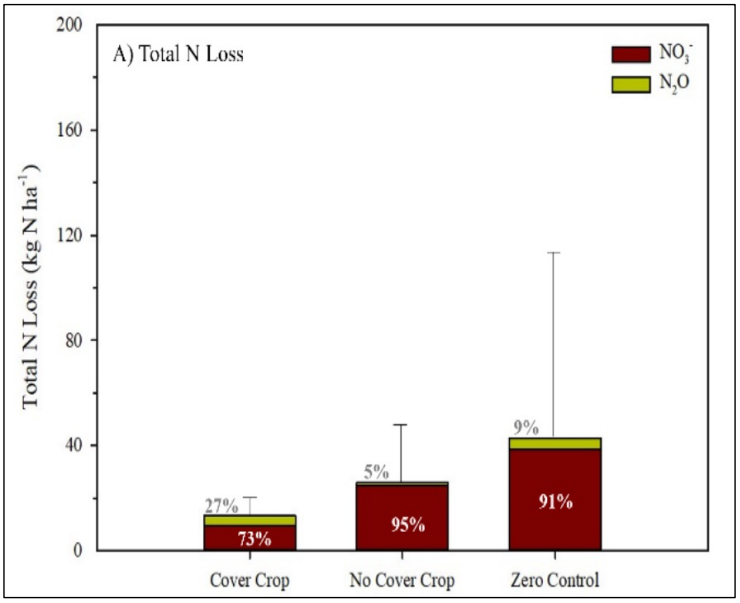


Impact of Cover Crops on N_2O Losses (2017-2018)



86% of the total IN loss is in the form of NO_3

>50% reduction in total N Loss and Environmental Damage Cost in a corn-soybean rotation

Johnson et. al, 2024 Agriculture, Ecosystems & Environment

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Crop Yield Implications

	Cash Crop Yield			
	Control	Cover Crop	Zero Control	LSD
		(Mg ha^{-1})		
Corn Years				
14-15	13.1a	12.5a	4.6b	0.6
16-17	12.9a	10.3b	5c	0.7
18-19	12a	10.4a	4b	2.3
19-20	14a	13.5a	7.3b	1.2
21-22	16a	15.8a	8.1b	0.5
23-24	15.1a	14.6b	9c	0.3
Average	13.8a	12.9b	6.3c	0.4
Soybean Years				
15-16	4.3	4.1	4.3	0.3
17-18	4.7	4.6	4.9	0.4
20-21	5.3	5.2	5.1	0
22-23	5.1	4.9	4.7	0.4
Average	4.8	4.7	4.7	0.3

- Soybean Yield: no significant difference over 4 years.
- Corn Yield: Cover crop resulted in a 6.9% reduction in yield relative to non-cover crop control.

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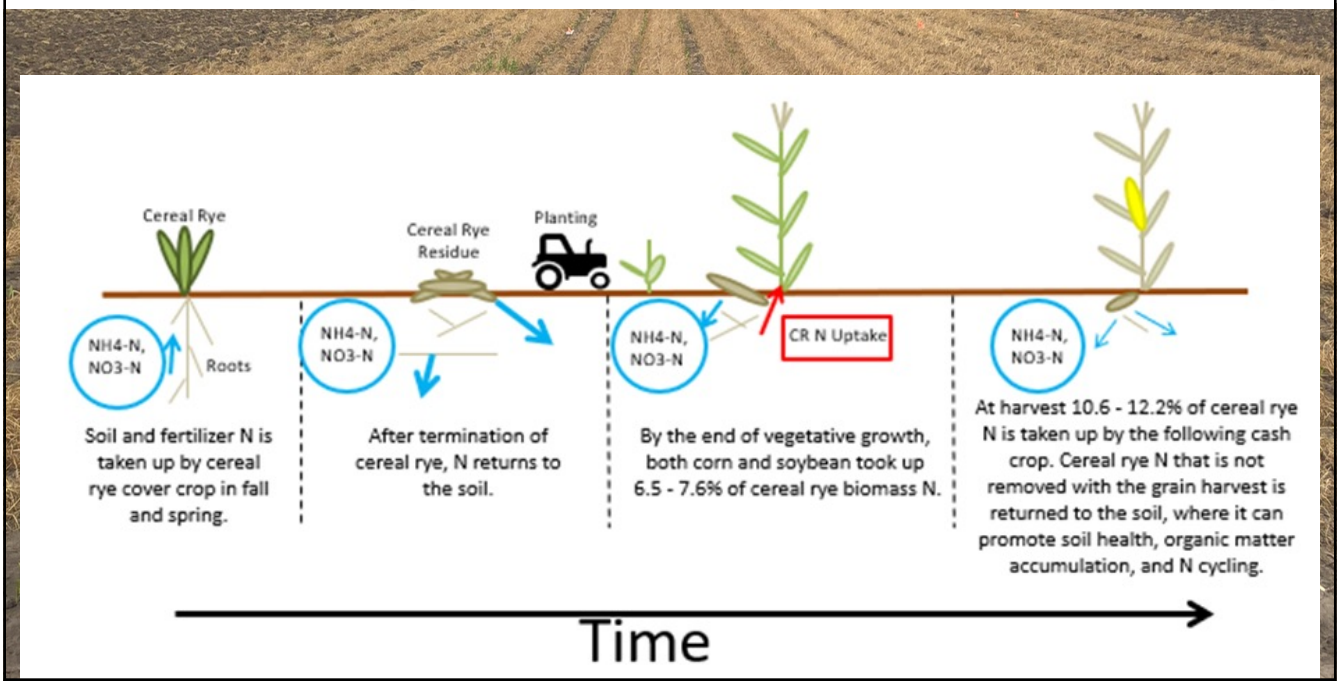
Deeper Investigation: Cereal Rye Residue N Tracking



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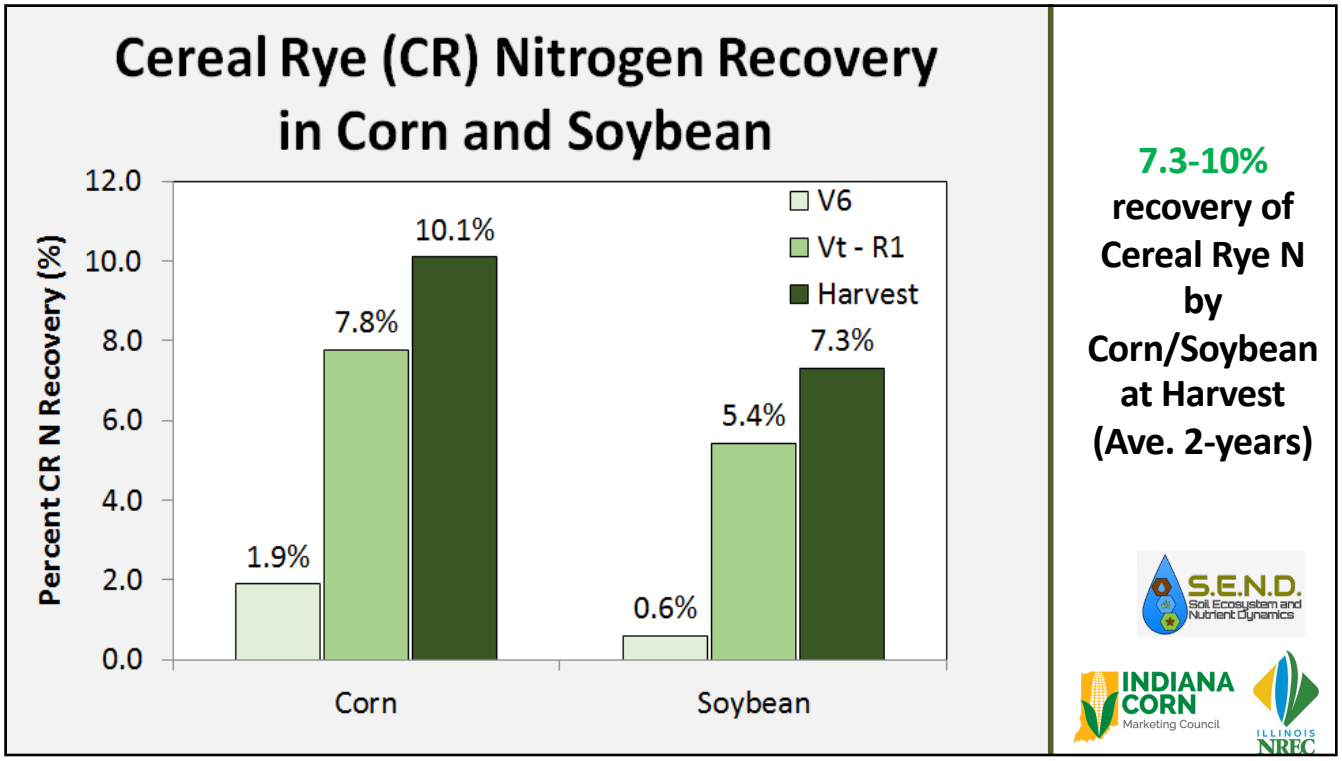
Cereal Rye (CR) Nitrogen Recovery in Corn and Soybean
Percent CR N Recovery (%)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
V6
Vt - R1
Harvest
1.9%
7.8%
10.1%
0.6%
5.4%
7.3%
Corn
Soybean
7.3-10%
recovery of Cereal Rye N by Corn/Soybean at Harvest (Ave. 2-years)
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INDIANA CORN
Marketing Council
ILLINOIS
NREC

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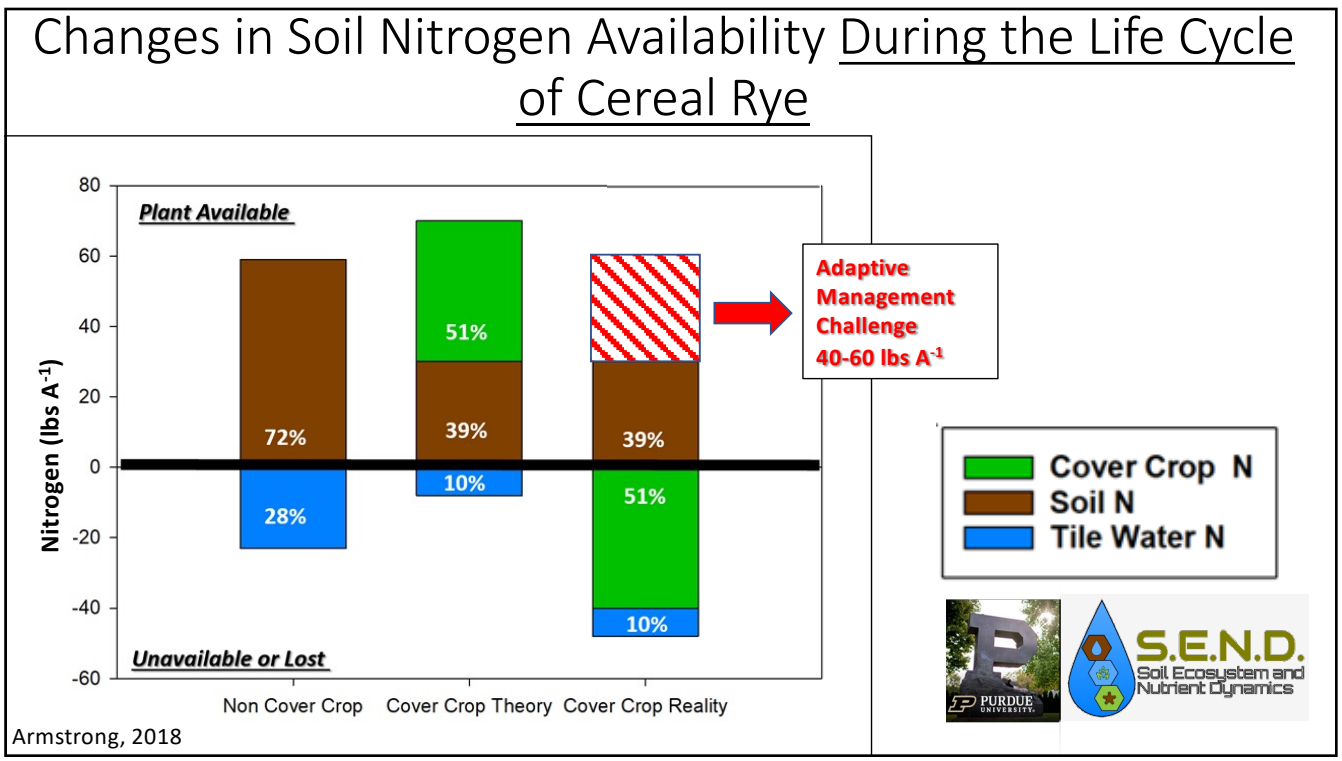
Changes in Soil Nitrogen Availability During the Life Cycle of Cereal Rye
Nitrogen (lbs A-1)
80
60
40
20
0
-20
-40
-60
Plant Available
Unavailable or Lost
72%
28%
51%
39%
10%
39%
51%
10%
Non Cover Crop
Cover Crop Theory
Cover Crop Reality
Adaptive Management Challenge
40-60 lbs A-1
Cover Crop N
Soil N
Tile Water N
PURDUE UNIVERSITY
S.E.N.D.
Soil Ecosystem and Nutrient Dynamics
Armstrong, 2018

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Long-term Analysis of Cereal Rye generated new questions and investigations

Environmental

- Consistent ground cover (Fall and Spring), erosion control, carbon capture
- Reduces Tile-drain NO_3 loss
- Potential reductions in N_2O emissions

Agronomic

- Retains Legacy soil N pool
- No impact on soybean yield
- 6-7% reduction in corn yield.
- Reduces soil N availability before corn

New Investigations

- Can we adjust our CR management to achieve better corn yield?
- Is there an alternative cover crop for CR?
- What are the benefits and risks of the alternative cover crop?

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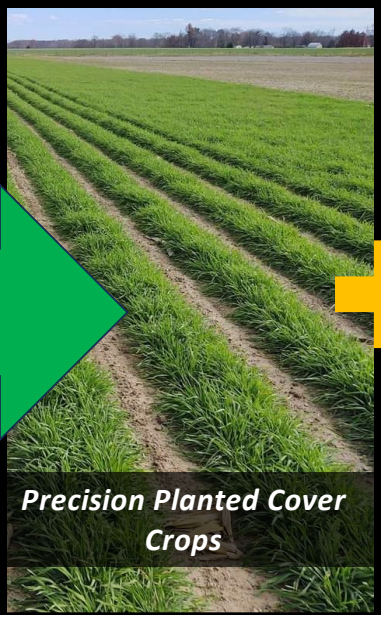
Adaptive Cover Crop Management

How do we overcome cash crop Yield lag following cover crop termination?



Precision Planted Cover Crops

Inclusion of Over wintering Legume

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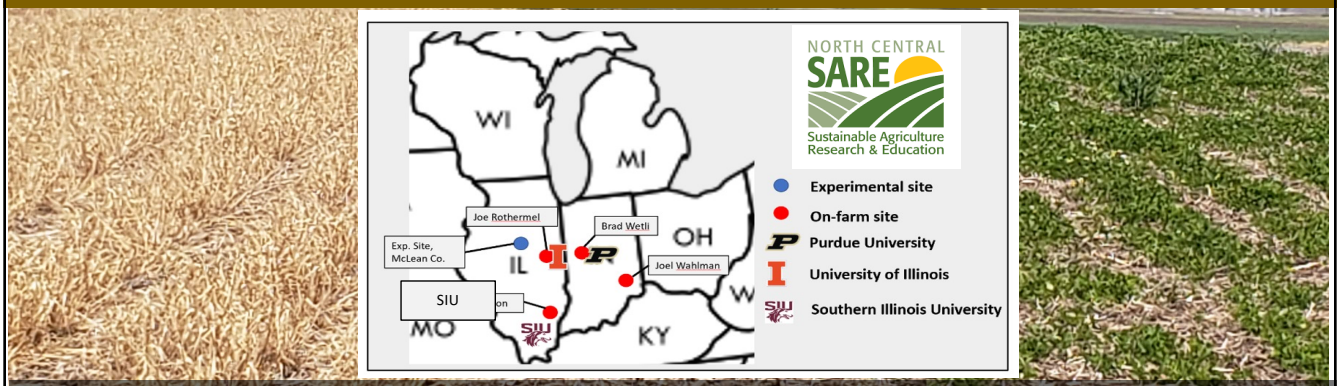
Precision Winter Cereal Rye Cover Cropping for Improving Farm Profitability and Environmental Stewardship



Dr. Shalamar Armstrong (Associate Professor of Agronomy, Department of Agronomy, Purdue University)
Dr. Amir Sadeghpour (Associate Professor of Soil Management, Department of Plant, Soil, and Agricultural Systems, Southern Illinois University)
Dr. Andrew Margenot (Assistant Professor of Soil Science, Crop Science Department, University of Illinois)

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SEPAC LOCATION

Cover Crop Species

1. Balansa Clover
2. Cereal Rye

Planting Method

1. Conventional
2. Precision

Nitrogen Rate

0, 40, 100, 150, 200, 250 lb A^{-1}

Cover crops

- **Planted Sept. 11th**
- **Terminated: CR (4/6) BC (5/20)**

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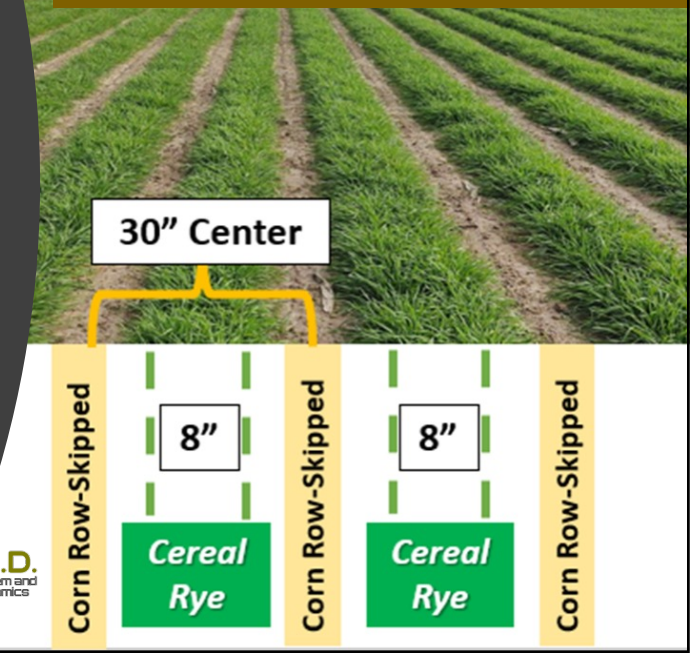
Precision Planted



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Cover Crop Growth
Balansa Clover May 15, 2021

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Patience!
Southern-IN
12-10-20
4-7-21
4-15-21
4-29-21

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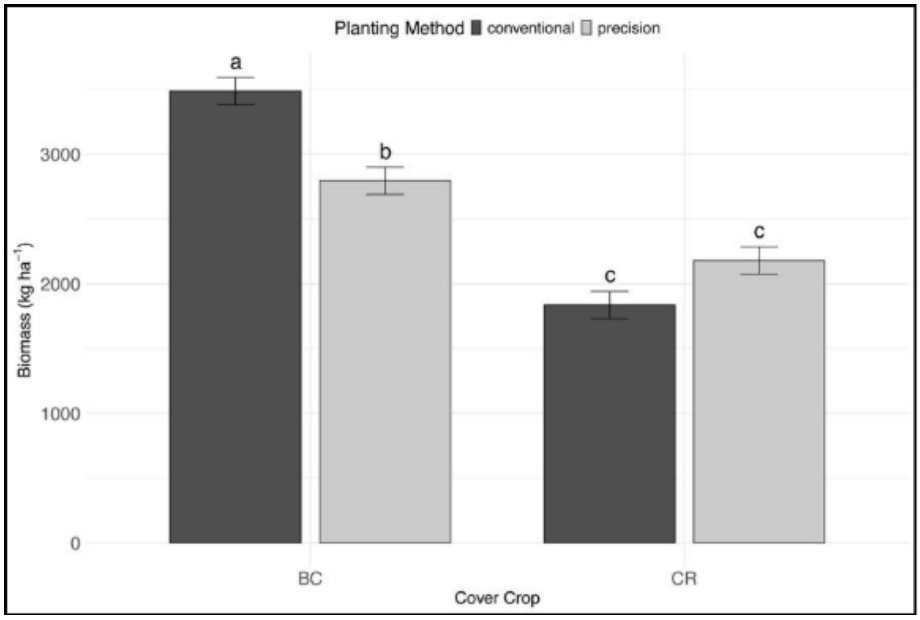
Cover Crop Performance 2021-2024



Nick Innes
M.S. Student

Average Biomass

- Balansa Clover **(3150 kg ha^{-1})**
- Cereal Rye **(2050 kg ha^{-1})**

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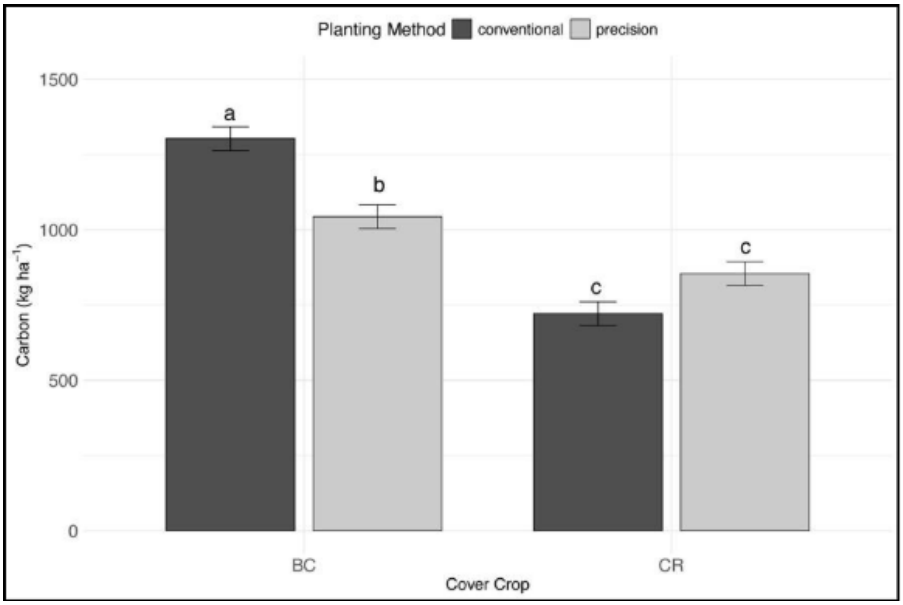
Cover Crop Performance 2021-2024



Average Biomass Carbon

- Balansa Clover **(1100 kg ha^{-1})**
- Cereal Rye **(675 kg ha^{-1})**

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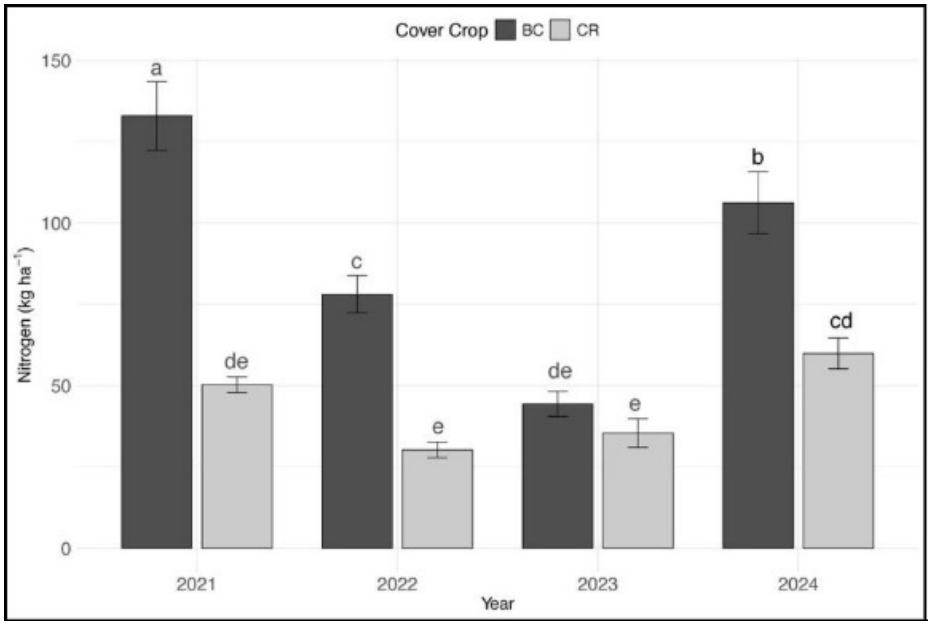
Cover Crop Performance 2021-2024



Average N Uptake

- Balansa Clover **(118 lbs A^{-1})**
- Cereal Rye **(45 lbs A^{-1})**

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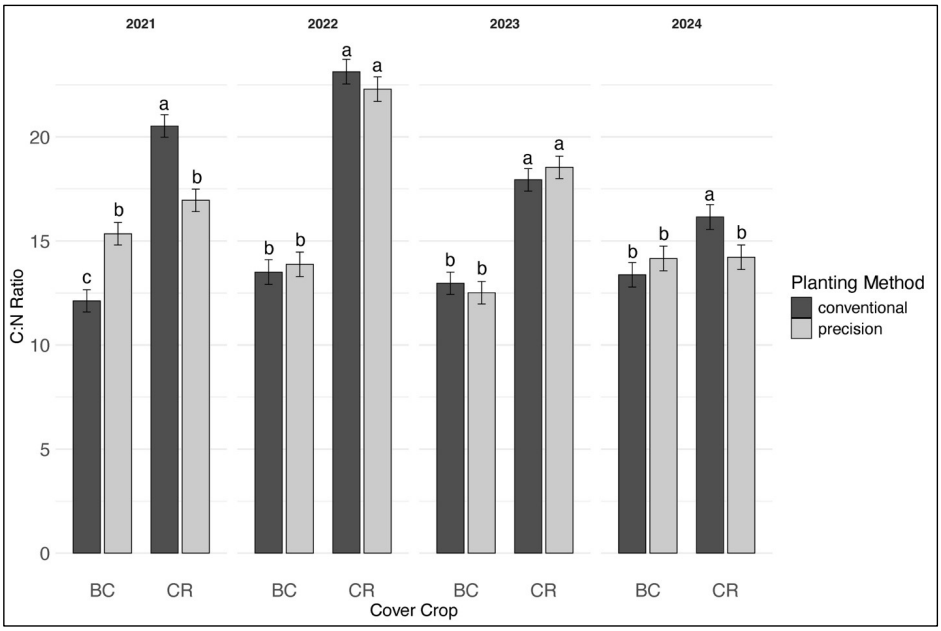
Cover Crop Performance 2021-2024



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Average C:N Ratio

Balansa Clover (13)
Cereal Rye (19)

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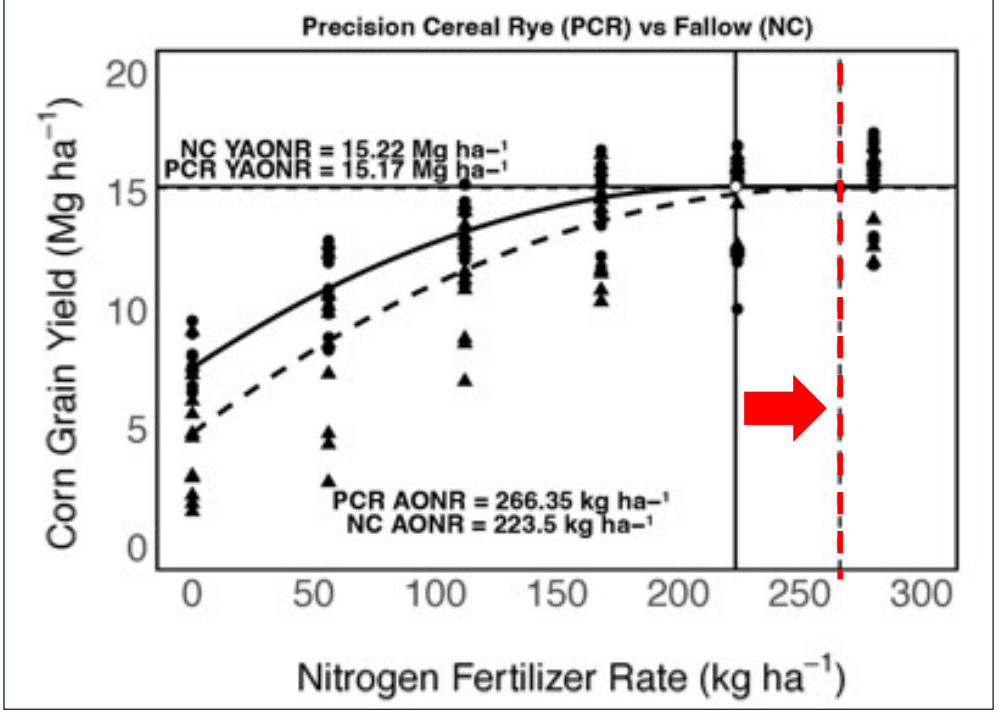

43 kg ha^{-1} more fertilizer N to achieve optimal yield for CR plots

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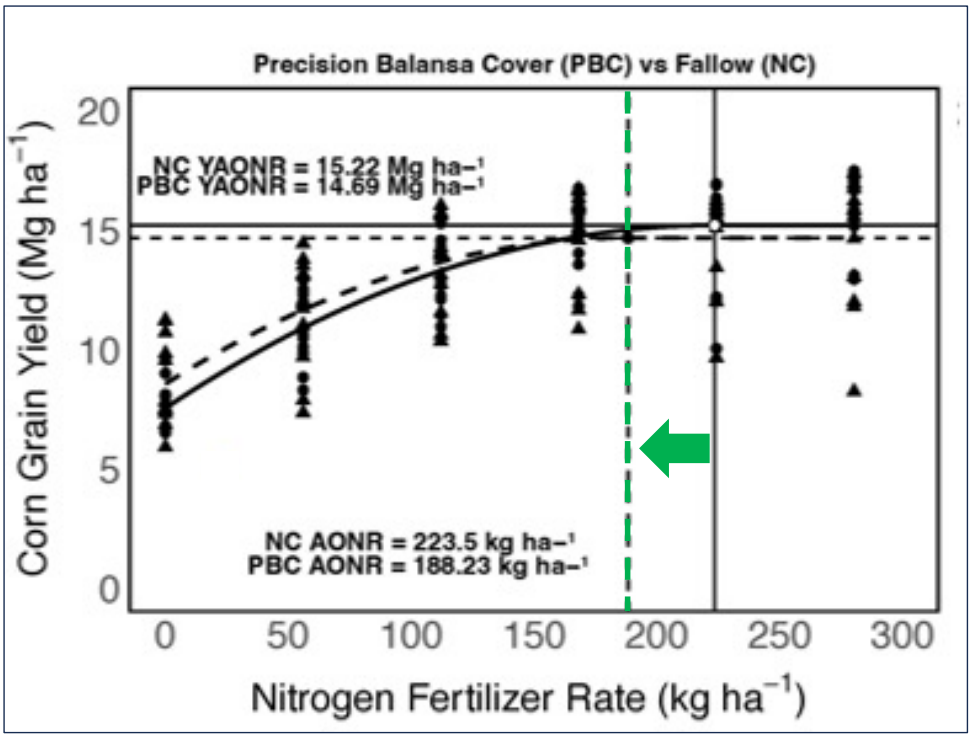

35 kg ha^{-1} less fertilizer N to achieve optimal yield for BC relative to NC.

78 kg ha^{-1} less fertilizer N to achieve optimal yield for BC relative to CR.

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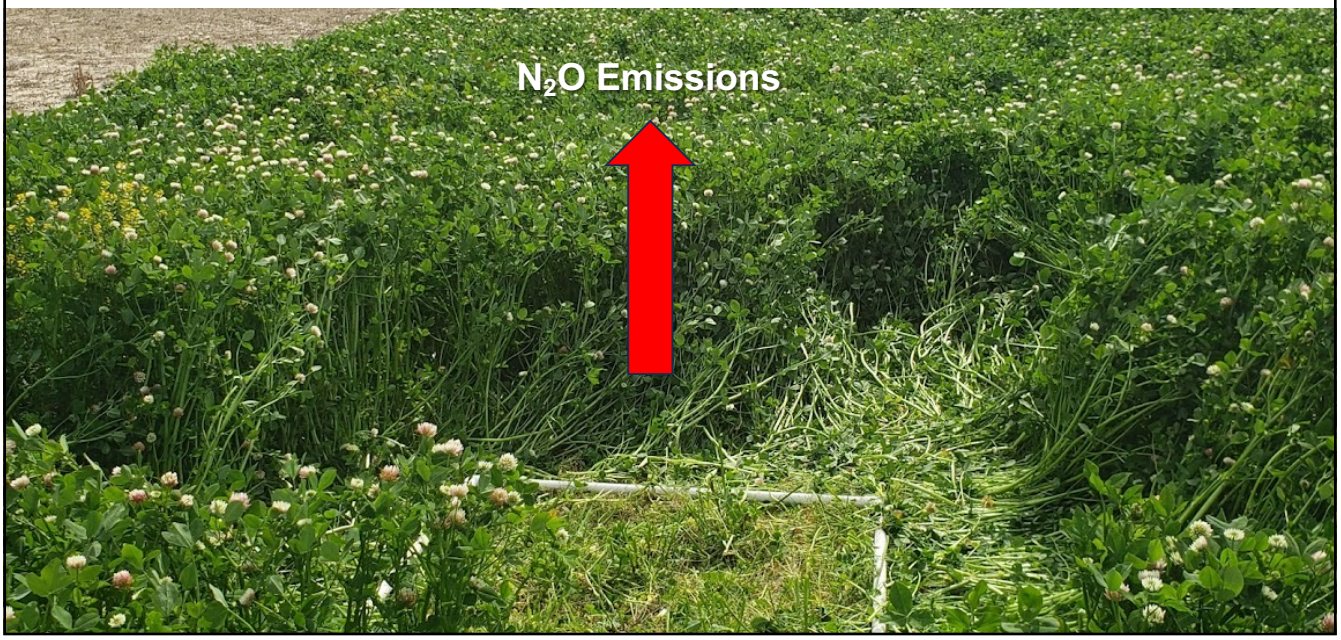
A Key Environmental Trade-off to Consider!



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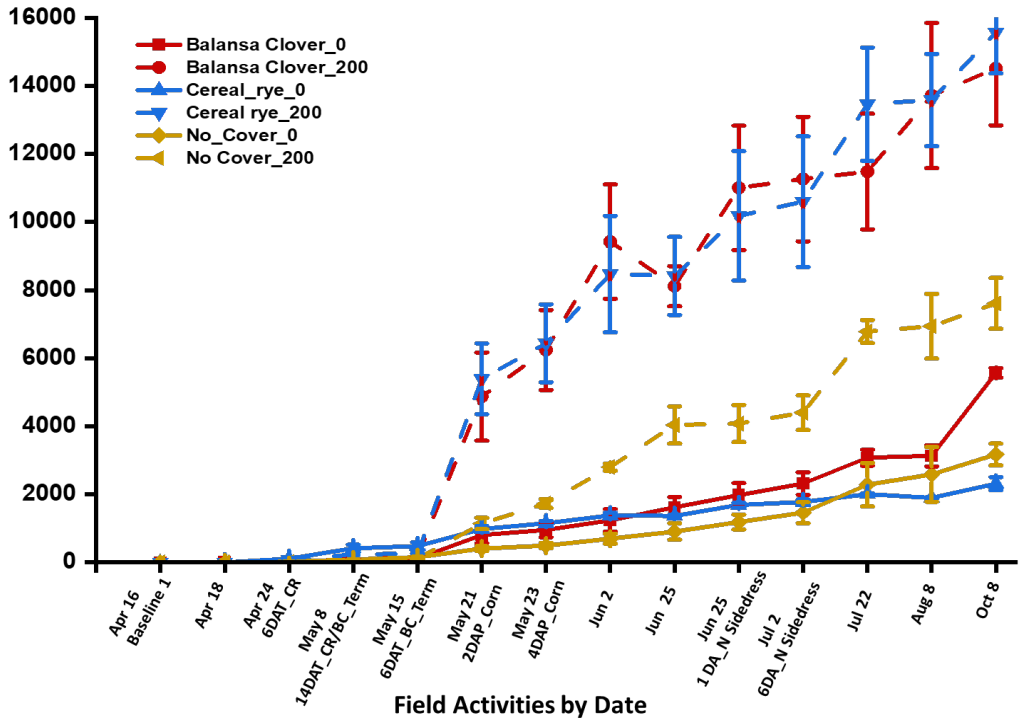
USDA Climate Smart Grant



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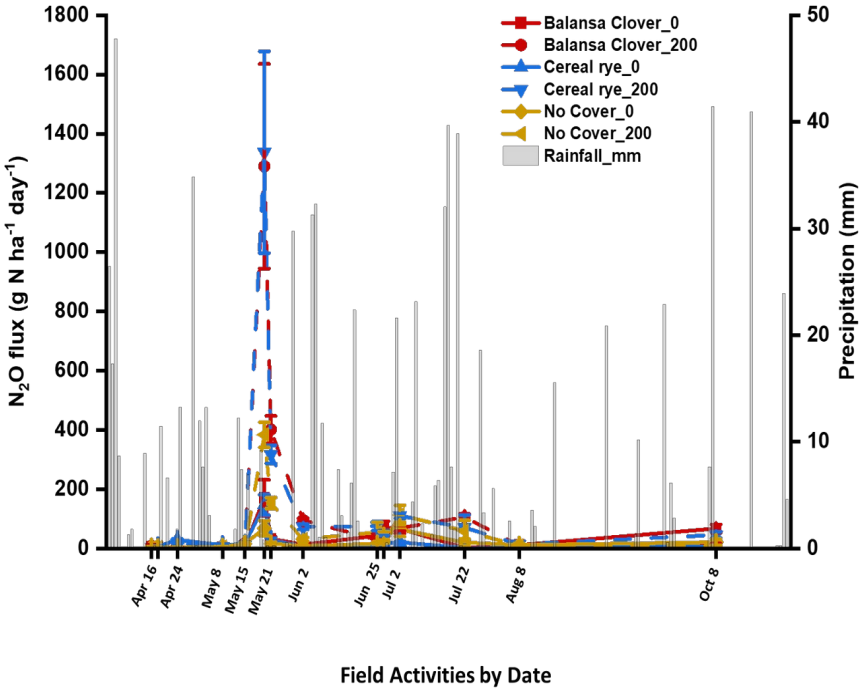
USDA Climate Smart Grant



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Partial N Balance (PNB)

Partial N Balance (PNB)

= AONR No Cover - AONR of Cover crops - N_2O losses by Cover C

Balansa Clover AONR and Partial N Balance

PNB= 35 - 9.7 = 25.3 kg ha^{-1}

Cereal Rye AONR and Partial N Balance

PNB = -43 - 9.9 = - 52.9 kg ha^{-1}

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Early Maturing Soybean

Soybean Maturity	Yield (bu/A)
2.8	82.09
3.2	81.26
3.5	82.91
3.7	80.95
4.3	78.48

5 maturities 5 replications all planted 4-24-2025, SE Indiana

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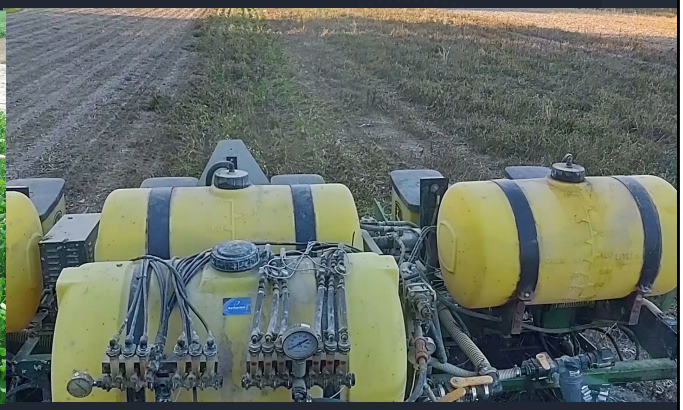
Corn Utility of Biomass N depended on termination management

Planting Green into Balansa Clover 2021



Planting Brown Green into Balansa Clover 2022

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Harvest 2021

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Central IL Balansa Cover Case Study- Lexington, IL

Spring Green-up Prior to Planting

4/17/2024 5/1/2024 5/8/2024

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Central IL Balansa Cover Case Study- Lexington, IL

- 5/11/2024- Corn Planted 5/24/2024- Clover Terminated

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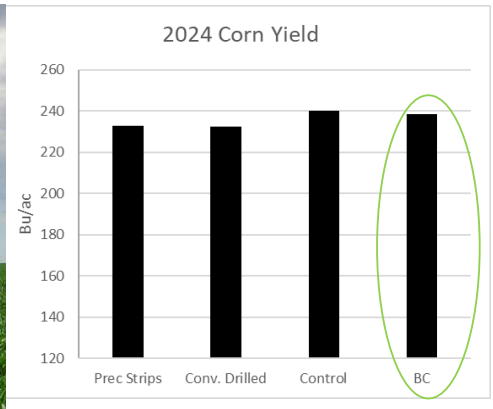
IL Balansa Cover Case Study- Lexington, IL



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Cover Crop Contributions

- Cereal rye dominated mix resulted in NO_3 loss reductions (30-49%) on the field scale.
- Cereal rye reduced N_2O by 50% relative to the non-cover crop control during a 2-year corn and soybean rotation
- Inclusion of winter-hardy legumes before corn gives the potential to achieve optimal yield with lower fertilizer N inputs.
- There are potential environmental trades with the inclusion of legumes before corn. Does the agronomic benefit outweigh the environmental risk?
- Cover crops photosynthetically capture carbon and contribute to soil health and resilience.

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Thank You

Dr. Shalamar Armstrong
Contact

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S.E.N.D. Soil Ecosystem and Nutrient Dynamics

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