# Comparing yields, profitability, and nutrient loss of C-S-W vs. Conventional C-S



Corn



Soybean



Wheat

#### Lowell Gentry

Principal Research Specialist in Agriculture University of Illinois

Indiana CCA

Indianapolis, IN

December 15, 2021



#### **Reducing Nutrient Loads to Gulf**



for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico and Improving Water Quality in the Mississippi River Basin



The Science Advisory Board called for 45% reductions in both N and P with a goal of reducing the hypoxic zone to 2,000 square miles.

#### **Target Dates:**

By 2025 = 15% for N and 25% for P

By 2035 = 45% for N and 45% for P





#### **Extremely Warm and Dry February**

#### Average Temperature (°F): Departure from 1981-2010 Normals

February 01, 2017 to February 24, 2017



Warmest February for the Cornbelt in 2017.

Record corn yields with largest hypoxic zone.

-N mineralization -Fall N application -Early spring N application

Are we draining the ecological capital from the prairie?



#### Tile drainage is a prerequisite for high yields



#### Tiles transport nutrients, especially nitrate.

## **Non-point Source**

#### • Nitrate

- Tile drainage (predominant source)
- Overland runoff
  - nitrate low in precipitation
- Phosphorus
  - Overland runoff (predominant source)
    - soil erosion
    - unincorporated P fertilizer
  - Tile drainage







#### Glaciation/Tile Drainage/Nitrate Loss



Reference: Mickelson and Colgan (2003)



#### Tile Drainage (by county in the MRB)





#### Nitrate loss across the Mississippi River Basin





#### Wabash River (Embarras River)







Topographic Map of Illinois

> Glaciated areas are flat and have poor natural drainage.







### **Upper Embarras River Watershed**

- 119,00 acres
- Flat topography
- Moraines
- 90% row crop
- Few animals
- Little sewage effluent





#### USGS River Gauge (Camargo, IL)

(Visited bridge 1700 times in past 28 years)





#### Large River Flow (Camargo, IL)

# Sediment load means soil erosion

#### and large Pload

#### **River Nitrate Concentration**

Upper Embarras R. at Camargo, IL



#### **River Dissolved P Concentration**

Upper Embarras R. at Camargo, IL



#### **River Sulfur Concentration**

Upper Embarras R. at Camargo, IL



#### Upper Embarras River Watershed (at Camargo IL) Annual N load = 27 lbs/A/yr





#### Tile Nitrate Load: Fall N vs. Spring N





## Can C-S-W compete with C-S?

A longer rotation (C-S-W) with cereal rye after corn and double crop soybean after winter wheat will...

- reduce nutrient loss (especially tile nitrate) and
- maintain yield and profitability.



#### Benefits of C-S-W Rotation

- Wheat in rotation benefits corn and soybean yield
- Pest cycles broken
- Double-cropped soybean opportunity after wheat
- "Soybean N credit" to wheat
- More ground cover (decrease erosion)
  C-S-W = 30 months covered of 36 months
  C-S = 10 months covered of 24 months

#### Net Mineralization Following Soybean (Formerly referred to as the "Soybean N Credit")



Winter wheat takes the position of a cover crop and utilize mineralized N following soybean, keeping nitrate out of the tile.



# Planting soybean "green" into standing cereal rye



This amount of biomass (2.5 tons/A) reduced tile nitrate to 1 ppm.

Planters can be equipped with roller crimpers to create a mat of cereal rye residue.



# How much cereal rye is needed to decrease tile nitrate concentrations?



This biomass (0.5 tons/A) is sufficient to significantly reduce tile nitrate concentrations. (6 to 8 inches tall).

Cover crops may improve soil health by adding C as well as retaining N that may have otherwise leaked out of the field via tile drainage.



## Benefits of cover cropping

- Decrease soil erosion
- Add organic matter
- Feed microbes/nutrient cycling
- Suppress weeds
- N catch crop



## Risks of cover cropping

- Delay row crop planting
- Cooler soil temperature
- N immobilization
- Allelochemicals
- Disease "green bridge"



#### Edge of Field Remediation

- Drainage water management
- Bioreactors
- Constructed wetlands

#### **In-Field Remediation**

- 4 R's of N management
- Cover crops



#### **Edge of Field Remediation**

- Constructed wetlands
  - expensive to build berms
  - requires topography
  - larger area
- Bioreactors





- less expensive and smaller footprint
- Drainage water management



- least expensive, but where does the water go?







#### **Bioreactor Monitoring Equipment**





#### **Bioreactor Performance**

Bioreactor 2 (Field W-2)



## Limitations of Bioreactors

- Cold tile temperatures
- Bypass flow or flooding
- Back pressure on tile (fate of retained water??)
- P source for the first year
- Size of bioreactor



#### Treat the cause not the symptom

#### In-field practices vs. end-of-pipe



### **On-farm research in Piatt County**





## Field Design and Crop Rotation



Wheat on east side in 2015 for tiling

I

Wheat

on west side

in 2014 for

tiling

#### C-S-W

- C-S-W with each phase of the rotation every year
- Cereal rye after corn, double crop soybean after winter wheat
- Strip-till corn, no-till soybean, and no-till wheat
- Corn N = 20 lbs/A starter; 160 lbs/A as side–dress
- Wheat N = 24 lbs/A as 1240D; 100 lbs/A as Super U with stabilizer



#### C-S

- C-S with each phase of the rotation every year
- Full width tillage in fall and spring
- If possible, fall N fertilization (125 lbs/A) with 20 lbs/A starter and 35 lbs/A as UAN side-dress
- If not, 20 lbs/A as starter with 160 lbs/A side dress



#### **Tile Nitrate Concentration**



#### Crop Yield in 2015





#### 2015 Corn Grain Yield



**I** ILLINOIS

#### 2015 Corn Stalk Nitrate





#### 2015-2016 Cereal Rye Cover Crop

Cover Crop	Biomass	Biomass
(April)		Ν
	Tons/A	lbs/A
Cereal Rye	0.61	21



# Cover crop after wheat instead of double crop soybean in 2015



John M. Green Research Assistant University of Illinois Pictured here collecting cover crop biomass



#### Radish and Turnip Sown in August and harvested in early November



#### **Total Biomass**

Cover Crop	Biomass
	tons/A
Radish	1.67
Turnip	0.73
Red Clover	0.26
Volunteer wheat	0.21
Total	2.87



## Tile Nitrate from C-S-W





#### **Corn N Rate Trials**







#### 2016 Corn Grain Yield





#### 2016 Corn Stalk Nitrate





#### Over-tightened the N cycle?



Flow weighted tile nitrate = <1 ppm following this radish and turnip cover crop (planted after wheat harvest in 2015).

Too much of a good thing?

Or maybe not that good of a thing when C/N ratio is 35:1?





#### Crop Yields in 2016





#### Crop Yields in 2017





### Corn N Rate Studies in 2017





## Corn N Rate Yield Curves in 2017

Lowest EONR <150 lbs of N/A following warm winter



#### EONR for corn 2018-2020

- 2018 EONR was 200 lbs/A for both C-S and C-S-W
  - Cold winter and spring

2019 = EONR was 155 lbs/A
 Late planted in C-S; prevent plant in C-S-W

2020 = EONR was 150 lbs/A for both C-S and C-S-W
 Big difference in yield at zero N rate



#### Corn N Rate Yield Curves in 2020 EONR was 150 bu/A for both C-S-W and C-S



• Note: Zero N rate has greater yield in C-S-W, but sufficient N fertilizer masks this effect.



#### Soybean planted "green" into cover



Photo by Mary Auth



#### Tile Nitrate from C-S-W (2015-2020)





#### Tile Nitrate from C-S (2016-2020)





#### Tile Nitrate from Field W-1 (2015-2020)





#### Corn Yields, 2015-2021



**I**ILLINOIS

#### Soybean Yields, 2015-2021



**I**ILLINOIS

#### Wheat/D.C. Soybean Yield, 2015-2021



**I**ILLINOIS

## Corn \$ Margin/acre, 2016-21



Revenue does not include any government payments. Expenses do not include any land costs. Corn price per bushel used was USDA market year average.



### Soybean \$ Margin/acre, 2016-21



Revenue does not include any government payments. Expenses do not include any land costs. Soybean price per bushel used was USDA market year average.



#### Wheat/D.C. Soy vs. Corn vs. Soybean \$ Margin/acre, 2016-2021



Revenue does not include any government payments. Expenses do not include any land costs. Crop price per bushel used was USDA market year average.



#### C-S vs. C-S-W Combined Average \$ Margin/acre, 2016-2021



Revenue does not include any government payments. Expenses do not include any land costs. Crop price per bushel used was USDA market year average.



#### Conclusions

- Timing of fertilizer N application is important
- Longer crop rotation with cover crops greatly reduce nitrate leaching (no long lag time)

Winter wheat absorbs mineralized N following soybean

Winter wheat residues add extra C to the soil

Cereal rye greatly reduces tile nitrate and adds extra C to the soil

- Double crop soybean after wheat needed for profitability
- Bioreactors can help, but still a work in progress



#### **Cover Crop Guide**

#### Cover crop for new adopters

By Dr. Shalamar Armstrong, Lowell Gentry, Dan Schaefer, Eric Miller and John Pike

A publication of the Illinois Nutrient Research & Education Council



#### **Funding Sources**

# Nutrient Research and Education Council (NREC)



### Thank You (Questions??)



