

Nitrogen and Sulfur Interactions with Cereal Rye in Soybean and Corn

Shaun Casteel

Purdue Extension Soybean

scasteel@purdue.edu

X @PurdueSoybean

Dan Quinn

Purdue Extension Corn

djquinn@purdue.edu

X @PurdueCorn



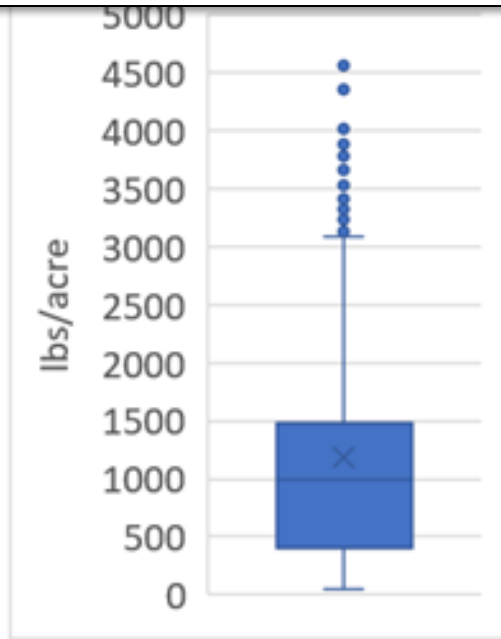
Can Cereal Rye Supply Nitrogen or Sulfur in Soybean?



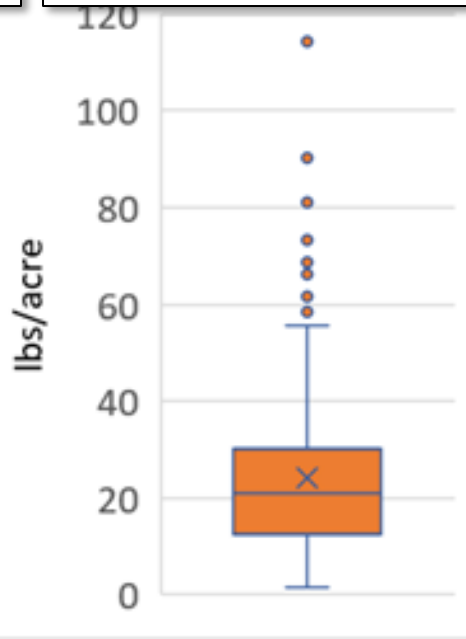
**Can Cereal Rye Immobilize
Nitrogen or Sulfur in Soybean?**

Cereal Rye Biomass, Nitrogen, and Sulfur

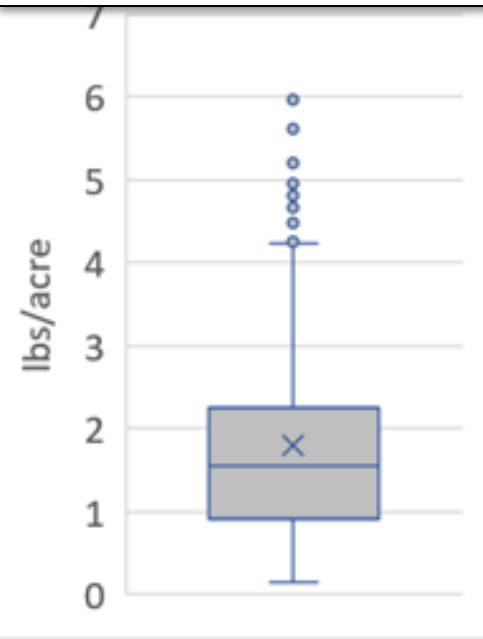
~1200 lb biomass/ac



~24 lb N/ac



~2 lb S/ac

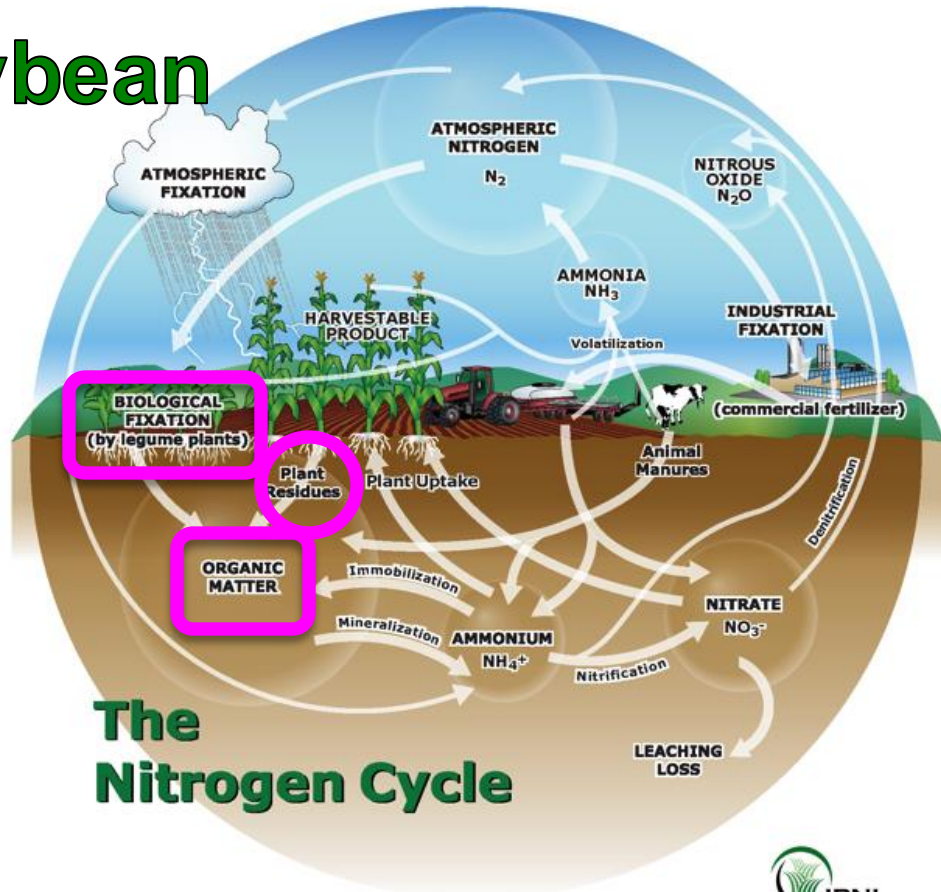


n = 357 observations

C. rye averaged C:N ratio 18:1 and C:S ratio of 255:1

Nitrogen for Soybean

- Organic Matter
- Plant Residue
- N Fixation
- (Fertilizer N)

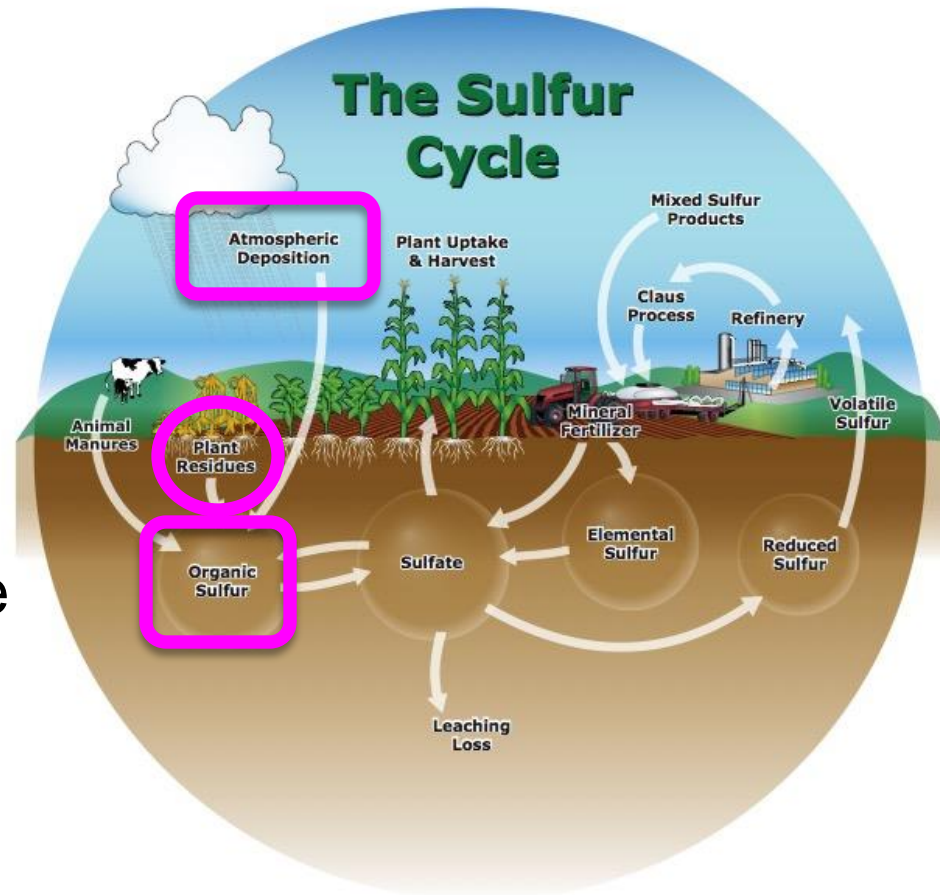


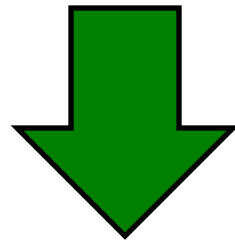
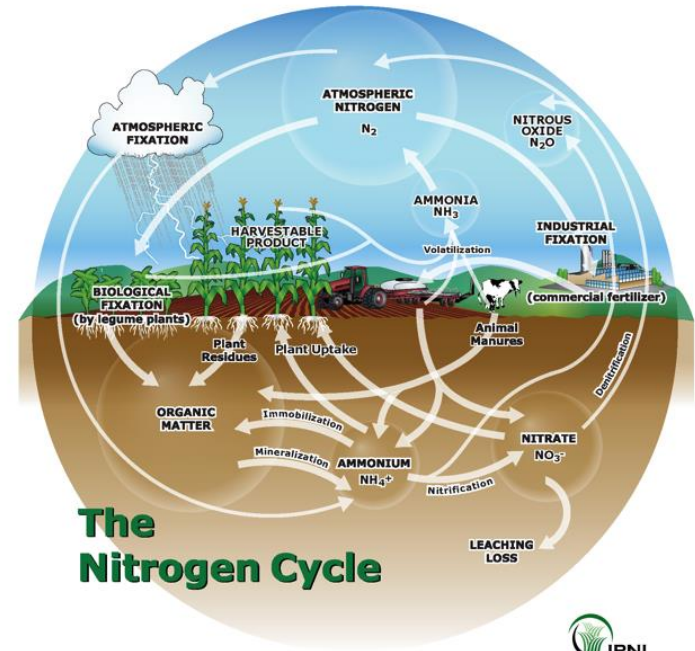
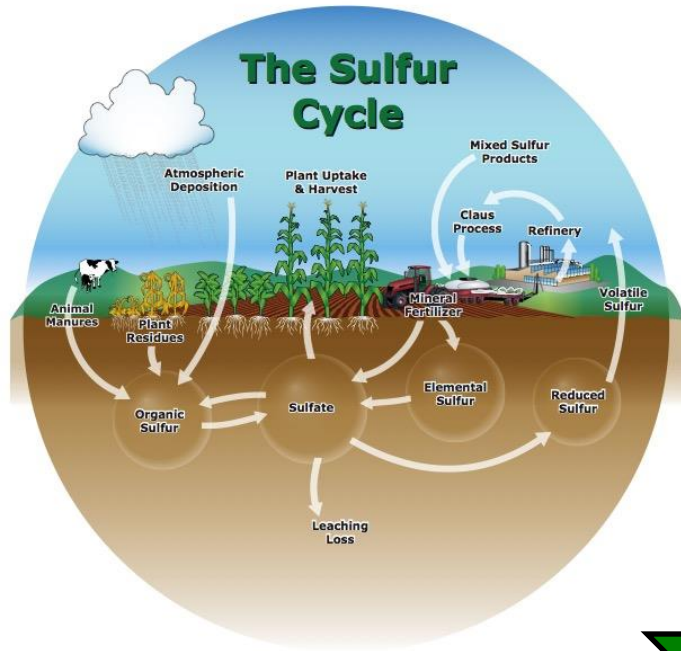
The Nitrogen Cycle



Sulfur Cycle

- Atmospheric Deposition
- Organic S
- Plant Residue





High Yielding Soybeans!



So Why Is Nitrogen So Important To Soybeans?

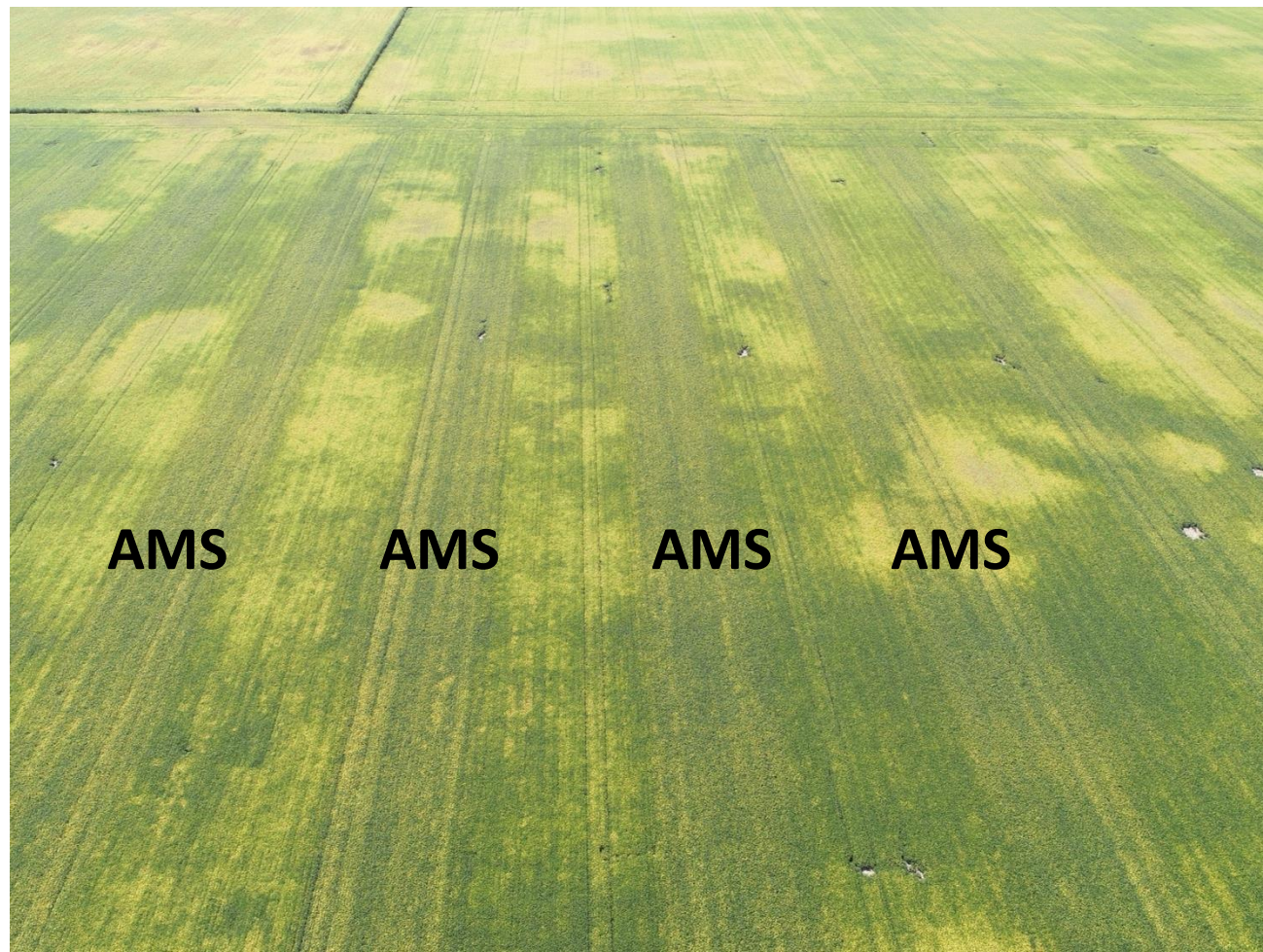
- For each unit of photosynthate, soybean requires 3 times more N than corn to produce biomass... protein, oil, etc.

How Much Nitrogen Is Supplied To Soybean From Biological Fixation?

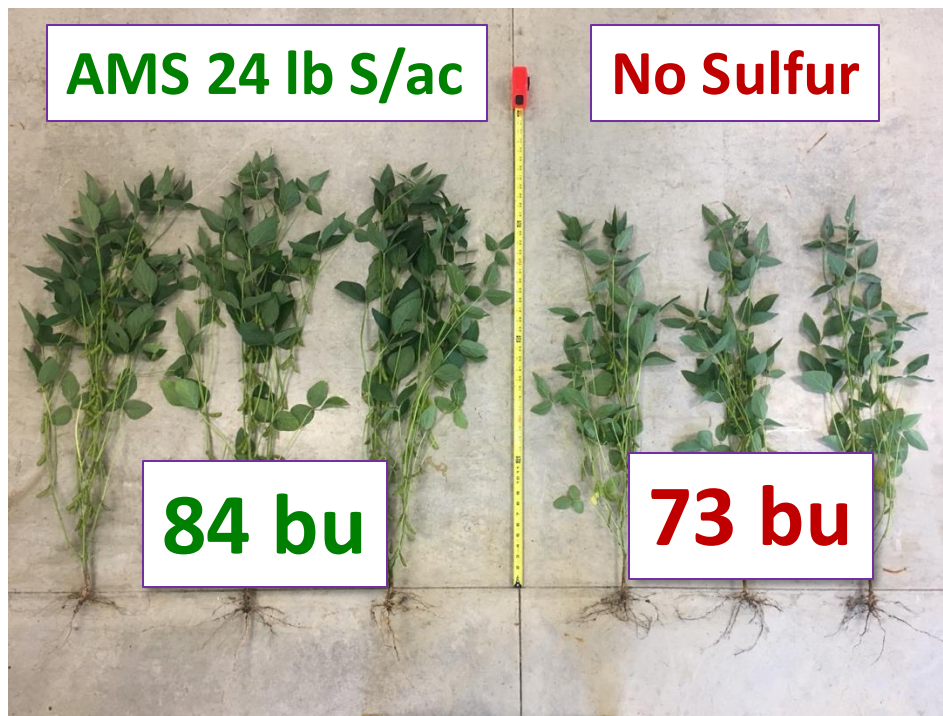
- 25 to 75% (Varco, 1999)
- Total amount varies based on:
 - Soil supply of N (organic matter, residual fertilizer, etc)
 - Rhizobial population

2018 Tipton

- Cereal Rye terminated ~12-in
- **100 lb AMS/ac** applied in strips when soybean were V2



18 INFA Tipton



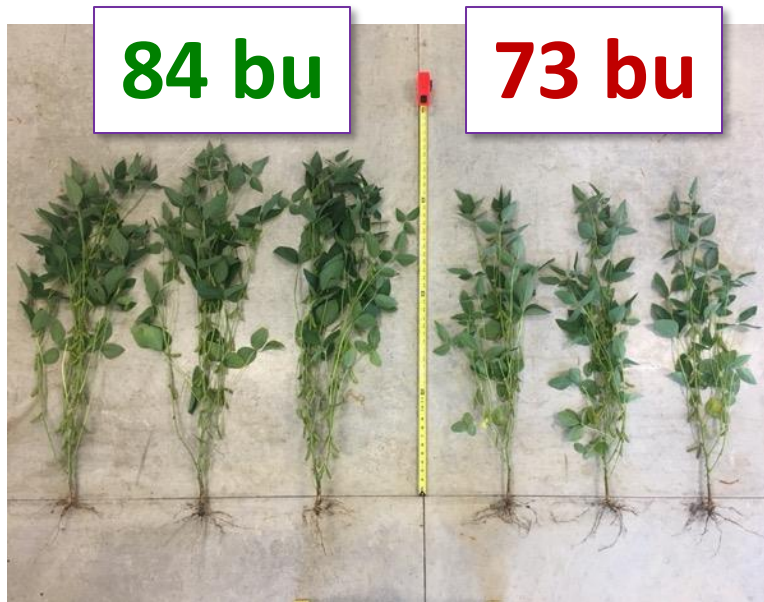
66 pods/plant
18.4 nodes

44 pods/plant
16.6 nodes



Cereal Rye x NS in Soybean: 23 & 24

- 2 x 4 Factorial at field-scale
- 2 Cereal Rye → Yes, No
- 4 NS Fertility
 - None
 - Sulfur: 20 lb S/ac (pelletized **Gypsum**)
 - Nitrogen: 40 lb N/ac (**Urea**)
 - N+S: 40 lb N, 20 lb S
- **Terminate** ~12-16 inches (April-ish)
- **Fertilize** and **Plant** ~2 weeks later
- 2023, 2024 in W. Lafayette
- 2023 in Columbia City



18 INFA Tipton

2023 Cereal Rye

Yr	Loc	Biomass	Carbon	Nitrogen	Sulfur	C:N	C:S
-----lb/ac-----							
23	W. Laf	553	228	11.4	0.9	20	257
23	C. City	1442	625	23.3	2.0	27	321

Yr	Loc	Soil NO ₃		Soil NH ₄		Soil SO ₄	
		0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
23	W. Laf	5.8 2.3	3.8 1.5	6.3	4.8	15.8	12.0
23	C. City	4.8 2.3	4.3 1.3	5.0	5.0	11.6	10.9

Supplying Sulfur to Our Fields

- ~3-4 lb S/ac mineralized per 1% OM per year
- Plant Residue – Mineralized or Immobilized?
 - C:S Ratio < 200:1 → MINERALIZED SO₄-S
 - C:S Ratio > 400:1 → IMMOBILIZED SO₄-S
 - Corn Stover ~350:1
 - Soybean Stover ~125:1
 - Wheat Straw ~300:1
 - Cover Crop? Other Factors?



INDIANA
SOYBEAN
ALLIANCE

23 Cereal Rye x NS: West Lafayette



April 18th
Terminate Cereal Rye



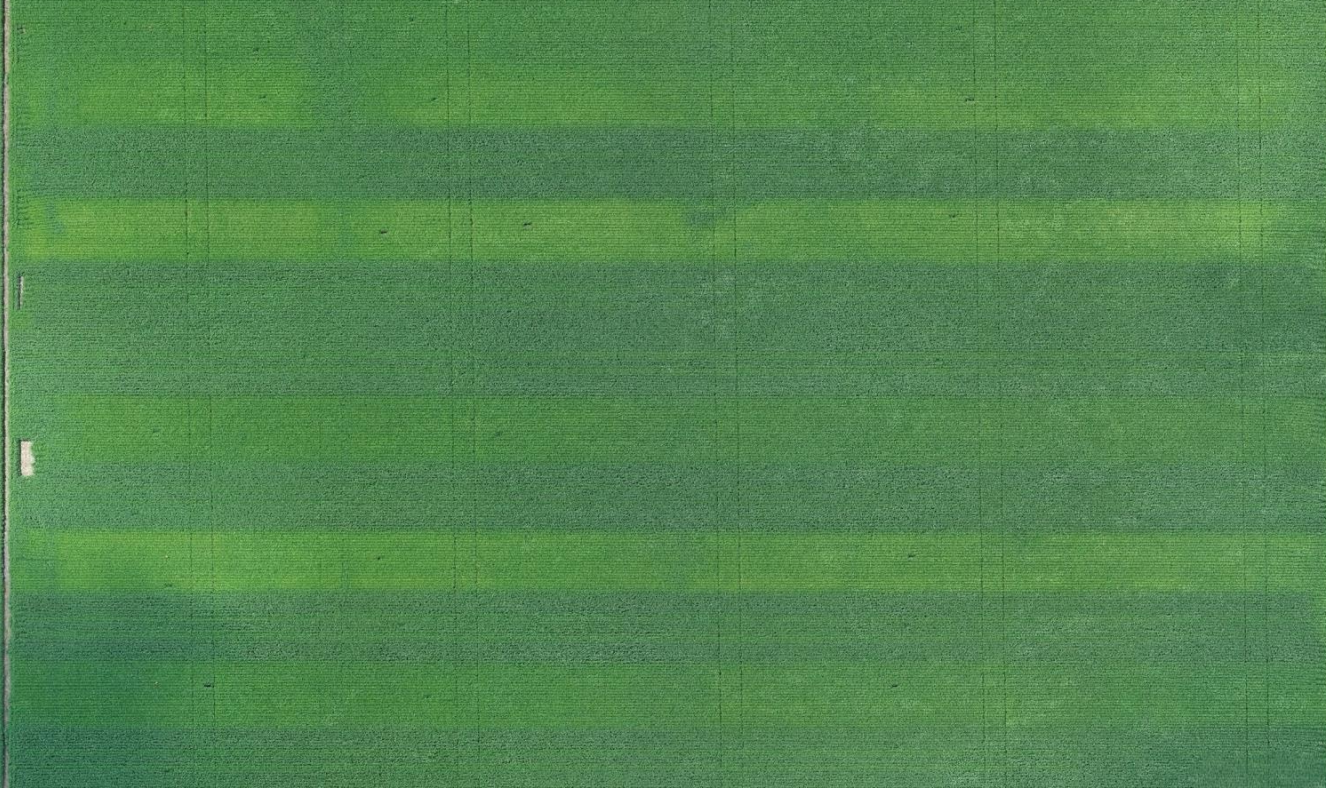
May 6th
Apply Fertilizer, Plant Soy



Sept 1st
Response of Soybean



23 Cereal Rye x NS: West Lafayette



Cereal Rye
No Cover
Cereal Rye
No Cover
No Cover
Cereal Rye
Cereal Rye
No Cover

Urea
Urea + Gypsum
Gypsum
Urea
Gypsum
None
Urea + Gypsum
None

Soybean Nitrogen: 23 W. Lafayette

Fertility	Cover Crop	Nitrogen Concentrations (%)						
		V4	R2		R4		R8 Seed	
None	None	3.9	5.1	5.1 c	4.5 b		5.8	5.7 b
None	Cereal Rye	3.7	5.1		4.1 c		5.6	
Urea	None	3.8	5.4	5.1 c	4.4 b		5.7	5.7 b
Urea	Cereal Rye	3.8	4.9		4.2 c		5.6	
Gypsum	None	3.8	5.3	5.3 b	5.2 a		6.1	6.1 a
Gypsum	Cereal Rye	3.9	5.3		5.2 a		6.1	
Urea + Gypsum	None	3.8	5.5	5.5 a	5.2 a		5.9	6.0 a
Urea + Gypsum	Cereal Rye	3.8	5.5		5.3 a		6.0	

Sulfur Effects on Soybean



No Sulfur



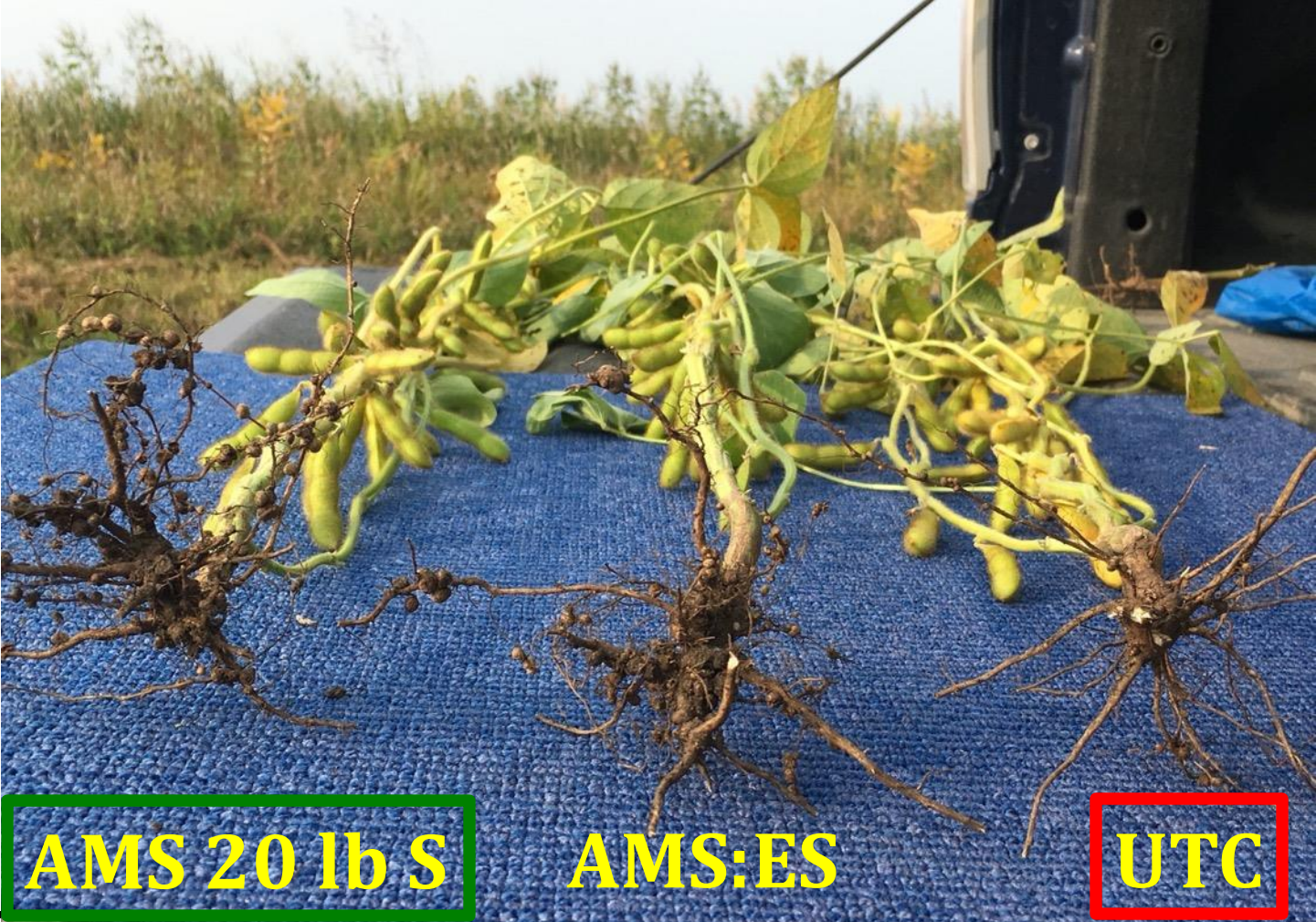
20 lb S/ac

No Sulfur



20 lb S/ac





AMS 20 lb S

AMS:ES

UTC

Soybean Sulfur: 23 W. Lafayette

		Sulfur Concentrations (%)							
Fertility	Cover Crop	V4		R2		R4		R8 Seed	
None	None	0.22	0.22 c	0.30 c		0.23 b		0.24 c	
None	Cereal Rye	0.22		0.28 de		0.21 d		0.20 d	
Urea	None	0.22	0.21 c	0.29 d		0.23 bc		0.23 cd	
Urea	Cereal Rye	0.21		0.27 e		0.21 cd		0.20 d	
Gypsum	None	0.26	0.26 a	0.34 b		0.30 a		0.31 ab	
Gypsum	Cereal Rye	0.27		0.35 ab		0.29 a		0.32 a	
Urea + Gypsum	None	0.24	0.25 b	0.36 a		0.29 a		0.28 b	
Urea + Gypsum	Cereal Rye	0.26		0.35 ab		0.29 a		0.31 ab	



C.Rye
Urea
Gypsum

No Cover
Gypsum

Soybean N to S Ratio: 23 W. Lafayette

Fertility	Cover Crop	Nitrogen to Sulfur Ratio							
		V4		R2		R4		R8 Seed	
None	None	17.7	ab	17.3	b	19.3	19.6 a	24.8	b
None	Cereal Rye	17.0	b	18.2	a	20.0		28.6	a
Urea	None	17.6	ab	18.8	a	19.3	19.6 a	25.1	b
Urea	Cereal Rye	18.4	a	18.2	a	19.9		29.0	a
Gypsum	None	14.6	d	15.6	c	17.7	17.9 b	20.1	c
Gypsum	Cereal Rye	14.8	d	15.5	c	18.0		19.3	c
Urea + Gypsum	None	15.8	c	15.6	c	17.9	18.0 b	21.6	c
Urea + Gypsum	Cereal Rye	14.8	d	15.9	c	18.1		19.5	c

C. Rye x NS in Soybean: 23 & 24 West Lafayette



Cover Crop	Fertility	23 Yield	24 Yield	Pooled
None	None	61.2 bc	81.5 b	71.3 b
	Urea	62.4 b	81.7 b	72.0 b
	Gypsum	71.4 a	86.3 a	78.8 a
	Urea + Gypsum	74.3 a	87.3 a	80.8 a
Cereal Rye	None	54.7 d	73.8 c	64.3 c
	Urea	58.2 cd	75.7 c	66.9 c
	Gypsum	71.0 a	87.3 a	79.1 a
	Urea + Gypsum	74.8 a	88.9 a	81.9 a



+ 7.5 bu

- 7 bu

+ 15 bu

— Soybean overcome and match yield level in both systems!

23 Cereal Rye x NS: West Lafayette



April 18th
Terminate Cereal Rye



May 6th
Apply Fertilizer, Plant Soy



Sept 1st
Response of Soybean

Residue with High Carbon: Immobilization of Sulfur

Sudden Death Syndrome

Fertilizer	Severity	Incidence	Disease Index
None	2.3 a	48%	12.6 a
Urea	2.0 a	48%	10.7 a
Gypsum	1.0 b	39%	3.6 b
Urea + Gypsum	1.1 b	33%	4.8 b

Pooled over cereal rye + no cover, West Lafayette, 2023

Cereal Rye x NS: Preliminary Conclusions

- Soybean development and yields were limited over two seasons due to S immobilization within **Cereal Rye** system.
- Sulfur addition (**Gypsum** in this study) increased S concentrations in soybean through the growing season, improved nodulation and N fixation, and increased soybean yield within **Cereal Rye** system to the same level as **No Cover** system.
- Carbon additions from **Cereal Rye** and field conditions (temperature and moisture) prior to and after plantings were likely the sources of our responses as they influence mineralization, nodulation, and fixation.

Thanks for the support!



Corn following a Rye Cover Crop: Management Considerations

Dan Quinn, Ph.D.

Extension Corn Specialist

Assistant Professor of Agronomy

Purdue University

Email: djquinn@purdue.edu

Web: thekernel.info



Corn Agronomy

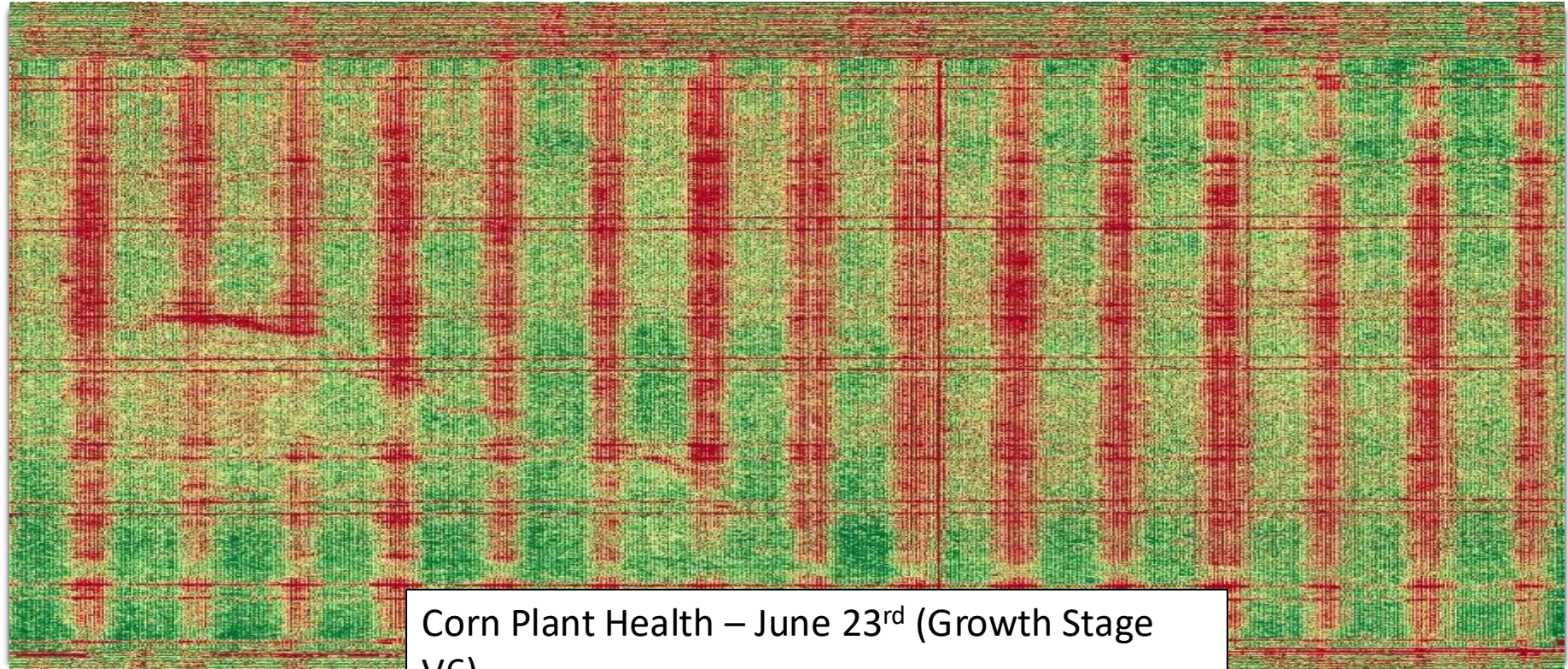


Rye is one of the most common species for cover crop in grain fields in the Midwest.

- May be the only choice they have

- Soil Erosion
- Nitrate Leaching
- Resistant Weed Populations
- Water Retention
- Soil Organic Matter





Corn Plant Health – June 23rd (Growth Stage V6)





Rye Cover Corn Yield Reduction Causes

- **Corn Yield Reduction Observed:** (Raimbult et al., 1990; Duiker and Curran, 2005; Miguez and Bollero, 2006; Kaspar and Bakker, 2015; Pantoja et al., 2015; Martinez-Feria et al., 2016)
- **Limited N Availability:**
 - **Rye N uptake** (Raimbult et al., 1991; Unger and Vigil, 1998; McSwiney et al., 2010; Krueger et al., 2011; Mirsky et al., 2015; Pantoja et al., 2015; Hill et al., 2016)
 - **N immobilization** (Reeves, 1994; Kuo et al., 1997; Kuo and Jellum, 2002; McSwiney et al., 2010; Pantoja et al., 2015; Nevins et al., 2020)
- **Reduced Plant Stand:**
 - **Disease** (Smiley et al., 1992; Bakker et al., 2016; Acharya et al., 2017)
 - **Equipment Interference** (Kaspar and Bakker, 2015; Marcillo and Miguez, 2017)
 - **Moisture Reduction** (Eckert, 1988; Kaspar and Bakker, 2015; Marcillo and Miguez, 2017)
 - **Insects** (Dunbar et al., 2016)

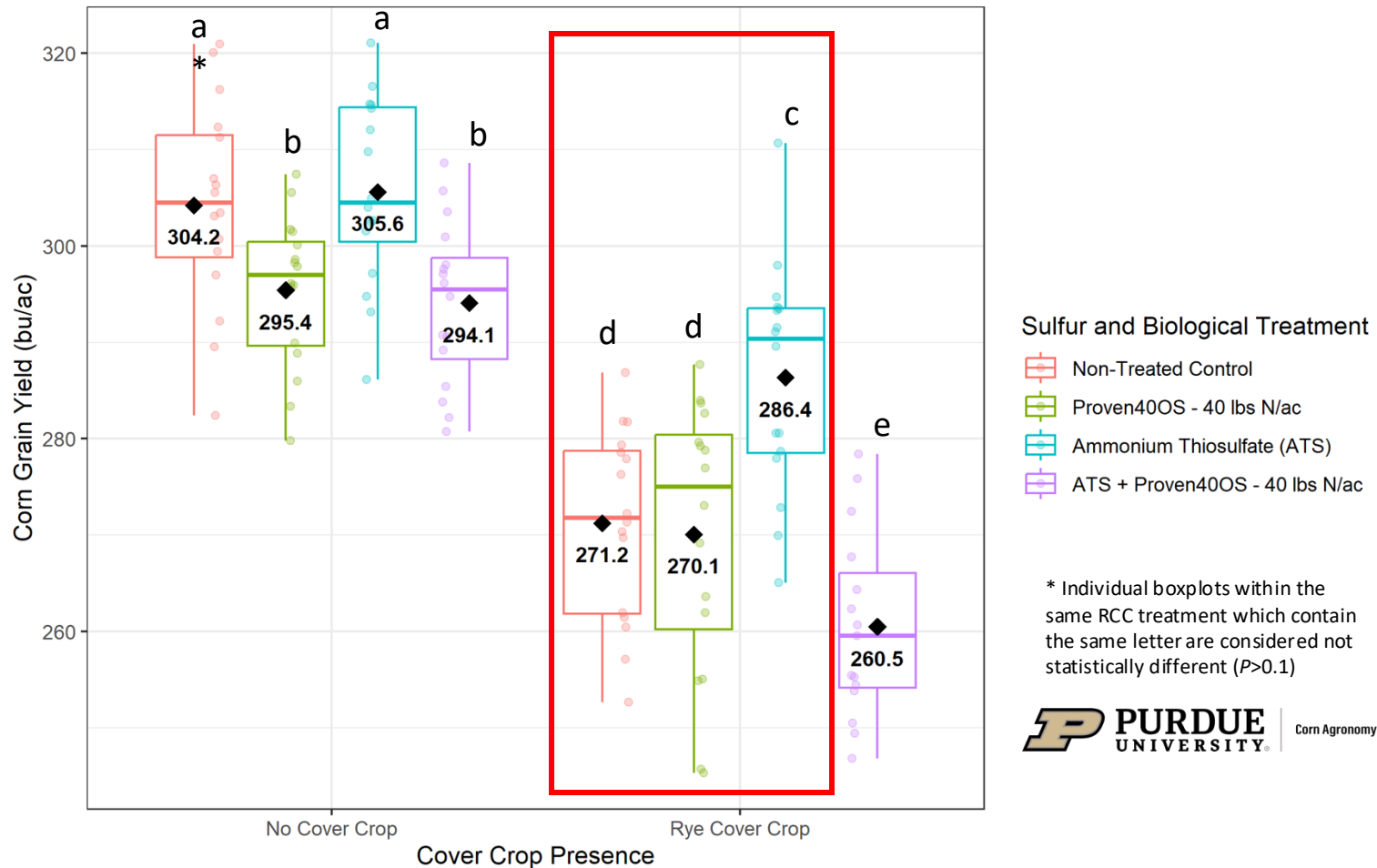


What have we learned so far?

- Starter fertilizer use (2x2) can help reduce early-season nutrient stress in corn when following cereal rye
- In-season N fertilizer application management can be used to reduce corn N stress, yield loss, and N fertilizer requirement following a rye cover crop.
 - Can get away with delayed sidedress N without a rye cover crop, can't get away with it with a rye cover crop (V5 sidedress essential)
- Closing wheel type improved visual furrow closure, emergence, and yield in certain locations when rye cover crop was present (biomass level likely played a role)
- Applied downforce differs with the presence of a cover crop. Active downforce systems may be best suited to account for field spatial variability of residue



Corn Response to Rye Cover Crop, Sulfur, and N Biologicals – ACRE (West Lafayette, IN) - 2024



No Rye Cover Crop + No Sulfur



Rye Cover Crop + Sulfur (15 lbs S/ac as ATS at V5)



Questions

Shaun Casteel

Purdue Extension Soybean

scasteel@purdue.edu

X @PurdueSoybean

Dan Quinn

Purdue Extension Corn

djquinn@purdue.edu

X @PurdueCorn

