Fluid Fertilizer Technology Workshop

"Which Starter Nutrients Close The Yield Gap When Corn Is Planted After Cereal Rye

Jacob Vossenkemper, PhD – Director of Research & Agronomy
For Twin State Inc.

Davenport, IA Nov 30th and Dec 1st 2022

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- **Special Thanks**
  - Lowell Gentry, Principal Research Specialist at Univ of Illinois
  - Dr. Shalamar Armstrong, Soil Ecosystems and Nutrient Dynamics Lab at Purdue Univ
  - Hunter Bielenberg, Agronomy Research Manager at Twin State Inc.
  - My “army” of interns who make all this work possible

Research Rationale/Background

- Increasing societal interest in addressing climate change
  - Soil health
  - Regenerative agriculture
  - Carbon/GHG markets
  - Nutrient loss reduction
  - Land stewardship etc……

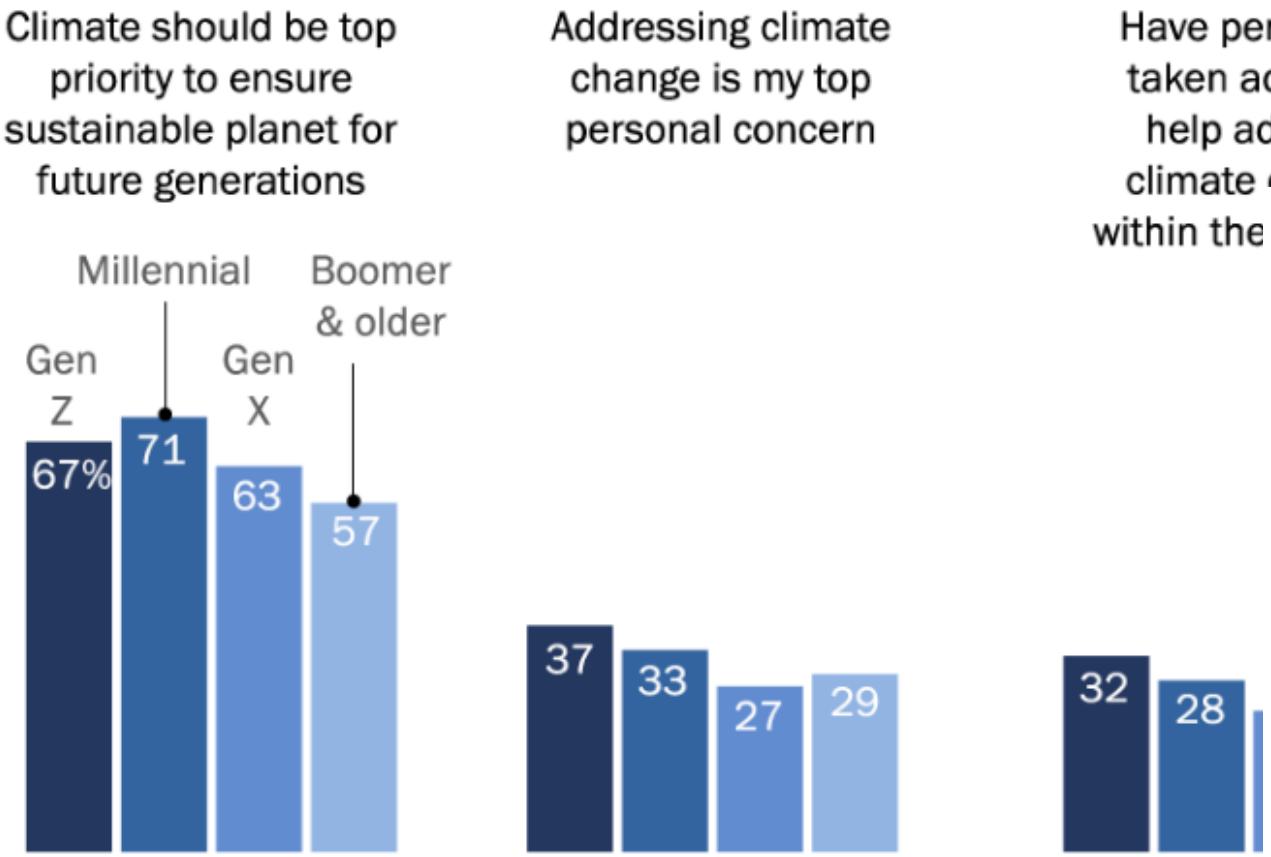
Pew Research Center Survey, May 2021

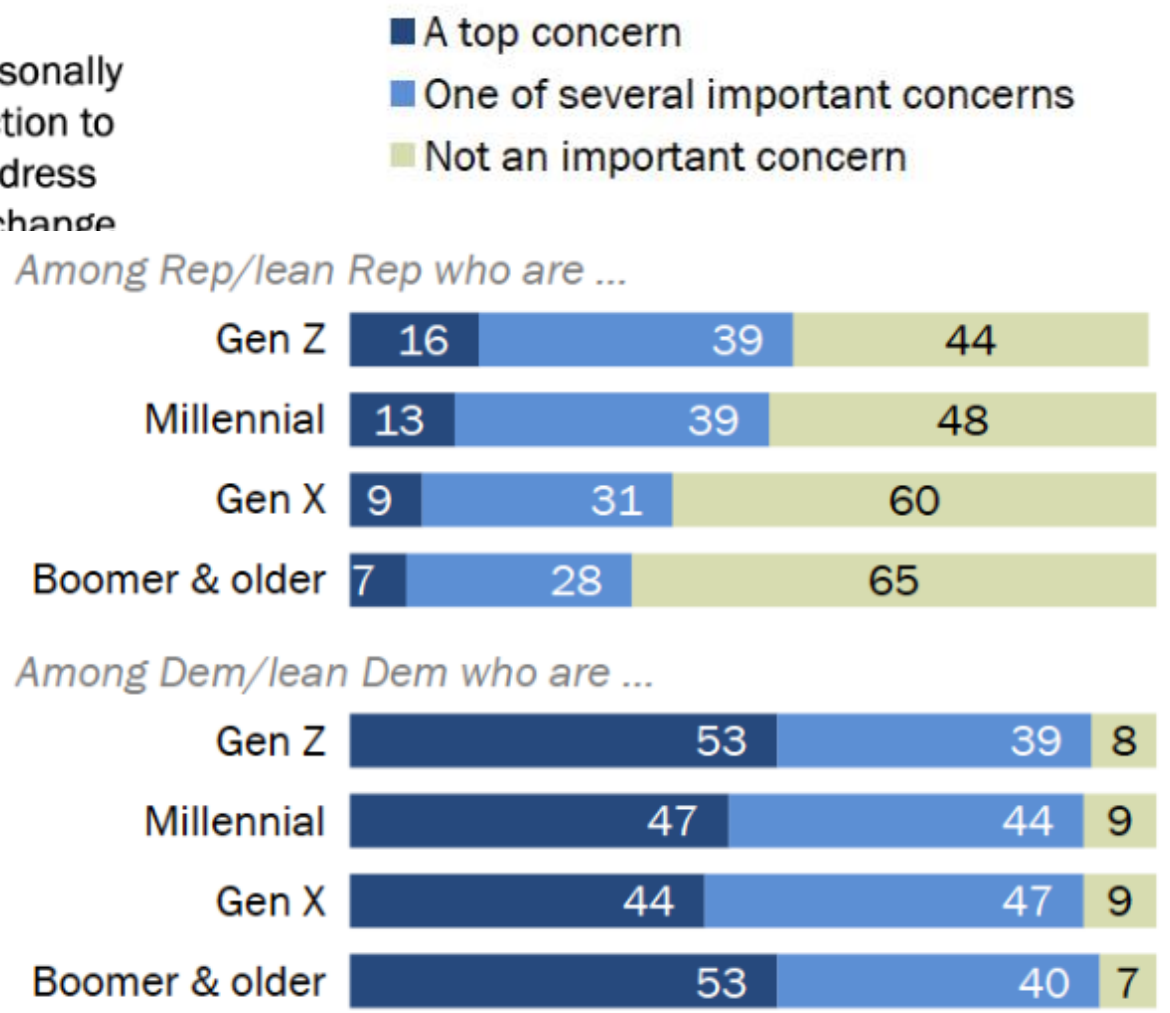
SCIENCE DRIVEN DECISIONS

Gen Z, Millennials more active than older generations addressing climate change on- and offline

https://www.pewresearch.org/science/2021/05/26/climate-engagement-and-activism/

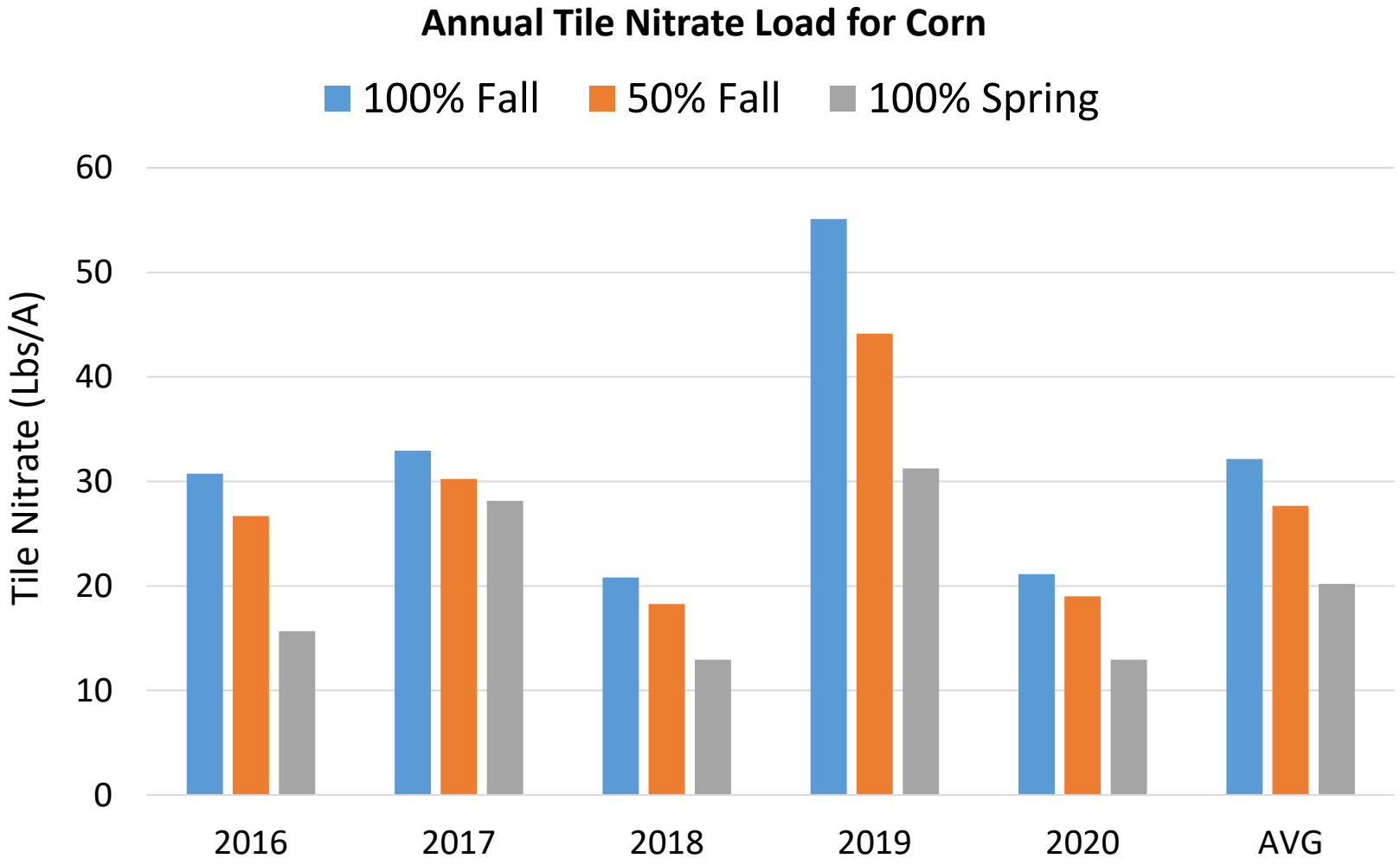
% of U.S. adults who say ...





Timing of N Application is Important

Figure Courtesy of Lowell Gentry, Univ of Illinois



Fall N plots lost 12 lbs/A more tile nitrate than spring N plots.

Research Rationale/Background

- Cover crops proposed to help address these issues that society is becoming more concerned about
  - Reduce soil erosion
  - Increase nutrient stewardship/reduce loss
  - Increase soil water retention/infiltration
  - Increase soil organic carbon
    - Store CO_2 in soil = less in atmosphere curbs global warming

4-yr Cumulative Tile Nitrate Load 2016-2019

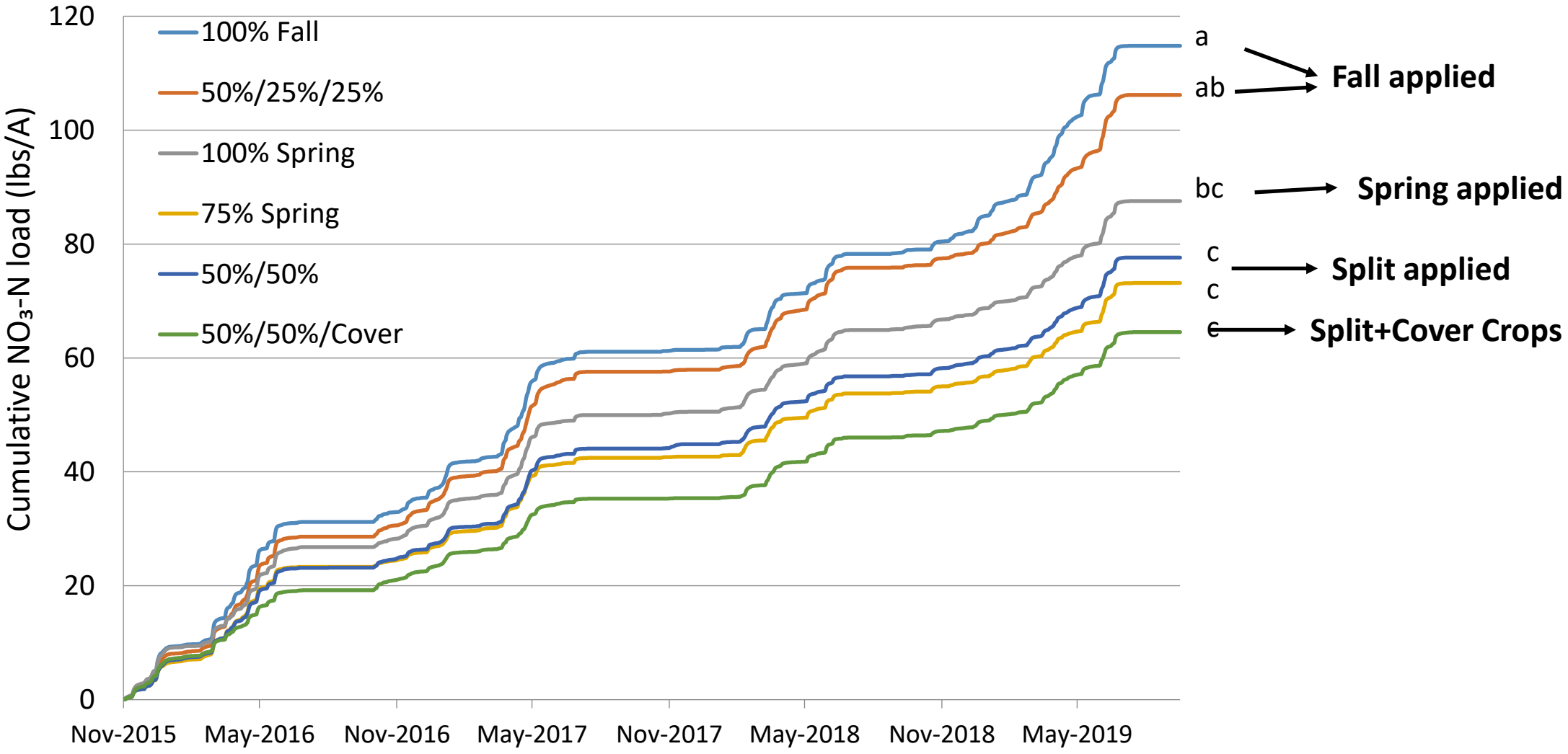


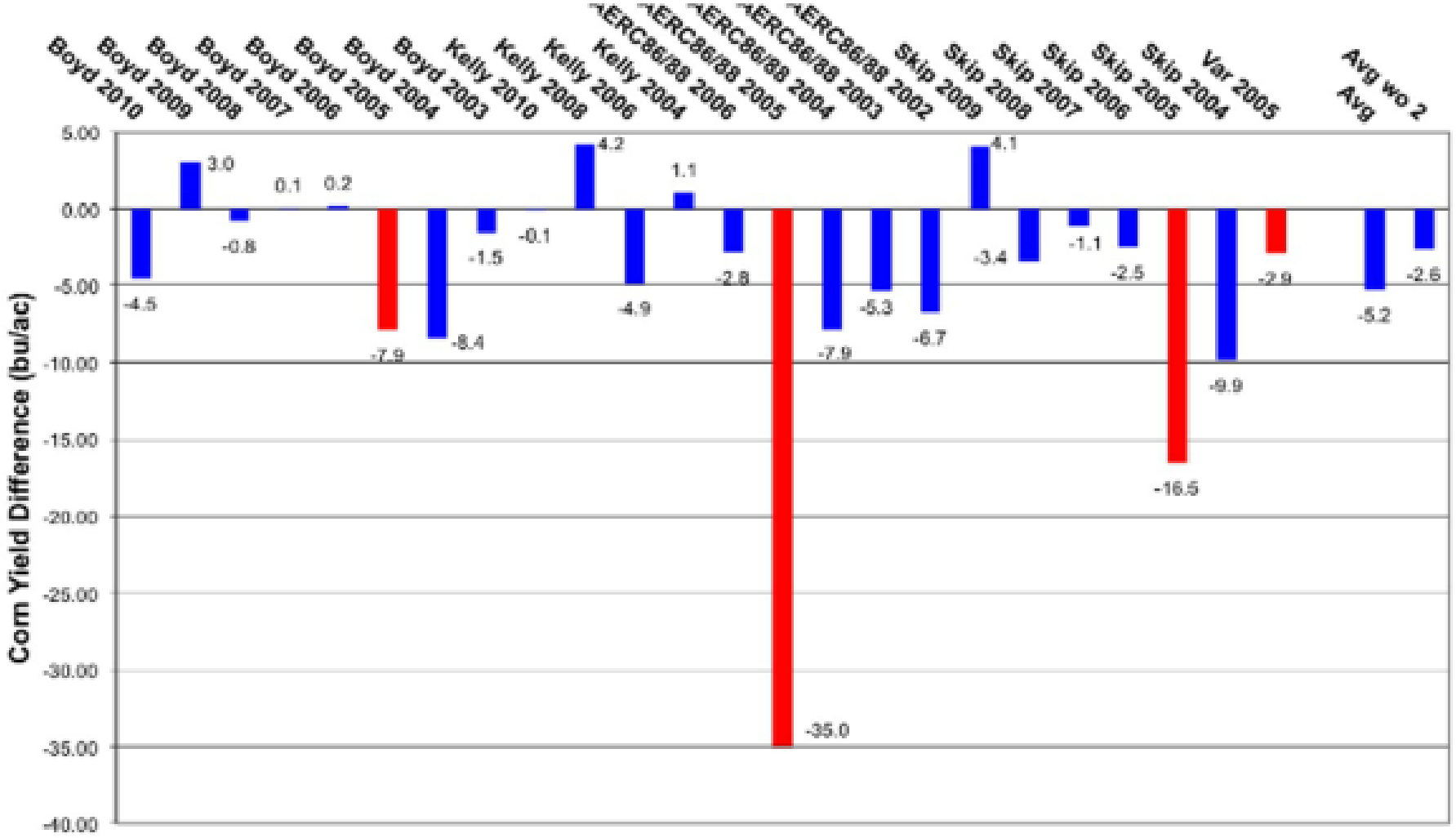
Figure Courtesy of Lowell Gentry, Univ of Illinois

Research Rationale/Background

- Cereal rye has become the most widely used cover crop in the north-central United States
  - Will germinate and grow at soil temps of 35 deg F
  - Deep rooted, excellent nitrogen scavenger
  - Quick green up and biomass in spring
  - Relatively easy to kill – winter annual suppression
  - Relatively inexpensive ($15/ac or so)
  - **Great cover crop – except????**

Corn Yield Differences Following a Rye Cover Crop

Summary of 23 trials from 2003 – 2010



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Averaged over the 23 trials 5.2 bu/ac yield decrease when corn followed cereal rye

$4.50 corn that's $23.40/ac, there went your payment

How can we avoid this?

Why **can** cereal rye reduce corn yields?

- **Stand** - Difficult to get effective seed to soil contact, need a no-till planter prepared for the job
- **Green bridge** – Pythium over winters very well in cereal rye and acts as a bridge to the next corn crop
- **Allelopathy?** – Debated, but natural herbicidal compounds are released from some grasses as they decay effecting germination and vigor of future crops
- **Nutrient deficiencies** – Because of cereal ryes aggressive root system and vigorous biomass accumulation it is an excellent scavenger of nitrogen and other mineral nutrients
  - Those nutrients may or may not be released to the proceeding corn crop in time to meet crop demand
- **Soil temps** can remain wet and cool if a mat of cereal rye is on soil surface in early spring

Species such as cereal rye, which has a high carbon-to-nitrogen ratio, will tie up fixed nitrogen during the beginning of subsequent planting season,

Green Bridge – Pythium

Plant Disease • 2017 • 101:591-600 • http://dx.doi.org/10.1094/PDIS-07-16-0975-RE

Time Interval Between Cover Crop Termination and Planting Influences Corn Seedling Disease, Plant Growth, and Yield

J. Acharya, Department of Plant Pathology and Microbiology, Iowa State University, Ames 50011; **M. G. Bakker, T. B. Moorman,** and **T. C. Kaspar,** National Laboratory for Agriculture and the Environment, United States Department of Agriculture–Agricultural Research Service, Ames, IA 50011; **A. W. Lenssen,** Department of Agronomy, Iowa State University, Ames; and **A. E. Robertson,** Department of Plant Pathology and Microbiology, Iowa State University, Ames

Acharya et al., 2017

Bottom line: burndown cereal rye 2 to 3 weeks before planting corn to avoid seedling diseases and yield loss

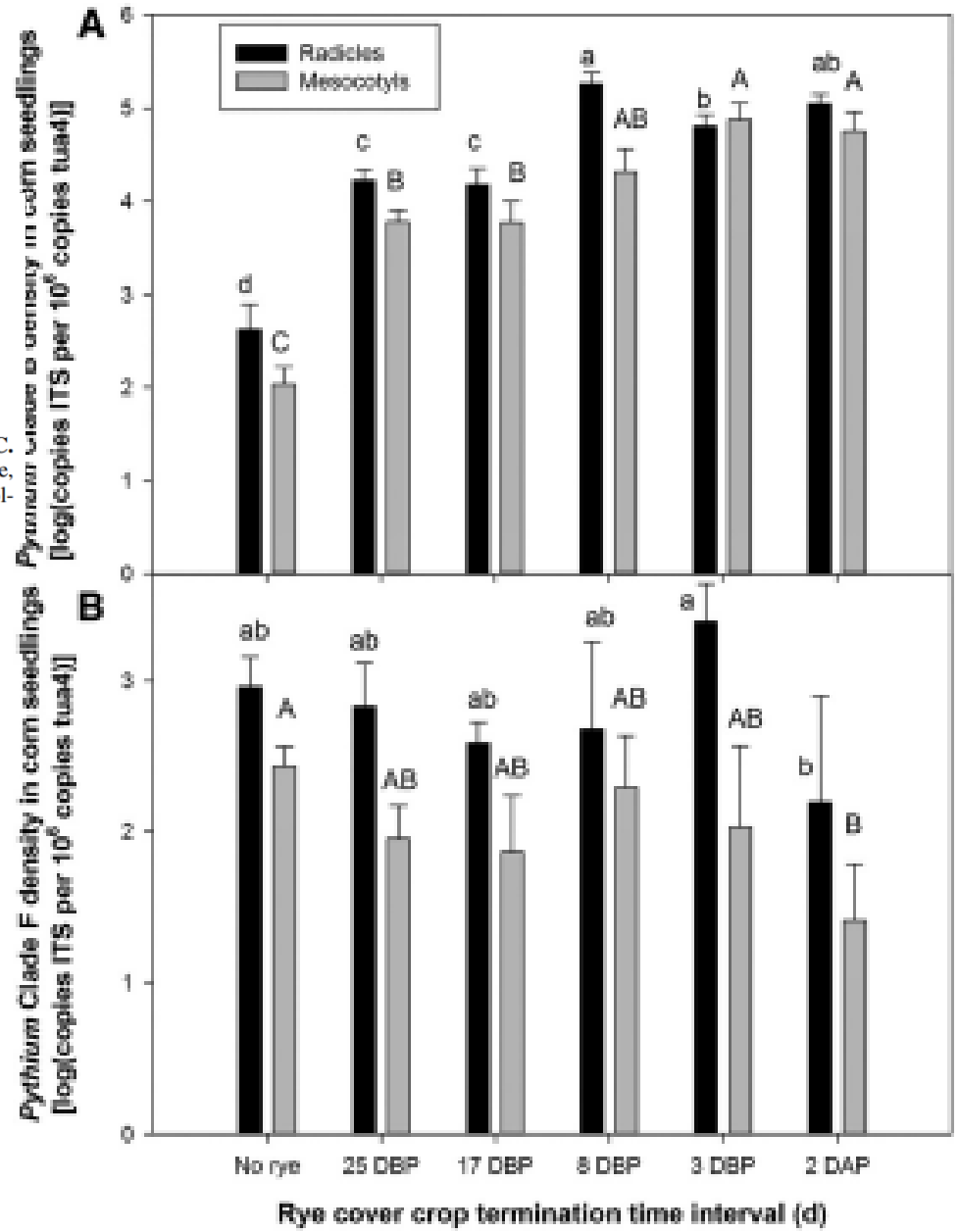

Fig. 3. Density of *Pythium* spp. belonging to **A**, clade B and **B**, clade F in radicles and mesocotyls of corn seedlings in the 2015 field experiment, in relation to rye cover crop termination-time interval (days). Pathogen density (copies of *Pythium* spp. internal transcribed spacer [ITS] gene) was assessed relative to host plant DNA (copies of corn tua4 gene). DBP = days before planting and DAP = days after planting. Bars topped with the same letter are not significantly different at *P* value = 0.05.

Research Rationale/Background

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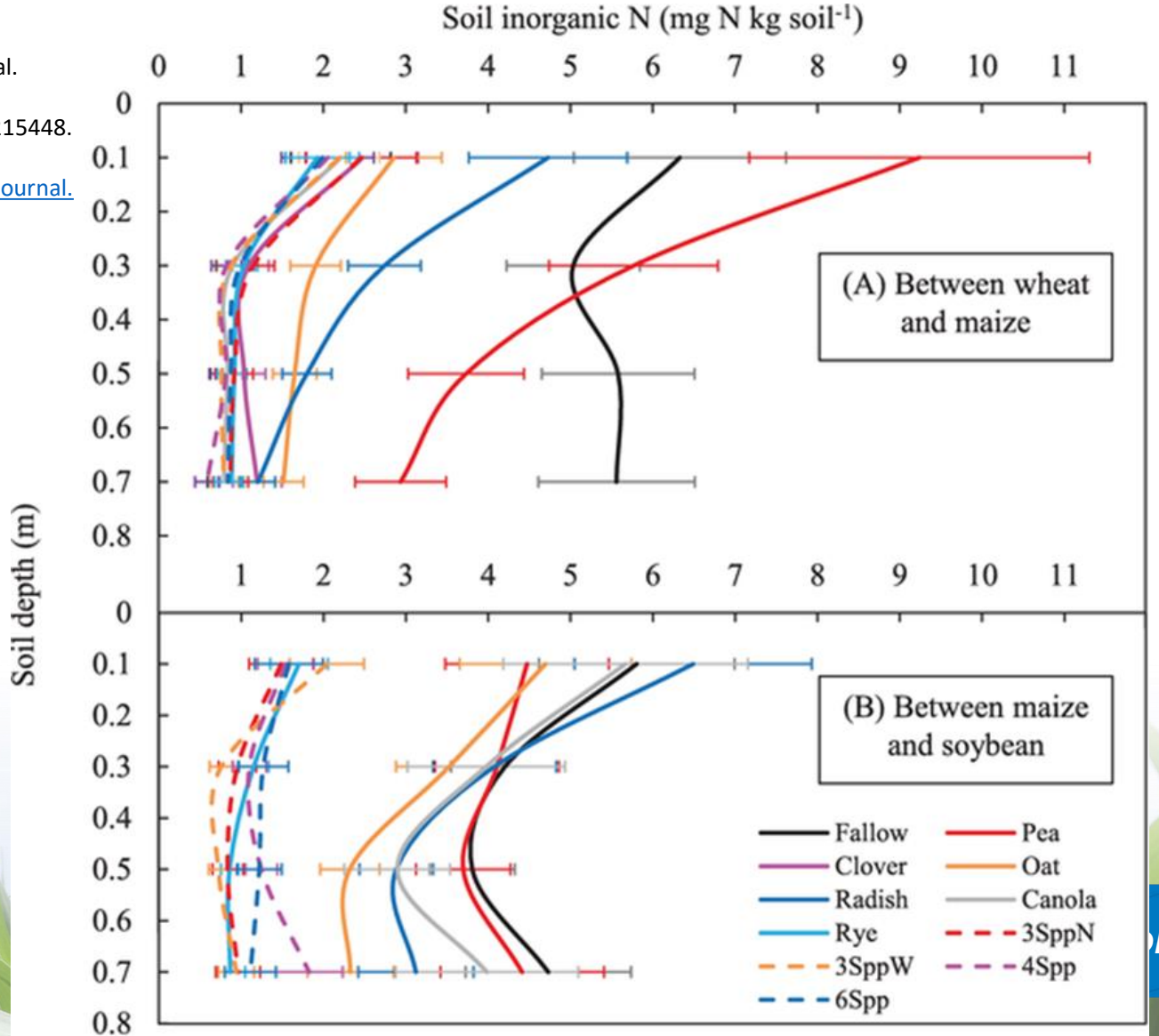
Fig 4. The concentration of extractable soil inorganic N with depth in spring 2014.

Kaye J, Finney D, White C, Bradley B, Schipanski M, et al. (2019) Managing nitrogen through cover crop species selection in the U.S. mid-Atlantic. PLOS ONE 14(4): e0215448. https://doi.org/10.1371/journal.pone.0215448
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0215448



Management Considerations

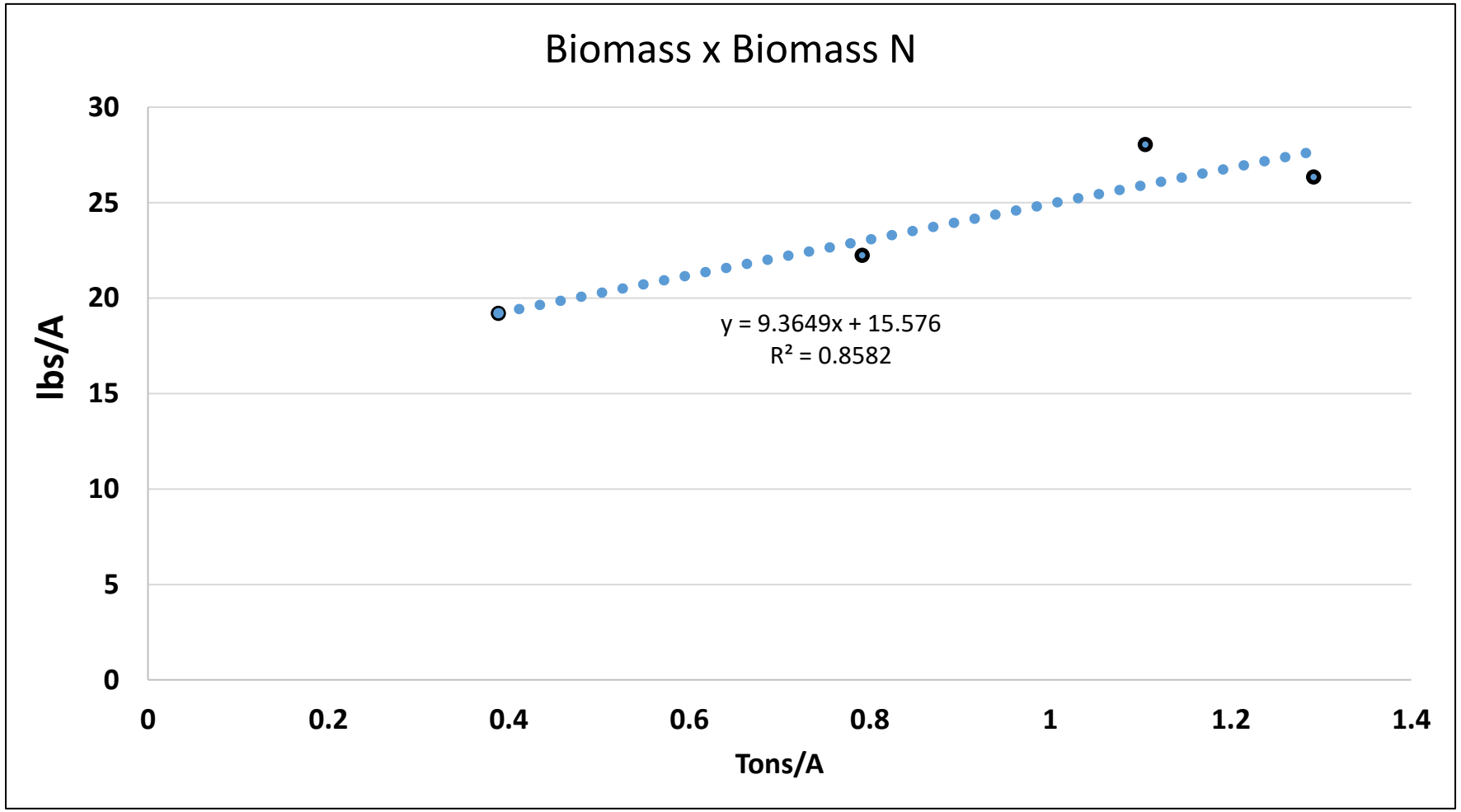


Figure Courtesy of Lowell Gentry, Univ of Illinois

Where Does The N In Cereal Rye Go?

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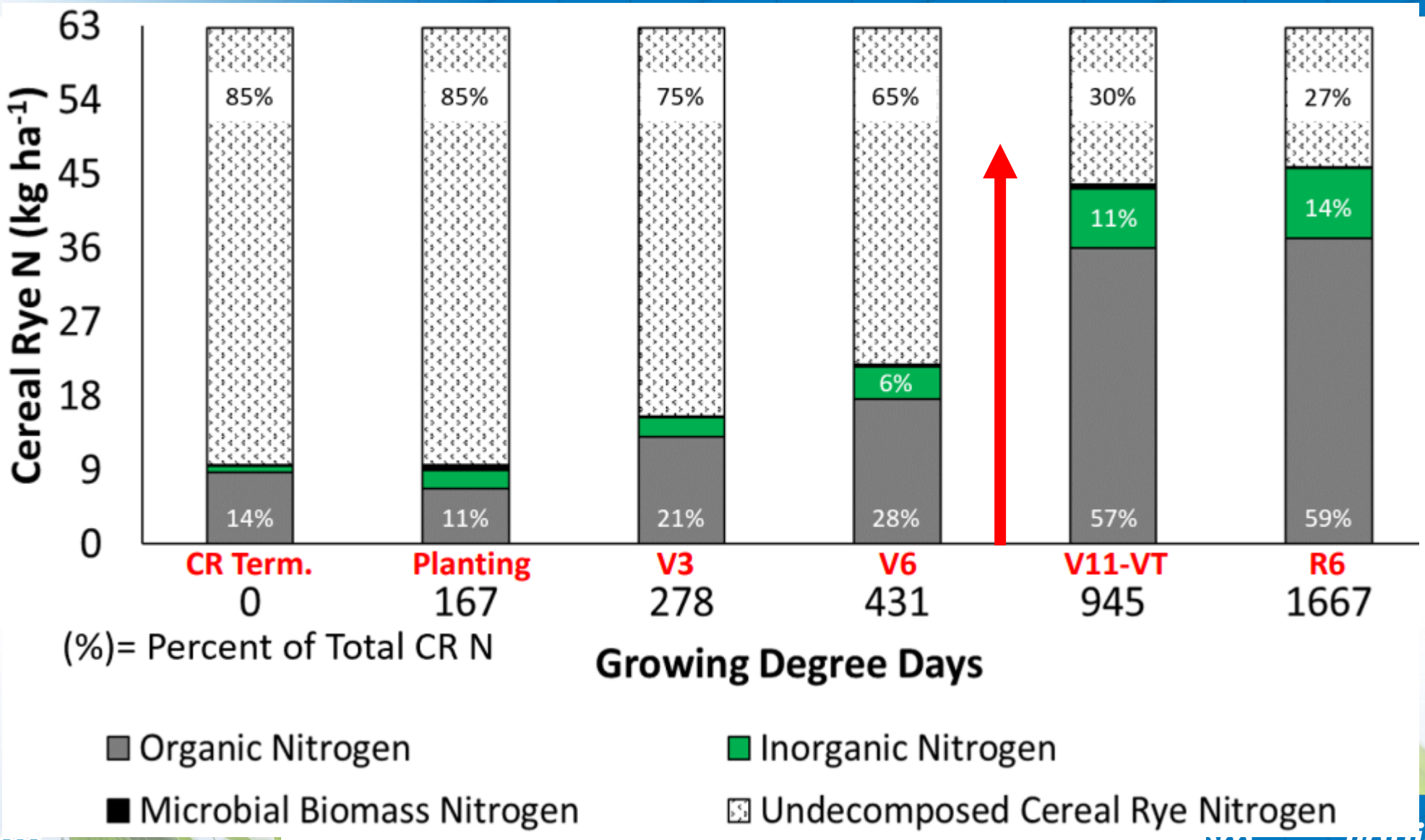


Figure Courtesy of Shalamar Armstrong, Purdue Univ

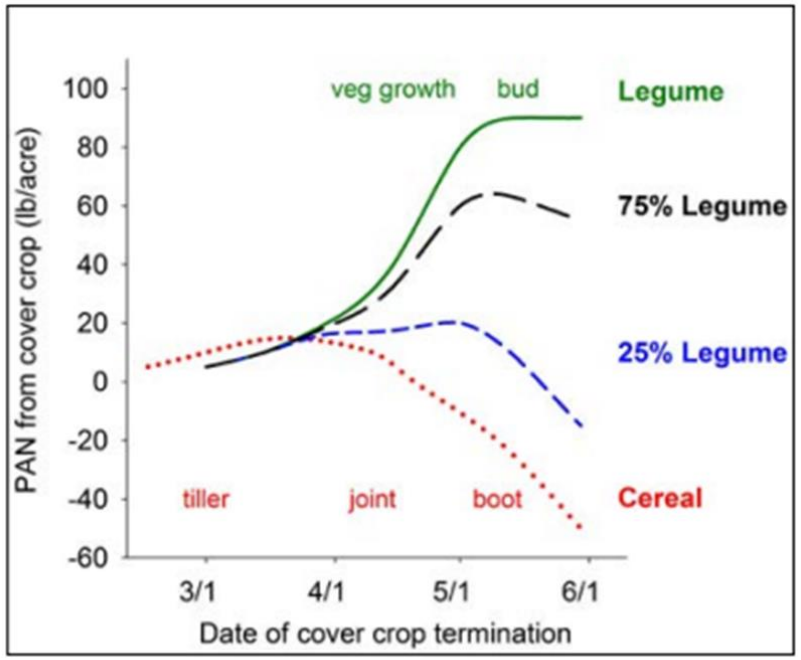
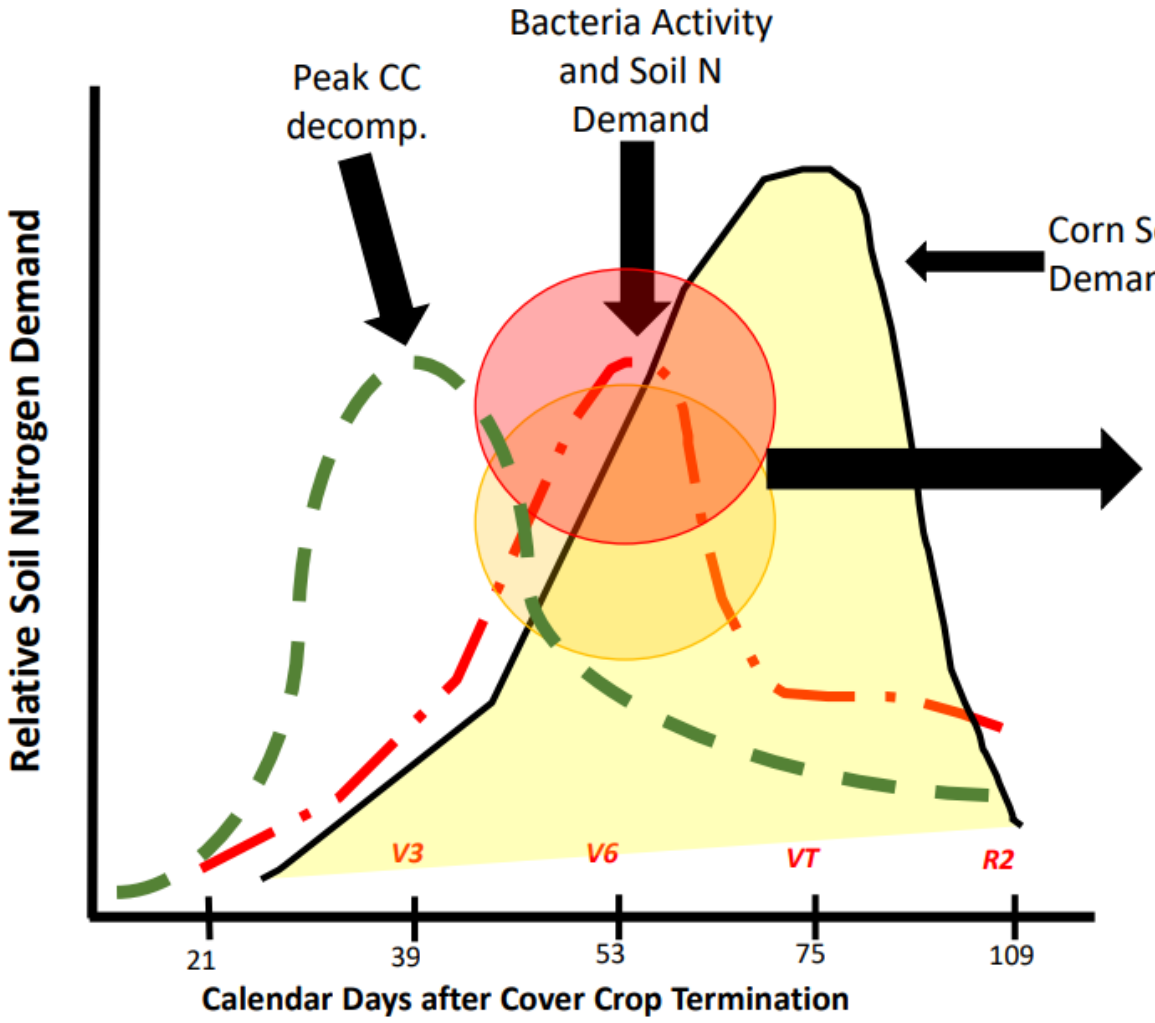


FIgure 4.—Effect of kill date on typical plant-available N (PAN) release from cereal, legume, or mixed stands. Based on compilation of field data from Willamette Valley cover crop trials. Source: D. Sullivan.

https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw636.pdf

Soil N Demand Synchrony



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

Figure Courtesy of Shalamar Armstrong, Purdue Univ

Corn and Cereal Rye The Nitrogen Problem

- Cereal Rye is an excellent scavenger of nitrogen
- Nitrogen concentrations in the soil often very low after cereal rye cover crop is grown
- As cereal rye gets larger in the spring C:N ratio goes up
- In some cases, the plant available N balance in the soil can be negative
- Explosion of microbes breaking down carbon (cereal rye residue) use up all available soil N
  - Including fertilizer N added to the soil – leaves very little N for corn
- Makes since that a well-placed N source that's not highly available to soil microbes and is available to corn would increase yields in this cropping system
  - 2x2, 0x2 etc…. Out-of-furrow high-rate planter applied N applications

Corn and Cereal Rye The Nitrogen Problem

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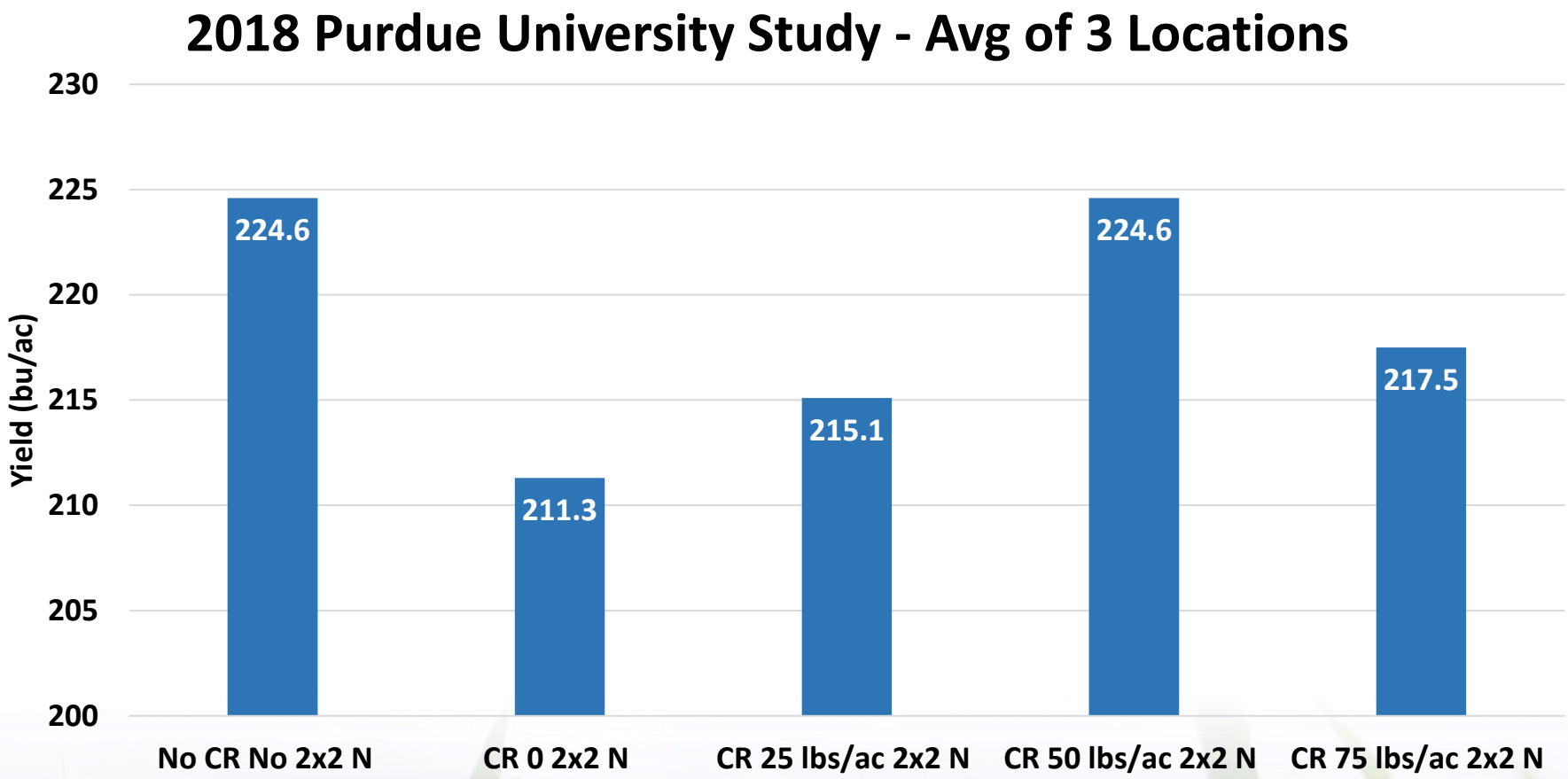

Figure adapted from: Preza-Fontes, G., Miller, H.,Camberato, J., Roth, R., & Armstrong, S. (2022).Corn yield response to starter nitrogen rates followinga cereal rye cover crop.Crop, Forage & TurfgrassManagement,8,e20187.https://doi.org/10.1002/cft2.20187

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John Sawyers Lab, Iowa State – 2014-2016

Table 3. Corn population, plant height, and grain yield, 2014-2016.

Practice		V6 Population	V6 Height	Yield
		plants/acre	*inch*	*bu/acre*
Tillage	Till	32,500b†	24a	209a
	No-till	33,500a	22b	203b
Starter	Starter **30 lbs N/ac 2X2**	33,000a	23a	207
	No starter	33,000a	22b	205
Cover Crop	With rye	33,000a	22b	204b
	No rye	33,000a	23a	208a

† Letters indicate significant difference ($p \leq 0.10$). No interaction between practices. Results across four locations.

2017 Integrated Crop Management Conference - Iowa State University
https://www.agronext.iastate.edu/soilfertility/info/NitrogenDynamics-RyeCoverCrop_ICM2017.pdf

- Not exactly cut and dry that out-of-furrow N applications are required, despite my speculation
- What about sulfur, similar soil dynamics/cycling at work as nitrogen (sulfur immobilizations/mineralization)
- Cereal rye probably results in colder wetter soils (particularly if terminated well before planting) so roots grow slower, and P&K would also diffuse slower toward roots
- What about root uptake efficiency with pythium, would this mean a higher NPKS concentration is needed to meet crop requirement?

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Materials and Methods

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						Sand	Silt	Clay	Bray P1	NH4 Acetate K	
Previous Crop	**Location Name**	**Grid Coordinates**	**CEC**	**O.M. %**	**Texture**	%			(ppm)		**1:1 pH**
Corn	Walnut, IL	41.476756, -89.635747	20.4	4.6	Silty Clay Loam	16	48	36	20	169	5.7
Soybean	Illinois City, IL	41.304872, -91.066138	14.1	2.3	Clay Loam	28	42	24	6	113	5.9
Soybean	Chillicothe, IL	40.912036, -89.556579	10.0	2.2	Loam	34	42	24	40	131	6.3

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Materials and Methods

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Starter Nutrient	Nutrient Rate	Source Fertilizer
	- - -lbs/ac N-P-K-S-Zn - - -	
Broadcast Nitrogen (UAN)	180	UAN 32%
+Starter N	60	UAN 32%
+Starter NP	60-10	+APP
+Starter NPK	60-10-10	+KCL
+Starter NPKS	60-10-10-10	+ATS
+Starter NPKSZn	60-10-10-10-0.5zn	+15% Ammoniated Zn

No other crop nutrients applied in these studies other than the nutrients in the high rate out-of-furrow starter

Materials and Methods

- Split plot design, cereal rye main-plots and starter treatments as sub-plots
- Mixed model ANOVA in SAS
- Fixed effects: starter treatments, cereal rye and cereal rye x starter treatments
- Random effects: location, blocks(location), split-plot error term cereal rye x blocks(location)
- Mean separation PDMIX 800 for LSD at alpha 0.10

Results

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Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Starter Treatment	5	138	13.17	<.0001
Cereal Rye	1	14	31.1	<.0001
Cereal Rye*Treatment	5	138	1.46	0.2061

Starter Nutrient	Nutrient Rate	Corn Yield	Delta Yield Over Base N
	- - -lbs/ac N-P-K-S-Zn - - -	- - - - - - - - - - - -bu/ac - - - - - - - - - - -	
Broadcast Nitrogen (UAN)	180	225.2	
+Starter N	60	228.5	3.3
+Starter NP	60-10	234.5	9.3*
+Starter NPK	60-10-10	**236.7**	11.5*
+Starter NPKS	60-10-10-10	**252.3**	27.1**
+Starter NPKSZn	60-10-10-10-0.5zn	259.4	34.2*
	Starter Nutrient Pr>F =<.0001	**LSD at 0.10 = 8.7**	

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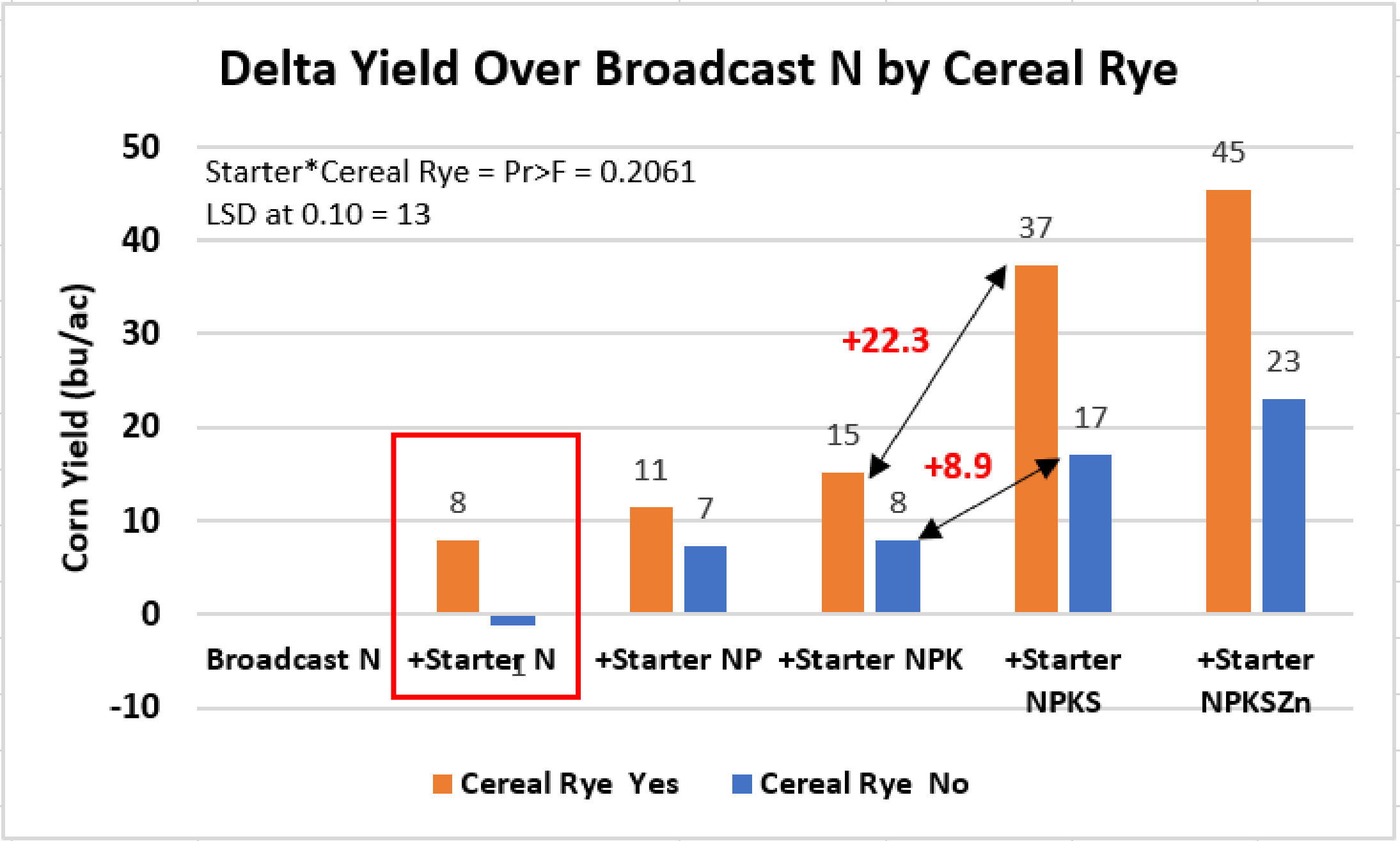
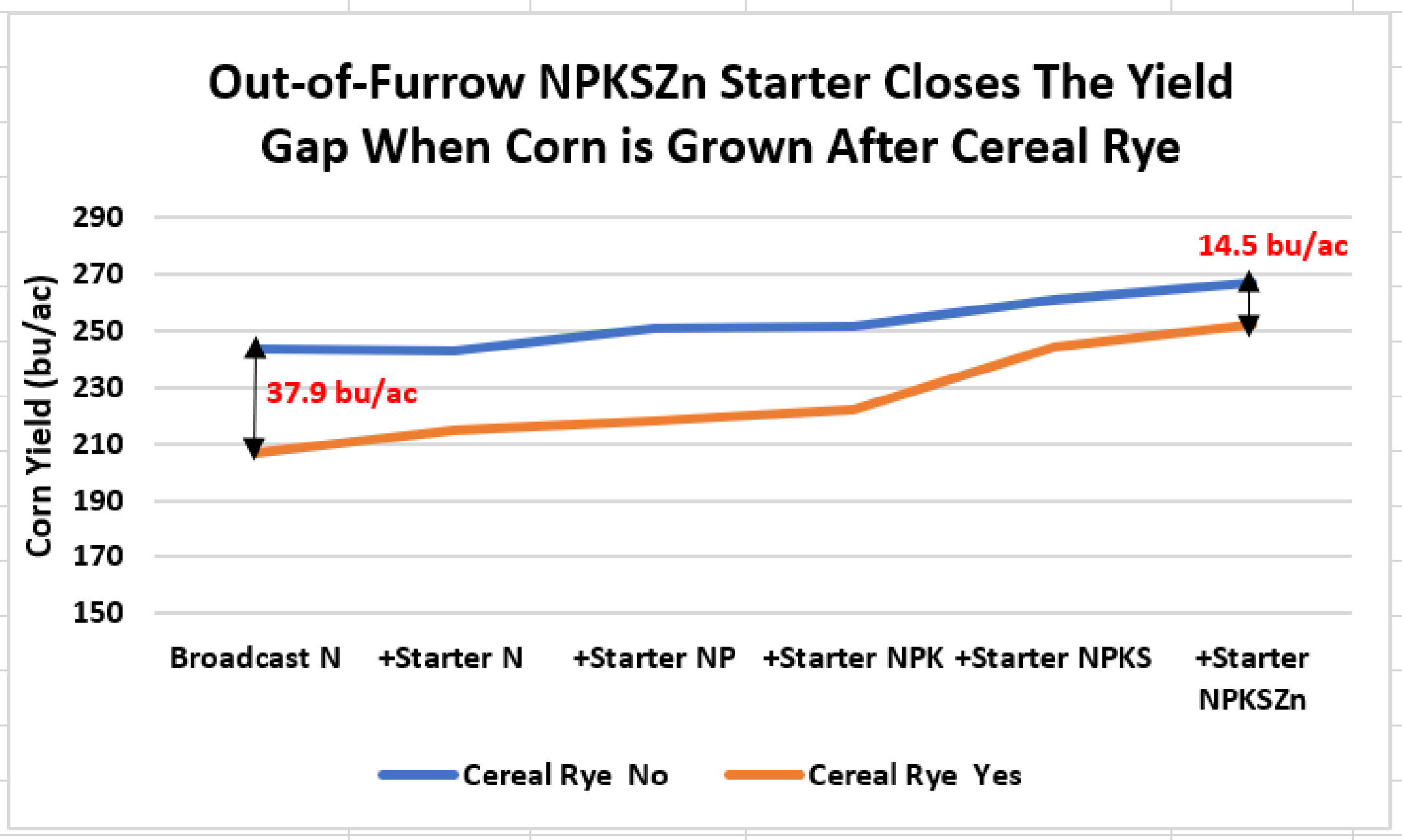

Delta Yield Over Broadcast N by Cereal Rye
Starter*Cereal Rye = Pr>F = 0.2061
LSD at 0.10 = 13
Corn Yield (bu/ac)
50
40
30
20
10
0
-10
8
11
7
15
8
37
17
45
23
+22.3
+8.9
Broadcast N
+Starter N
+Starter NP
+Starter NPK
+Starter NPKS
+Starter NPKSZn
Cereal Rye Yes
Cereal Rye No

Res


Out-of-Furrow NPKSZn Starter Closes The Yield Gap When Corn is Grown After Cereal Rye
Corn Yield (bu/ac)
290
270
250
230
210
190
170
150
14.5 bu/ac
37.9 bu/ac
Broadcast N
+Starter N
+Starter NP
+Starter NPK
+Starter NPKS
+Starter NPKSZn
Cereal Rye No
Cereal Rye Yes

Manage Research & Development

Sales Support (grower meetings/key account visit's)

Lead Agronomic Trainings

Agronomic Service Calls

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