Nitrogen and Phosphorus Management to Increase Nutrient Use Efficiency and Corn Grain Yield

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University of Illinois at Urbana-Champaign

2020 Fluid Fertilizer Forum

Scottsdale, AZ February 18, 2020

Crop Physiology

Why is February my Favorite Month?

- I get paid by the month
- Groundhog Day

Groundhog Does Not See Shadow in 2019

Predicts an Early Spring

Crop Physiology

Why is February my Favorite Month?

- I get paid by the month
- Groundhog Day
- Valentines Day
- Presidents Day

President Trump Likes Corn

Why is February my Favorite Month?

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- Presidents Day
- Fluid Fertilizer Forum

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Test Your Knowledge of High Yield Corn

- **What is the world record corn yield and what is the corn yield gap?**

The Corn Yield Gap

- **World Record yield of 616.1953 bushels per acre in 2019**
- **US average record yield of 177 bushels per acre in 2017**
- **Yield Gap = Record Yield – Average Yield = 439 bushels**

The NCGA Corn Yield Contest

- 9 categories that include: state corn area, conventional, no-till and strip tillage, and irrigated, non-irrigated with 3 winners in each category

- All but 1 of the 27 contest winners in 2019 exceeded 300, 3 exceeded 400, 3 exceeded 500, and 1 exceeded 600 bushels

2019 National Corn Growers Contest Winners
Top Ten Yields and Locations

David Hula, Virginia @ 616.2
Bridget Dowdy, Georgia @ 553.0
Craig Hula, Virginia @ 545.8
Randy Dowdy, Georgia @ 523.0
Kevin Dowdy, Georgia @ 478.0
Dustin Dowdy, Georgia @ 432.0
Drew Haines, Maryland @ 422.4
Kevin Kalb, Indiana @ 394.5
Michelle Dowdy-Deese, Georgia @ 393.0
Heath Cutrell, Virginia @ 381.5

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Seven of the Top Ten Yield Winners Were Irrigated

David Hula, Virginia @ 616.2
Bridget Dowdy, Georgia @ 553.0
Craig Hula, Virginia @ 545.8
Randy Dowdy, Georgia @ 523.0
Kevin Dowdy, Georgia @ 478.0
Dustin Dowdy, Georgia @ 432.0
Drew Haines, Maryland @ 422.4
Kevin Kalb, Indiana @ 394.5
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Heath Cutrell, Virginia @ 381.5

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Highest Yields in 2019 National Corn Growers Contest are Typically Not From Corn Belt States

David Hula, Virginia @ 616.2
Bridget Dowdy, Georgia @ 553.0
Craig Hula, Virginia @ 545.8
Randy Dowdy, Georgia @ 523.0
Kevin Dowdy, Georgia @ 478.0
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Test Your Knowledge of High Yield Corn

- **Which management factor for corn production has changed the most in the last 50 years?**

Which Management Factor for Corn Production has Changed the Most in the Last 50 Years?

a) The tillage system used

b) The yield potential of hybrids

c) The plant population or number of plants per unit area

d) The amount of liquid fertilizer applied

e) A shift towards earlier planting

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c) The plant population or number of plants per unit area

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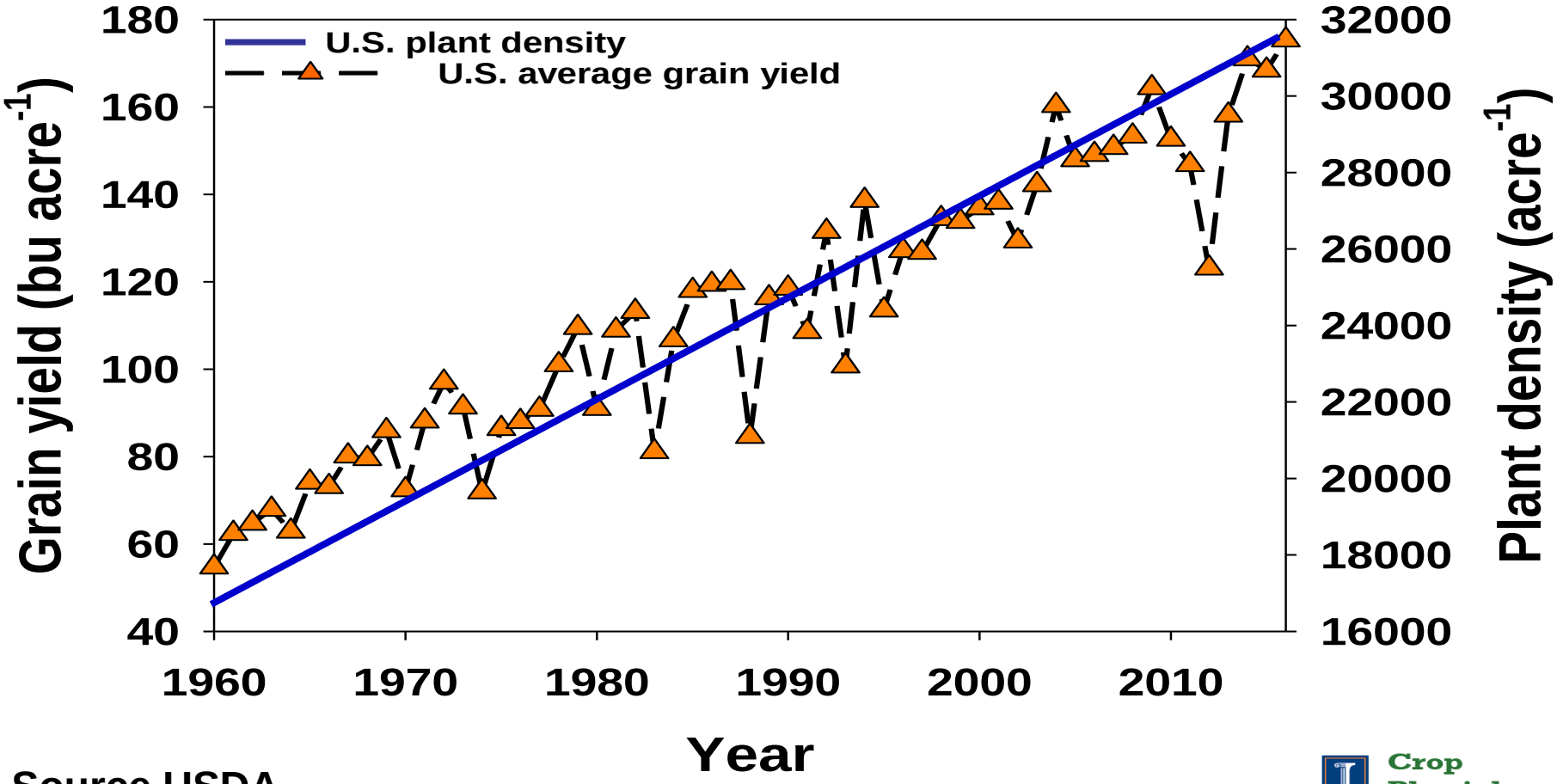
e) A shift towards earlier planting

How Have Corn Yields Increased?



Source USDA

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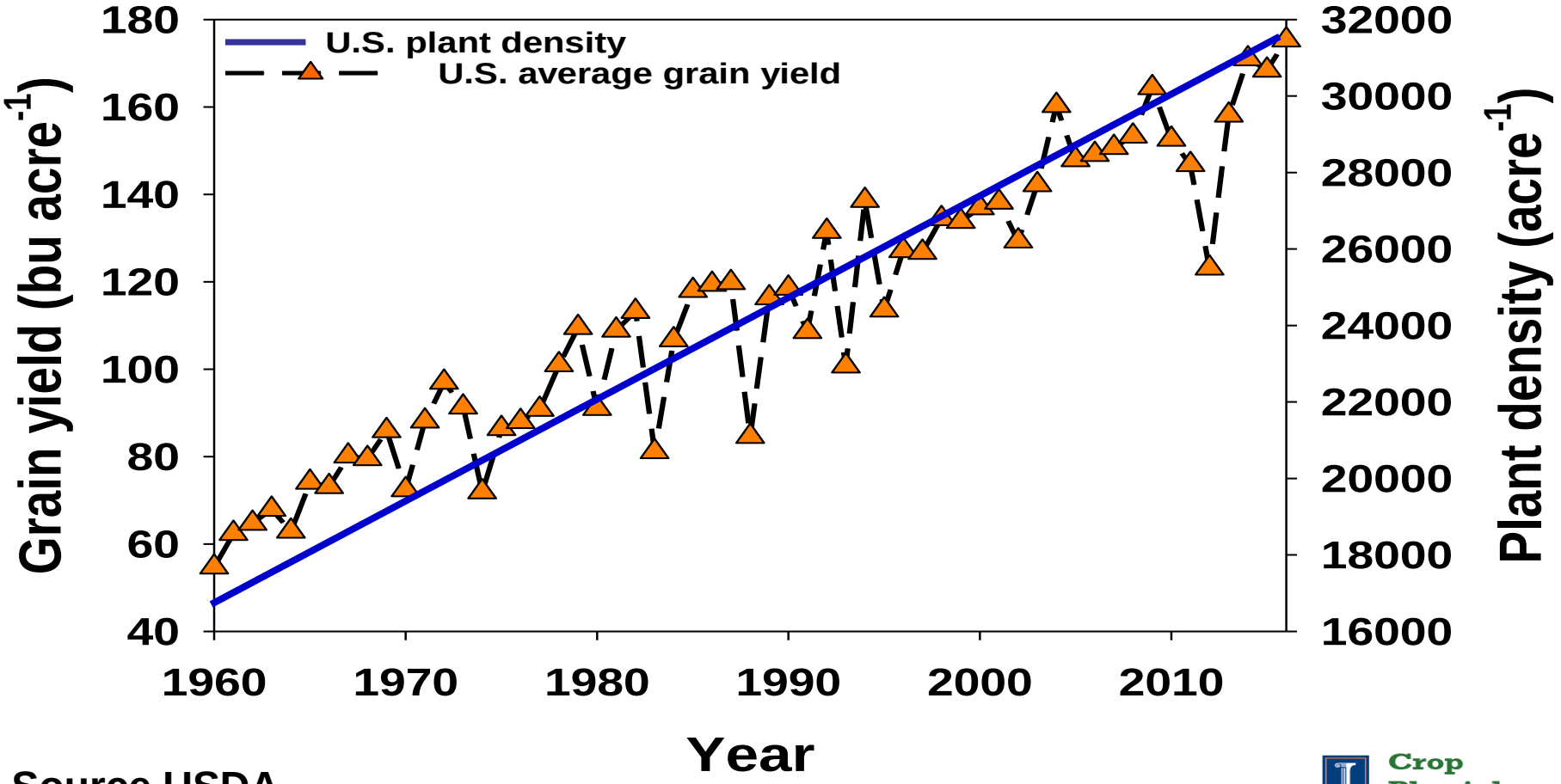
Grain Yield is a Product Function of Yield Components

Yield = (plants/acre) x

(kernels/plant) x

(weight/kernel)

Density Increases 400 Plants per Acre per Year



Source USDA

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Test Your Knowledge of High Yield Corn

- **What happens to the size of each plant's root system as the plant population is increased?**

It Gets Smaller

Root Digging/ Washing

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Root Size Decreases with Increasing Density

32,000	38,000	44,000	50,000
Root Weight (grams/plant)			
14.6	12.2	10.2	8.6

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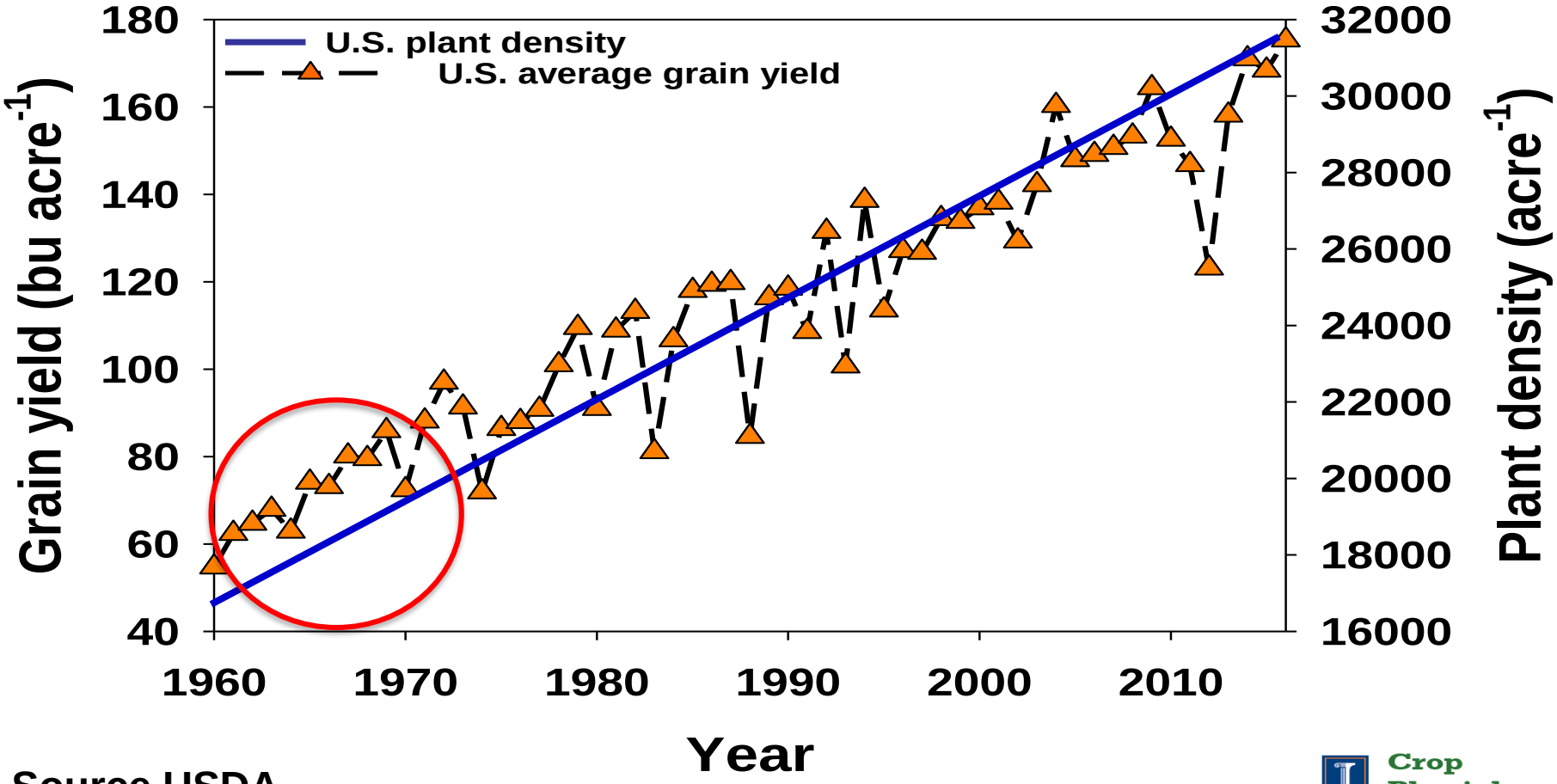
Test Your Knowledge of High Yield Corn

- **When were soil test values calibrated to corn yields?**

In the 60's and Early 70's

Soil Test Values Calibrated to Yield in the 60's and 70's



Source USDA

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Fertility Needs for Corn Based on Soil Test Data

- **Soil test values calibrated to yield in the 60's and 70's**
- **Do higher plant populations and more productive germplasm necessitate better fertilization strategies for corn?**

Test Your Knowledge of High Yield Corn

- **How can we ensure adequate soil fertility for high yields?**

Better Placement, Source, Time, and Rate

Banding MicroEssentials-SZ Fertilizer 4-6 Inches Deep Directly Under the Future Crop Row

To provide in lbs/acre 30 N, 100 P_2O_5, 25 S and 2.5 Zn

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Seeding Corn Crop 2 Inches Deep Directly Over the Fertilizer Band

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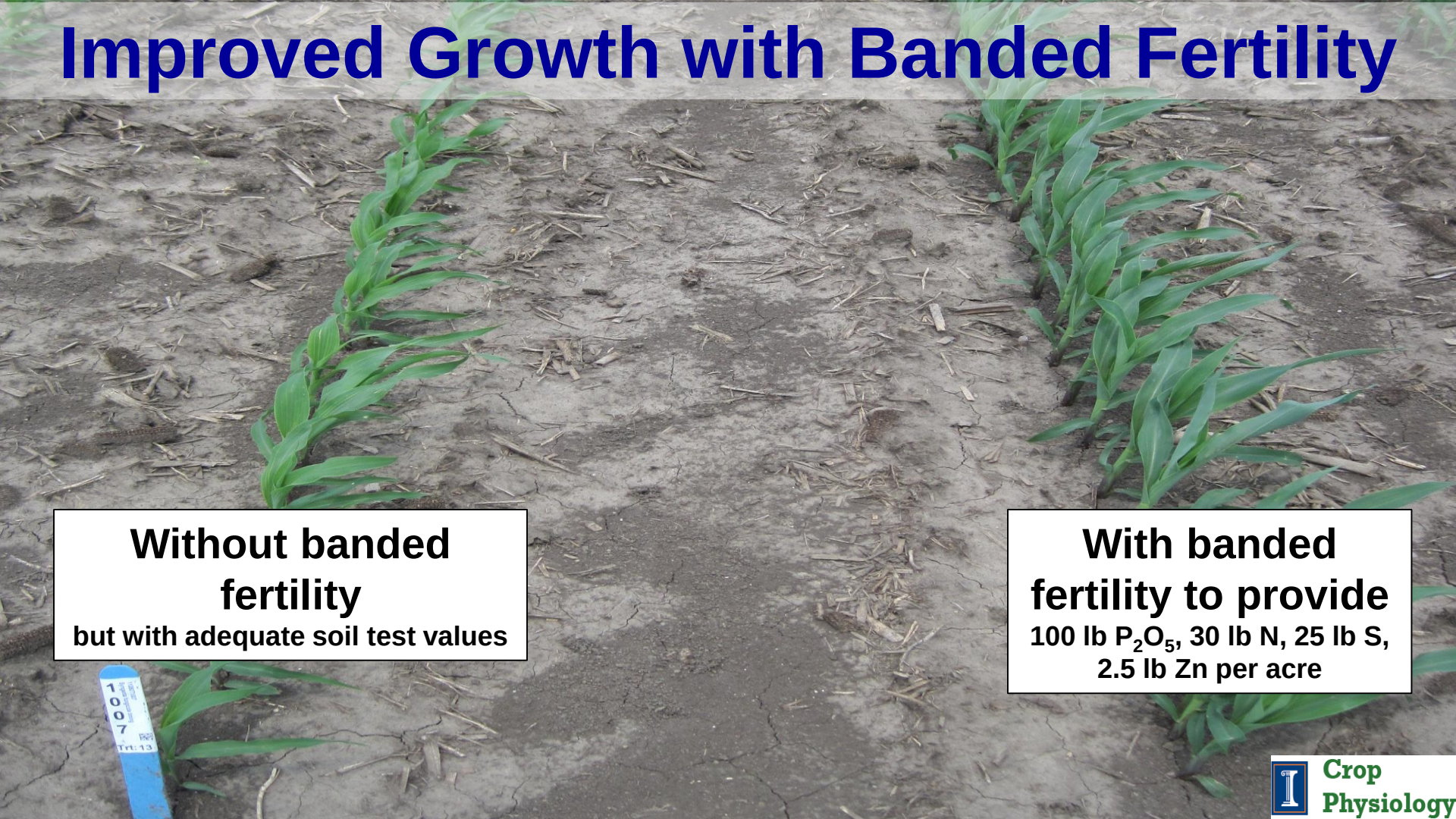
Improved Growth with Banded Fertility



Without banded fertility
but with adequate soil test values

With banded fertility to provide
100 lb P_2O_5, 30 lb N, 25 lb S, 2.5 lb Zn per acre

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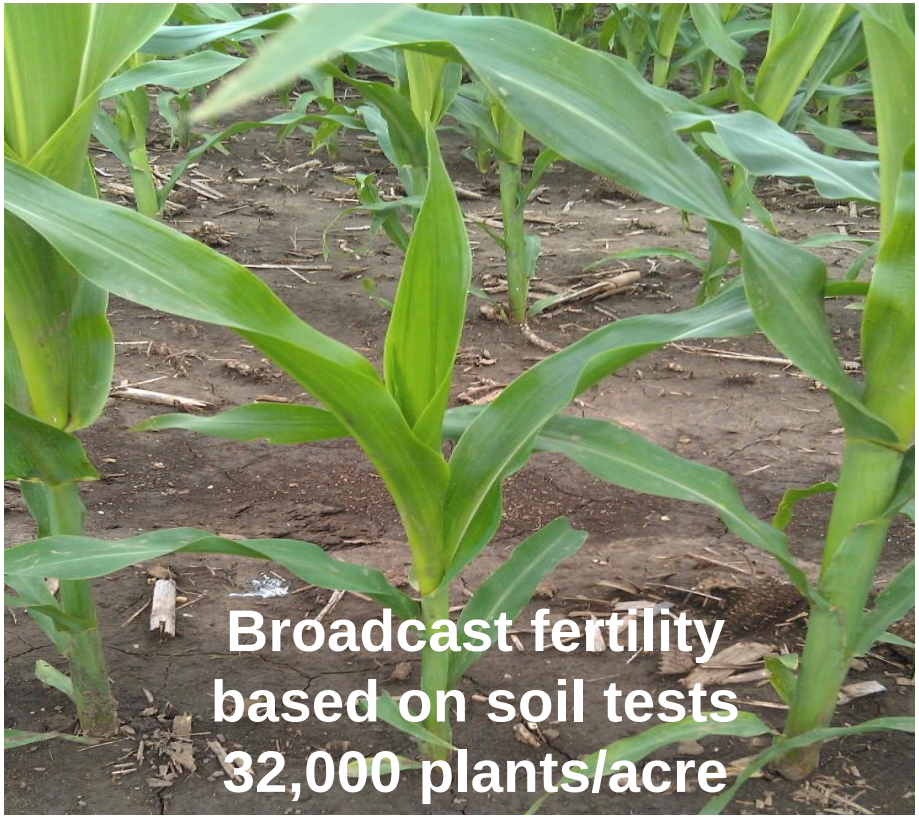
No Corn Plant Left Behind



Banded Fertility = 250 lbs/acre MicroEssentials-SZ = 30 N, 100 P_2O_5, 25 S, and 2.5 Zn

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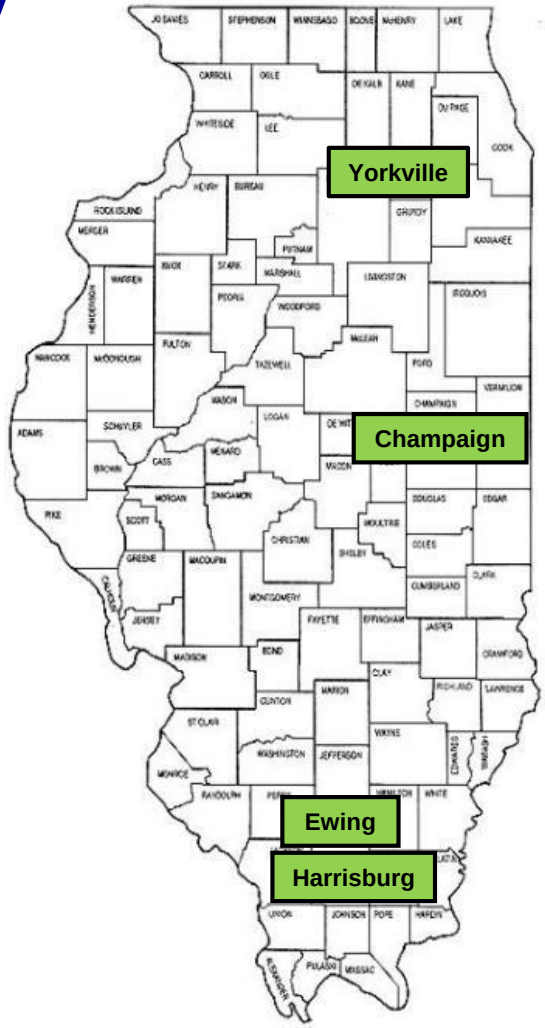
Average Soil Analysis at Crop Physiology Laboratory Research Sites (2017-2019)

	Location		
	Yorkville	Champaign	Harrisburg/ Ewing
OM (%)	4.5	3.6	2.0
pH	6.3	6.3	6.8
CEC	21.9	19.6	11.6
P (ppm)†	45	38	28
K (ppm)†	197	166	103

† Mehlich 3 extraction

All soils are silt loams or silty clay loams



Crop Physiology Lab Equipment Transport CONVOY

Crop Physiology Lab Equipment Transport CONVOY

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Test Your Knowledge of High Yield Corn

- **How can we ensure adequate soil fertility for high yields?**

Better Placement, Source, Time, and Rate

In-Season Liquid Fertilizer Applications

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Research Y-Drop Applicator
Courtesy of Yield 360

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Mechanical Y-Drop Reseach Applicator

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In-Furrow Application Capabilities

Effect of Properly Placed Fertilizer

3 gal 10-34-0 In Furrow

No Starter

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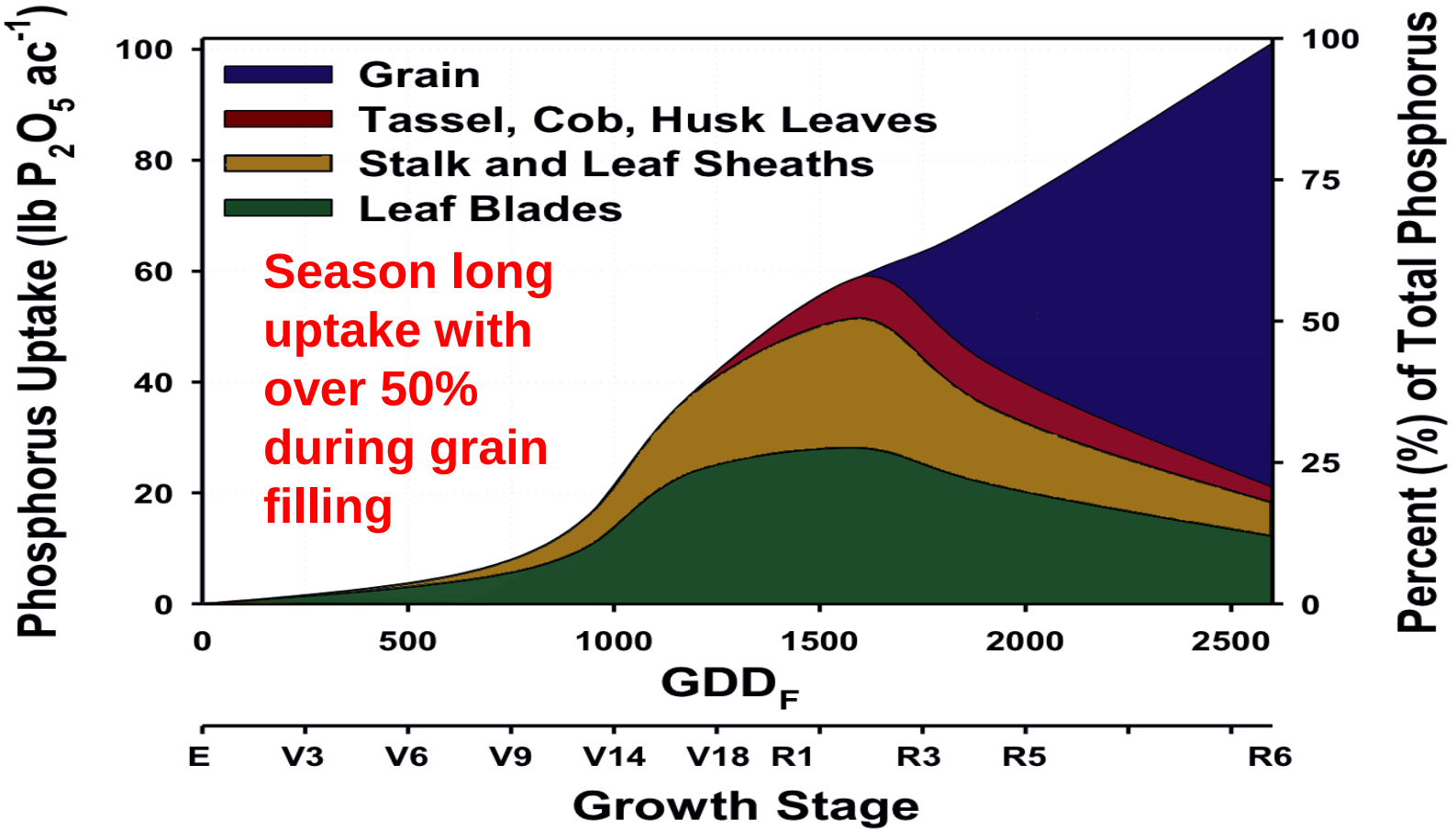
Can P Fertilization be Improved with Better Application Timing and Placement?

- How much 10-34-0 can be put in furrow?
- Will sidedressing 10-34-0 with Y-drops at V8 increase late season P uptake?
- Can a humic acid improve P availability?

P Uptake & Partitioning for 230 Bushel Corn



Average of 6 hybrids in Champaign and DeKalb IL in 2010

Agron. J. 105:161-170 (2013)

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Timing, Rate and Method of Liquid P Application

Application Timing/Rate of 10-34-0

Planting	5 gallons/acre
	10 gallons/acre
V8 Sidedress	15 gallons/acre

Application Method

Planting: In-furrow

V8 Sidedress: Y-dropped

Fertilizer Additives

With/Without Hydra-Hume

Treatments Gallons of 10-34-0

In Furrow @ Planting	Sidedress @ V8
Control (0)	-
5	-
5 + HH	-
10	-
15	-
-	10
5	10
5	10 + HH
5 + HH	10 + HH
-	15

Base rate of 180 lbs N/acre before preplant in 2017
Hydra-Hume application rate was 1gal/10gal of 10-34-0

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Treatments Gallons of 10-34-0

In Furrow @ Planting	Sidedress @ V8
Control (0)	-
5	-
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5	10 + HH
5 + HH	10 + HH
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Base rate of 180 lbs N/acre before preplant in 2017
Hydra-Hume application rate was 1gal/10gal of 10-34-0

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Untreated
5 gallons 10-34-0
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15 Gallons 10-34-0
Crop
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Yield Difference From In Furrow 10-34-0

Treatment		Location			
In-Furrow	Sidedress	Harrisburg	Champaign	Yorkville	All
gallons 10-34-0		Δ bushels/acre			
5	-	+5	+10	+5	+7*
5 + HH	-	+5	+5	+8	+7*
10	-	-2	+3	+6	+3
15		-5	-5	-5	-5

Control Yields (bu/acre) 250 in Harrisburg, 250 in Champaign, 291 in Yorkville
*Significant at (α = 0.10)

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Treatments Gallons of 10-34-0

In Furrow @ Planting	Sidedress @ V8
Control (0)	-
5	-
5 + HH	-
10	-
15	-
-	10
5	10
5	10 + HH
5 + HH	10 + HH
-	15

Base rate of 180 lbs N/acre before preplant in 2017
Hydra-Hume application rate was 1gal/10gal of 10-34-0

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Yield Difference From In Furrow plus Sidedress

Treatment		Location			
In-Furrow	Sidedress	Harrisburg	Champaign	Yorkville	All
gallons 10-34-0		Δ bushels/acre			
	10	+7	+14*	+9	+10*
5	10	+11*	+14*	+8	+11*
5	10 + HH	+15*	+20*	+9	+15*
5 + HH	10 + HH	+8	+13*	+11*	+11*
	15	+6	+17*	+8	+11*

Control Yields (bu/acre) 250 in Harrisburg, 250 in Champaign, 291 in Yorkville
*Significant at (α = 0.10)

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Key Takeaways – In Furrow

- **5 gallons of 10-34-0 in furrow was the best rate for increasing yield, but it was not enhanced by humic acid**

- **10 or 15 gallons of 10-34-0 in-furrow resulted in crop damage and reduced grain yield**

Key Takeaways – Sidedress

- **Y-drop applications of 10-34-0 at V8 consistently increased yield**
- **Combinations of in-furrow plus sidedress were not consistently better than sidedress alone**
- **Humic acid with the Y-drop applications tended to produce the highest yields**

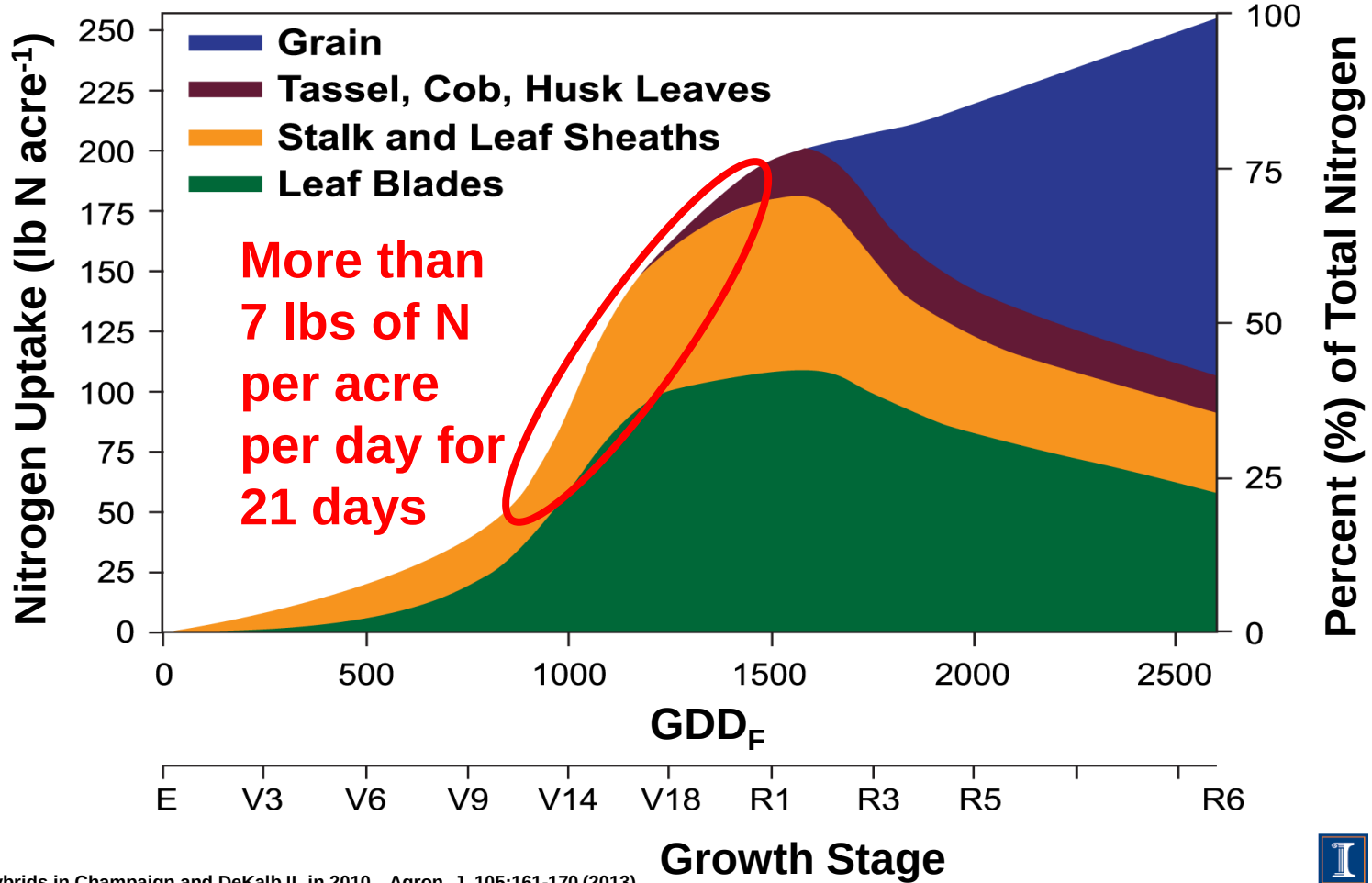
Test Your Knowledge of High Yield Corn

- **Are split applications of N better than applying all the N upfront at preplant?**

Test Your Knowledge of High Yield Corn

- **When does N need to be available for maximum N uptake and grain yield?**

Nitrogen Uptake and Partitioning for 230 Bushel Corn



Average of 6 hybrids in Champaign and DeKalb IL in 2010 Agron. J. 105:161-170 (2013)

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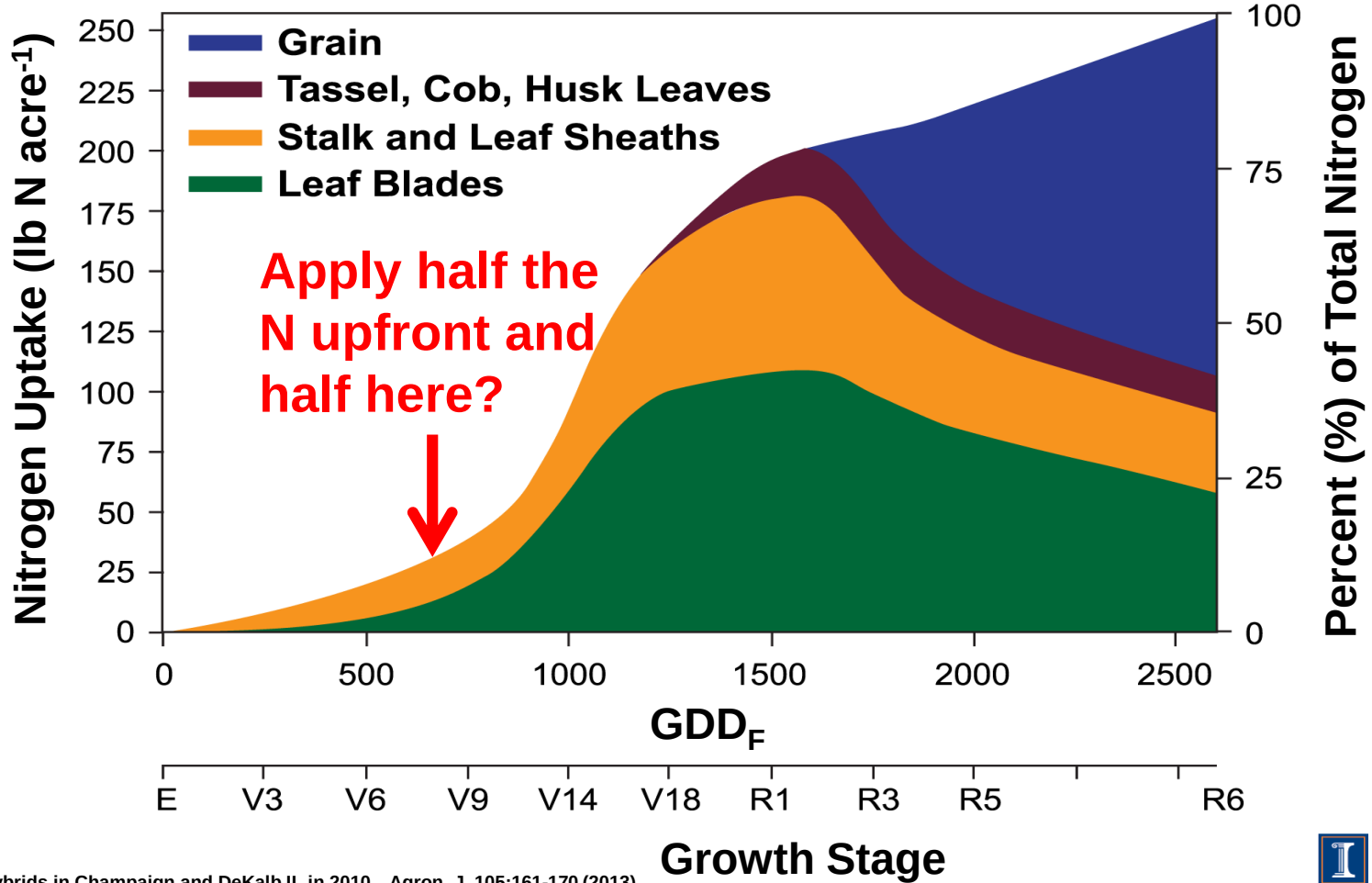
Are Split Applications of Nitrogen Better?



Average of 6 hybrids in Champaign and DeKalb IL in 2010 Agron. J. 105:161-170 (2013)

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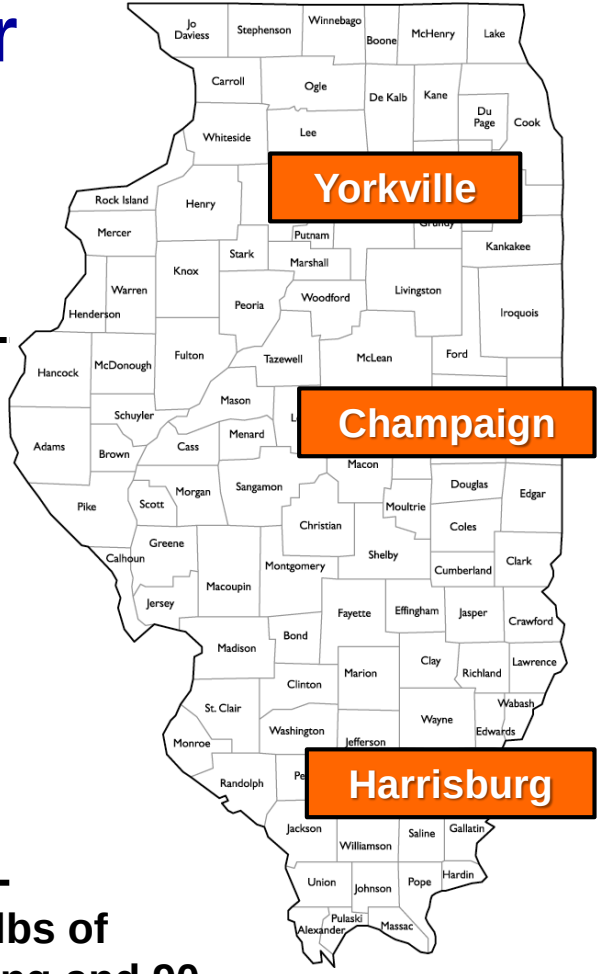
Are Split Applications of N Better than all N at Planting?

Planting	Sidedress
No Nitrogen	-
Urea Broadcast	-
Urea Broadcast	Urea Broadcast
Urea Broadcast	UAN Mid-Row
Urea Broadcast	UAN Y-Drop



All treatments (except the no N control) received a total of 180 lbs of N/acre. Split applications received 90 lbs of N just before planting and 90 lbs of N/acre at the V8 growth stage. Two years 2017 and 2018.

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Urea Broadcast

UAN Center of Row

UAN Y-Drop

Crop Physiology

Are Split Applications of N Better than all N at Planting?

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No Nitrogen	-
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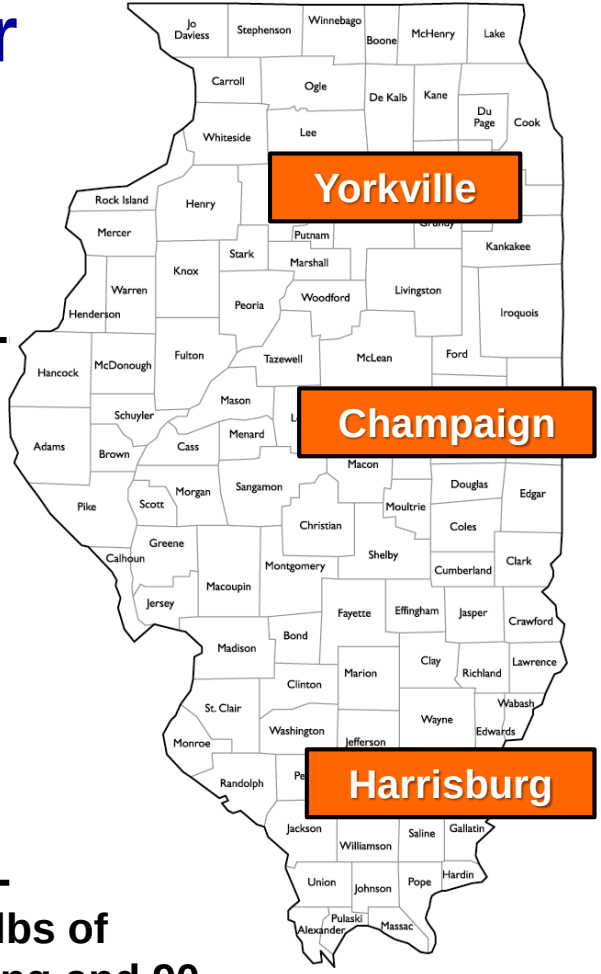

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Differences in Check Plot Yield Per Site

Year and Location	Check Plot Yield
	bushels/acre
2018 Harrisburg	97
2018 Champaign	103
2017 Champaign	184
2018 Yorkville	195
2017 Yorkville	208
2017 Harrisburg	224

Check Plot is yield without any N fertilizer application; what the soil supplies

Differences in Check Plot Yield Per Site

Year and Location	Check Plot Yield
	bushels/acre
2018 Harrisburg	97
2018 Champaign	103
2017 Champaign	184
2018 Yorkville	195
2017 Yorkville	208
2017 Harrisburg	224

Check Plot is yield without any N fertilizer application; what the soil supplies

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Yield Difference from all N Applied Upfront and Sidedress with Different Placements

Check Plot Rank & Yield	Upfront Urea Broadcast	Placement of 90 lbs N Sidedress†		
		Broadcast	Center Row	Y-Drop
	bu/acre	Δ bu/acre		
18HB (97)	190	-7	-2	9
18CU (103)	222	-8	-17*	6
17CU (184)	256	-3	-25*	-11
18YV (195)	232	3	9	15*
17YV (208)	265	7	0	13
17HB (224)	265	8	9	11

† Split application received 90 lbs N as broadcast urea upfront

* Nitrogen treatment significantly different than Upfront Urea Broadcast at α=0.05

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Key Takeaways

- When the N supplied from the soil was low (as indicated by a low check plot yield), more N is needed at preplant
- Split applications of N increased yield in years and fields with high initial soil N, and the Y-drop method was the best way to sidedress N

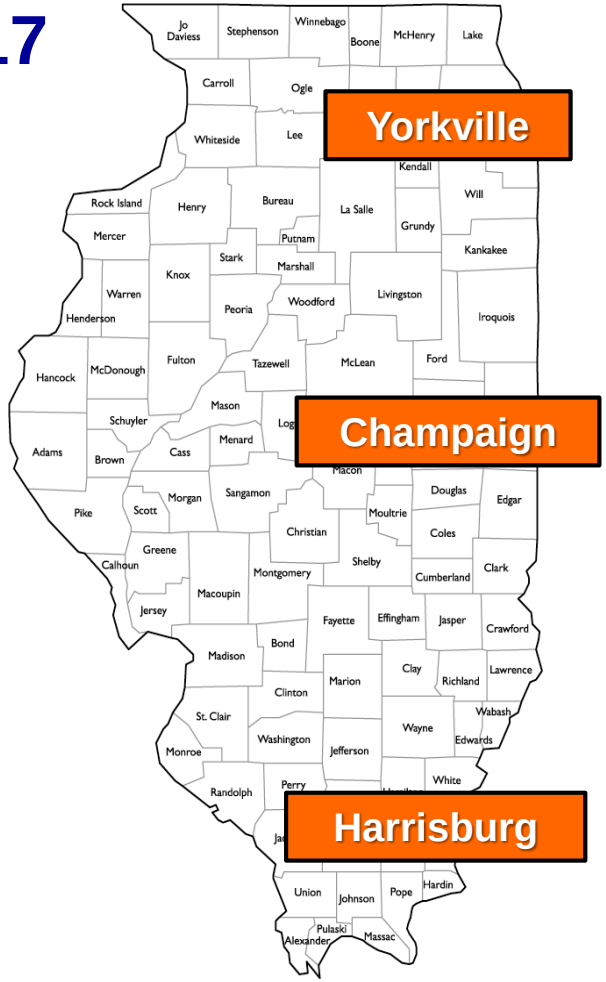
Test Your Knowledge of High Yield Corn

- **What percentage of fertilizer N is needed upfront in a split applied program where the upfront and the sidedress N are broadcasted?**

Ratio of Preplant vs Sidedress N - 2017

Total N Applied	Split Rates	
	Preplant	Sidedress
lbs N/acre	% of Total N Applied	
No Nitrogen		
140	0	100
	25	75
	50	50
220	75	25
	100	0

Sidedress application at the V8 growth stage
All nitrogen applications were broadcasted urea



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Effect of Varying Ratios of N Upfront and Sidedressed on Grain Yield

Split Rate	Location			Average
	Harrisburg	Champaign	Yorkville	
%	bushels/acre			
No Nitrogen	252	168	190	203
0/100	288	267	270	275
25/75	288	270	270	276
50/50	292	276	273	280
75/25	294	278	280	284
100/0	292	288	275	285

Split rate is the percent the of total N applied as urea at preplant / sidedressed at the V8 growth stage
Averaged across total N rate of 140 and 220 lbs of N/acre
LSD Total N Applied (α = 0.10) = 6

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Effect of Varying Ratios of N Upfront and Sidedressed on Grain Yield

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Averaged across total N rate of 140 and 220 lbs of N/acre
LSD Total N Applied (α = 0.10) = 6

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Key Takeaway

- **More than half of the total nitrogen needs to be applied before or at planting when the preplant and the sidedress N are broadcasted**

Test Your Knowledge of High Yield Corn

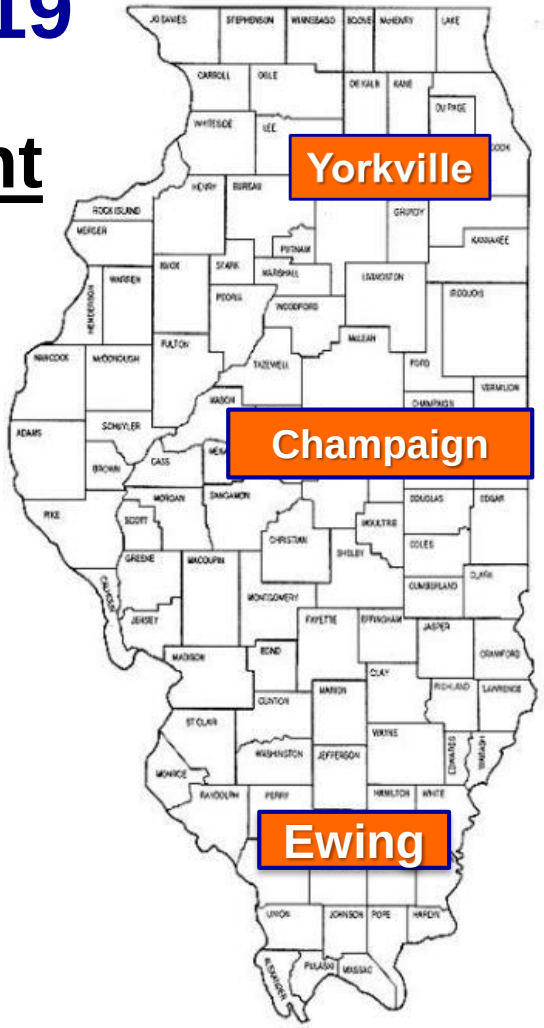
- **Does the percentage of the total nitrogen supply that needs to be available at planting differ depending on nitrogen placement?**

Split Rate Ratio by Placement - 2019

Split-Rate Ratios (lbs/acre as UAN)	Preplant Placement
45/35	Broadcast
90/90	2x2 Band
135/45	
180/0	

Sidedress

Y-drop @ V6



All treatments received a total of 180 lbs N/acre

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Crop Physiology

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Late Planting was the Theme in 2019

May 27th, 2019 in Champaign, IL

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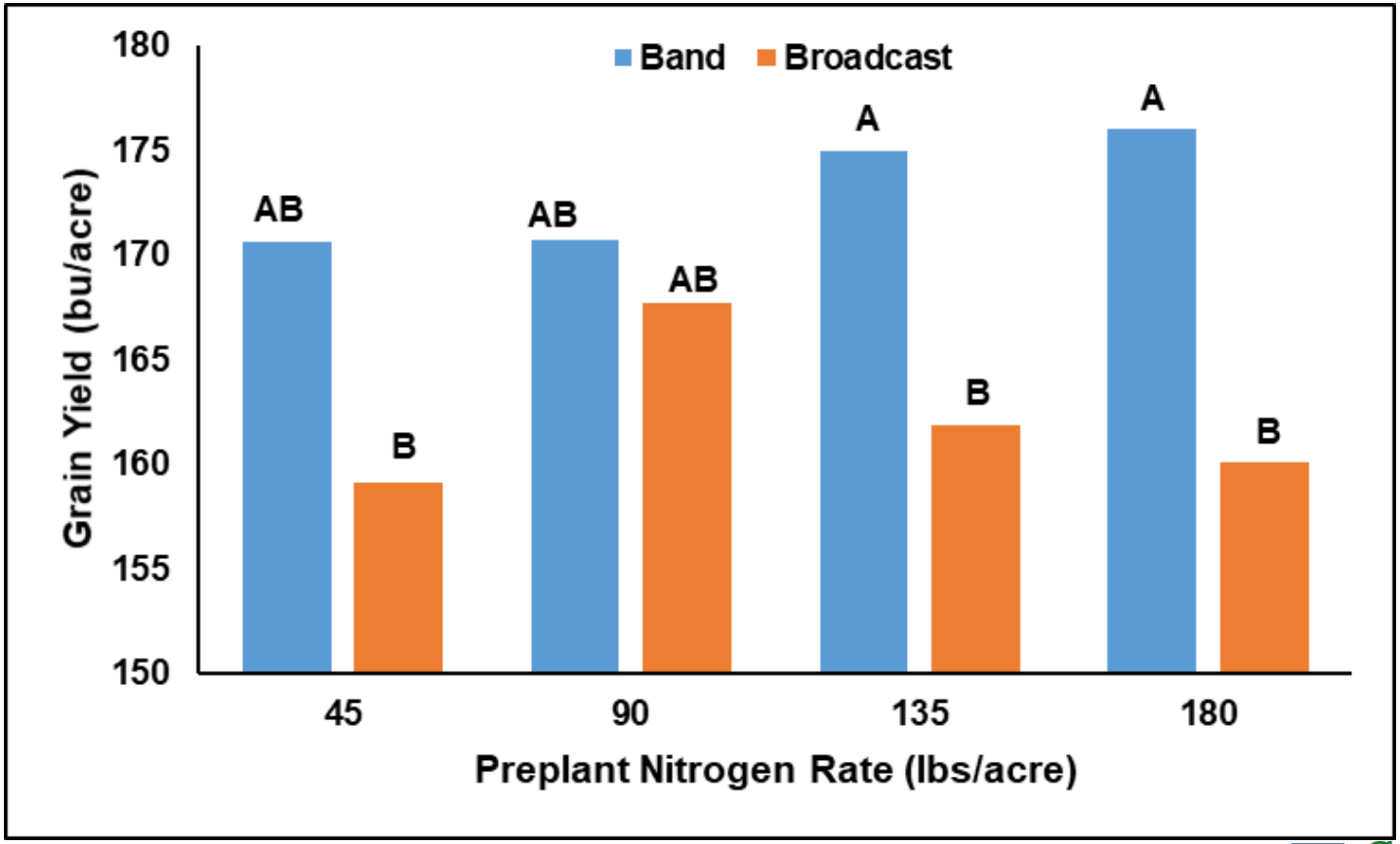
Split Rate Ratio and N Placement on Grain Yield



Average of two locations (Ewing and Yorkville) in Illinois in 2019

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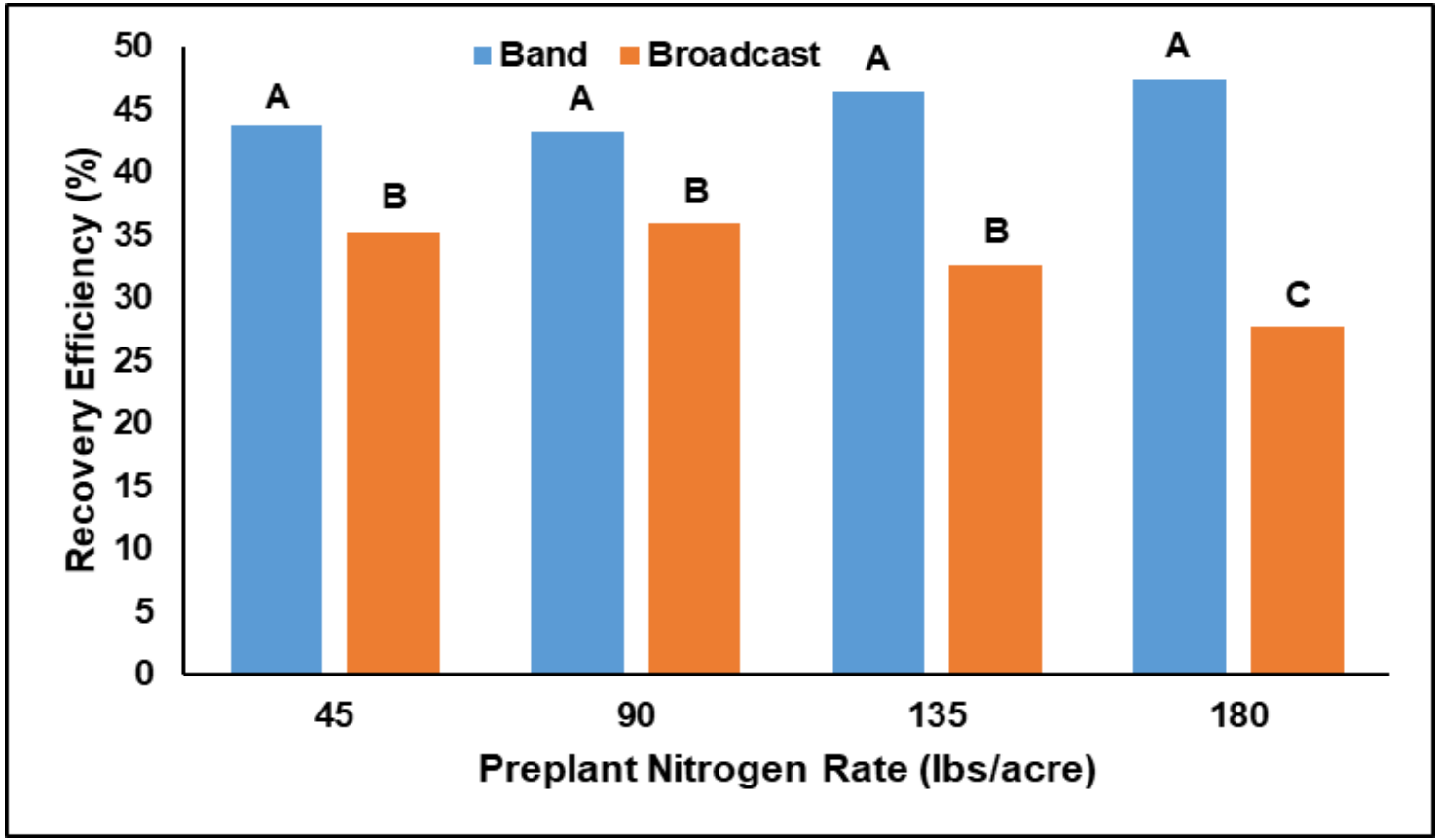
Split Rate Ratio and N Placement on N Recovery Efficiency



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Key Takeaways

- **For all split N ratios, banding UAN 2x2 at planting increased yield over the same N treatments broadcasted**

- **Banding of UAN 2x2 increased N recovery efficiency even for the low ratio of preplant N**

Crop Physiology Research Teams 2017-2019

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Past and Current Crop Physiology Lab Sites & Farm Cooperators

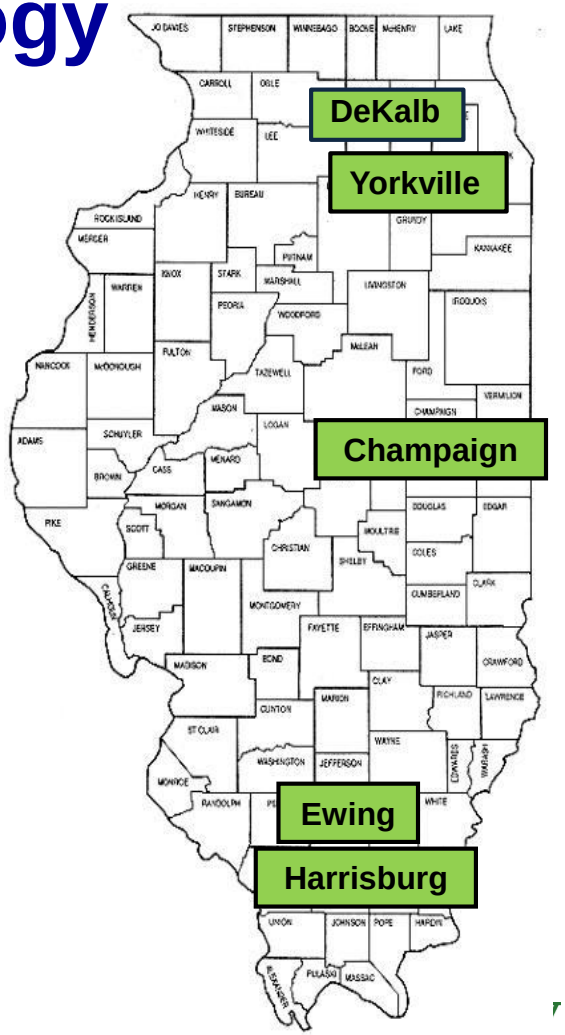
DeKalb - Eric Lawler
H.B. Babson Farms

Yorkville - Bob and Brad Stewart
Stewart Farms LLC

Champaign - UI Research Farm

Ewing - Talon Becker

Harrisburg - Scott Berry
Berry Farms



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- Crystal Green Fertilizer
- Fluid Fertilizer Foundation
- Helena
- Illini FS
- John Deere
- Montag
- Mosaic
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- NREC
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- Sirius Minerals
- Soil Biotics
- Sound Ag
- Stewart Farms
- Syngenta
- Tessenderlo Kerley
- United Prairie
- United Soybean Board
- Valagro
- Verdesian
- West Central
- WinField United

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Special Thanks to The Fluid Fertilizer Foundation

For More Information:

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http://cropphysiology.cropsci.illinois.edu