Corn- How Will Yield and Technology Advances Change Fertilizer Use?

Fred Below

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Department of Crop Sciences
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Fertilizer Outlook and Technology Conference
Savannah, Georgia November 19, 2019

Test Your Knowledge of Agriculture and US Politics

- **What does President Trump think about Corn?**

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President Trump Likes Corn


MAKE CORN
GREAT AGAIN

Test Your Knowledge of High Yield Corn

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

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The Corn Yield Gap

- World Record yield of 542.2740 bushels per acre in 2017

- US average yield of 178 bushels per acre in 2018

- Yield Gap = Record Yield – Average Yield = 364 bushels

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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?**

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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 fertilizer applied

e) A shift towards earlier planting

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

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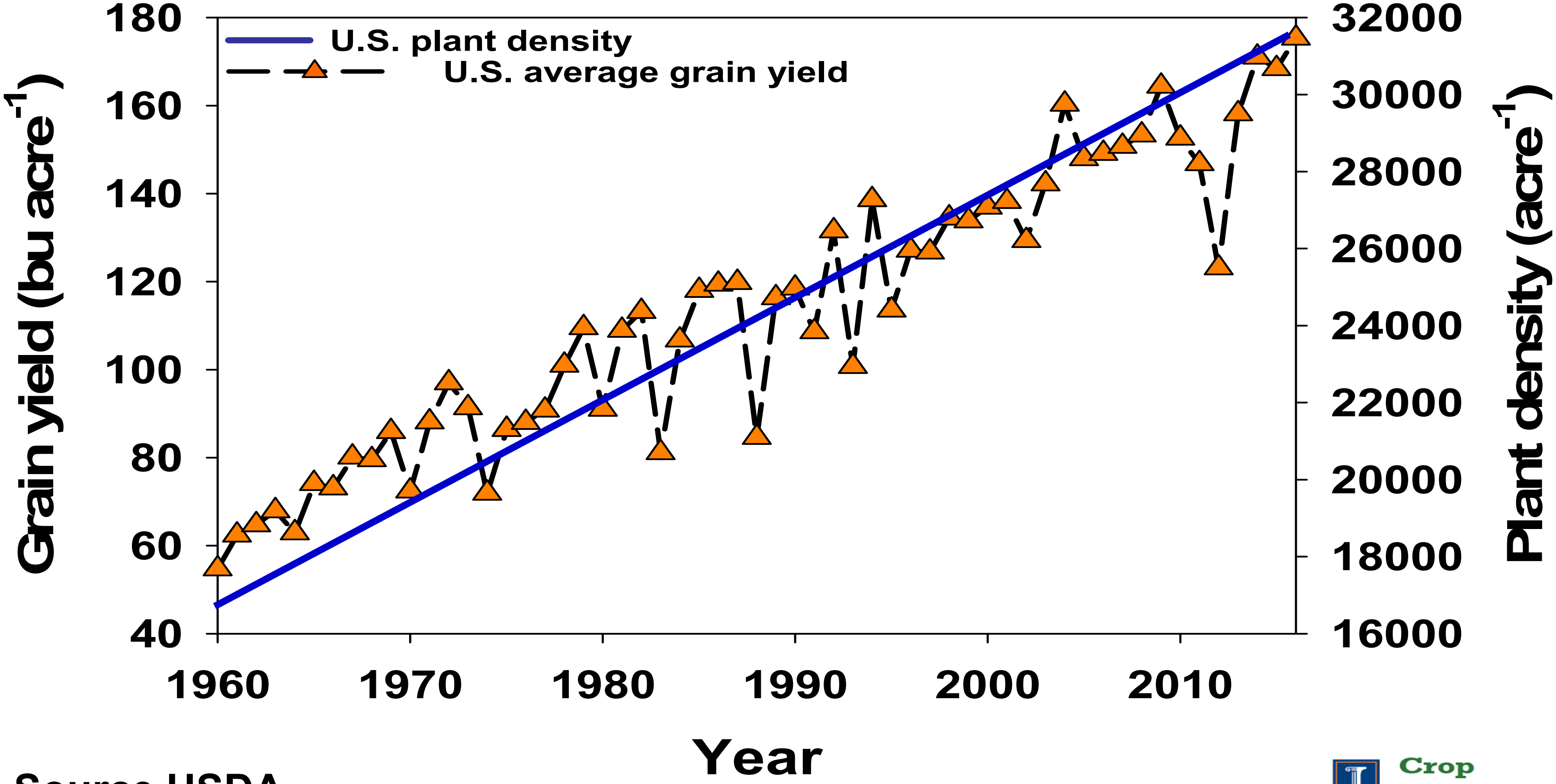
How Have Corn Yields Increased?



Source USDA

Crop Physiology

Grain Yield is a Product Function of Yield Components

Yield = (plants/acre) x

(kernels/plant) x

(weight/kernel)

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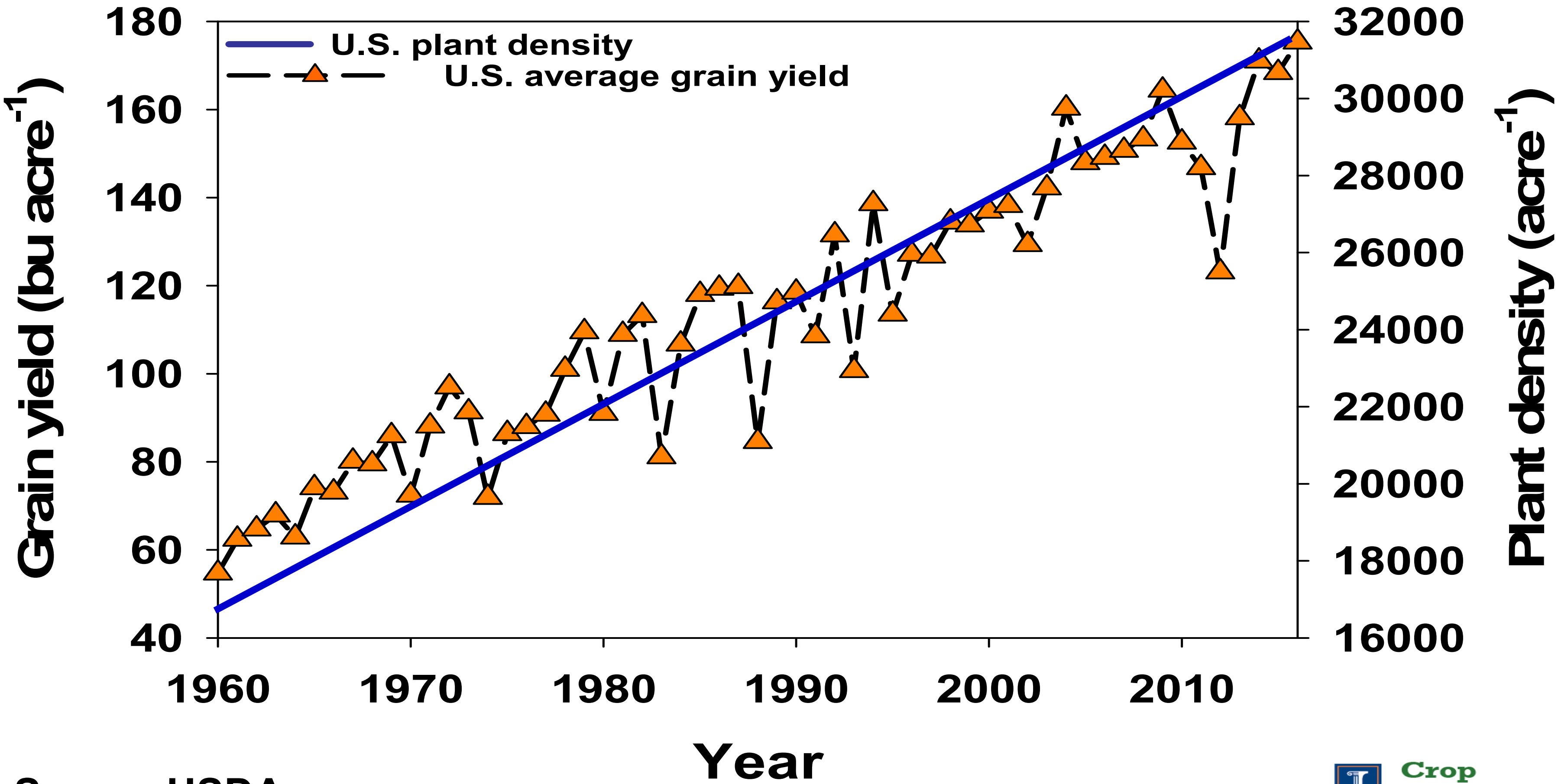
Density Increases 300 Plants per Acre per Year



Source USDA

Crop Physiology

Grain Yield is a Product Function of Yield Components

Yield = (plants/acre) x

(kernels/plant) x

(weight/kernel)

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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

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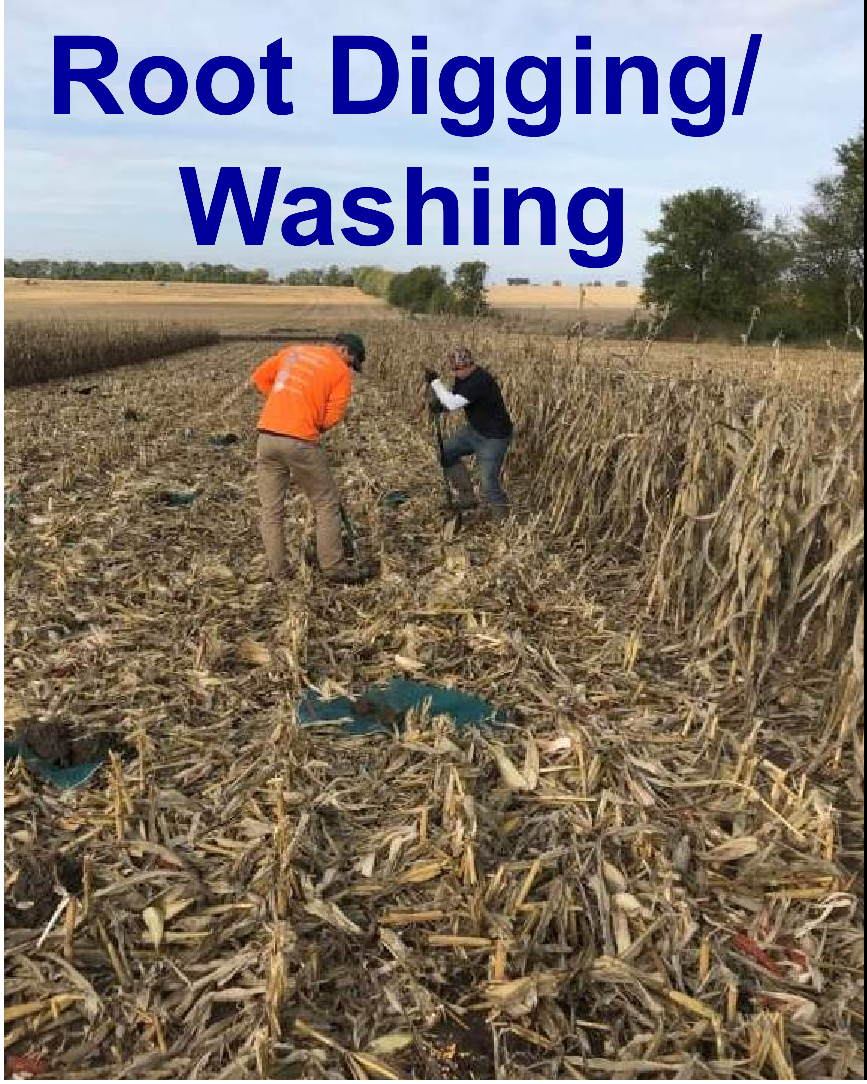
Root Digging/ Washing



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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

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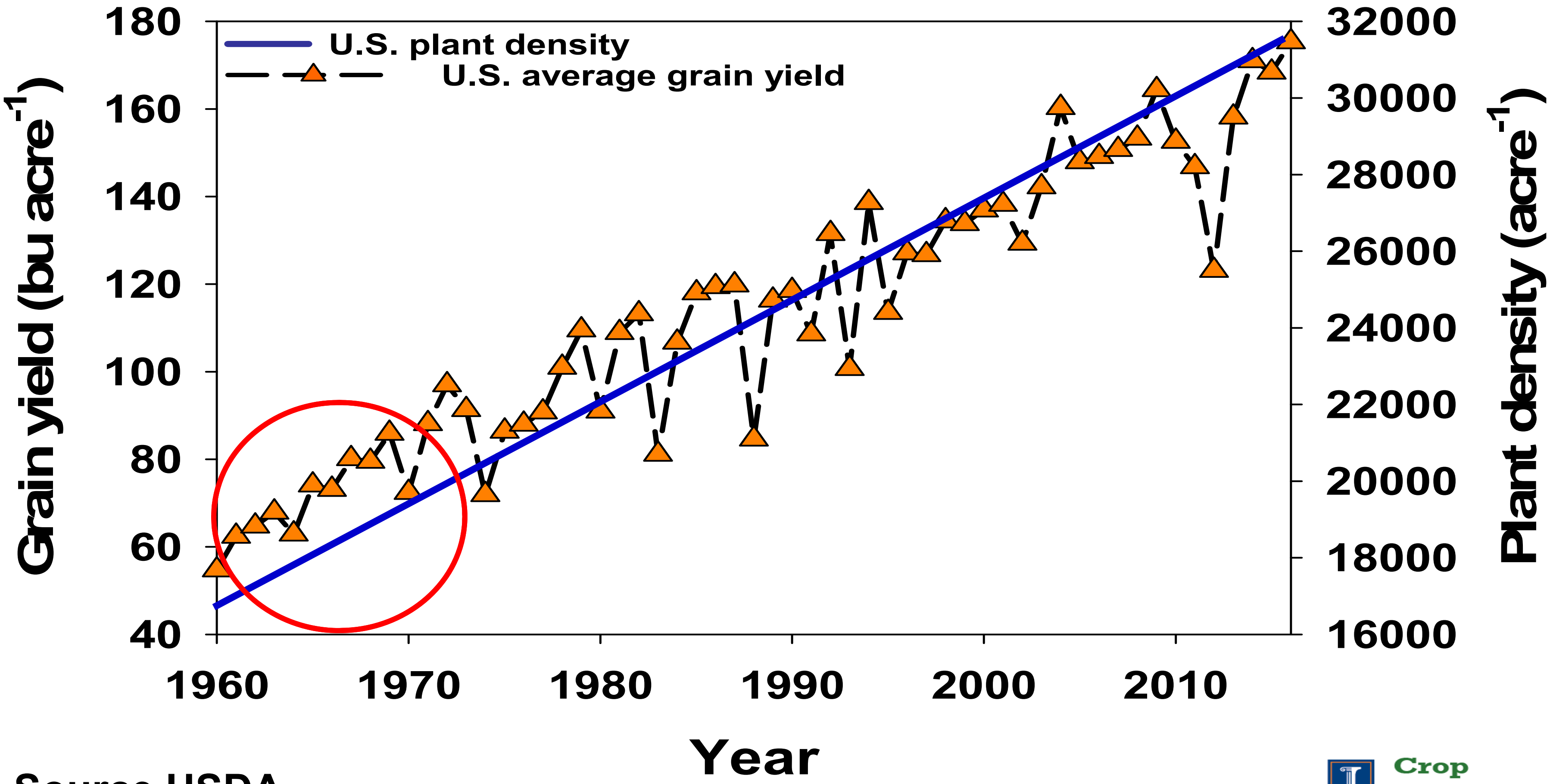
Soil Test Values Calibrated to Yield in the 60's and 70's



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?

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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

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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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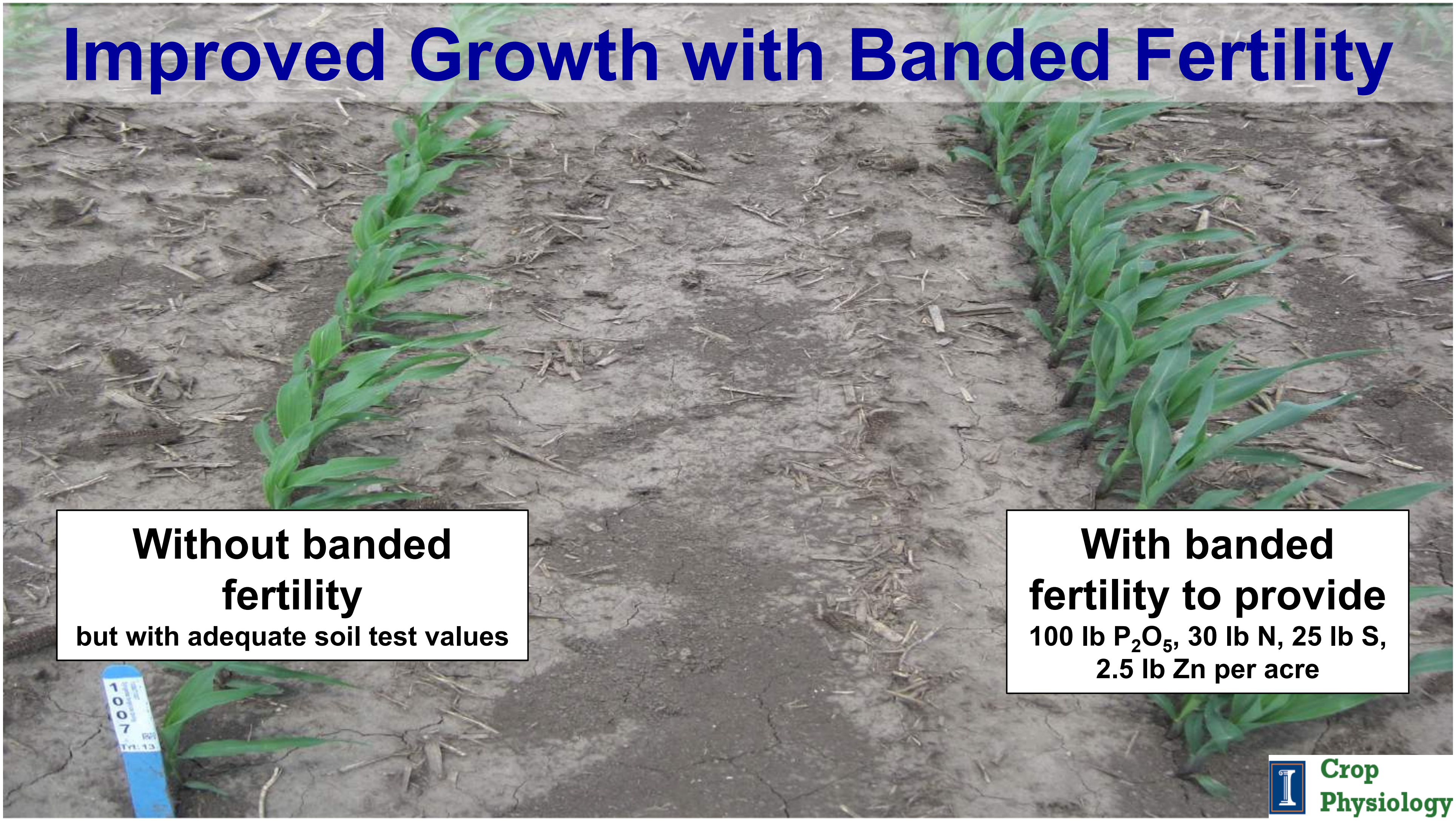
Seeding Corn Crop 2 Inches Deep Directly Over the Fertilizer Band

Improved Growth with Banded Fertility



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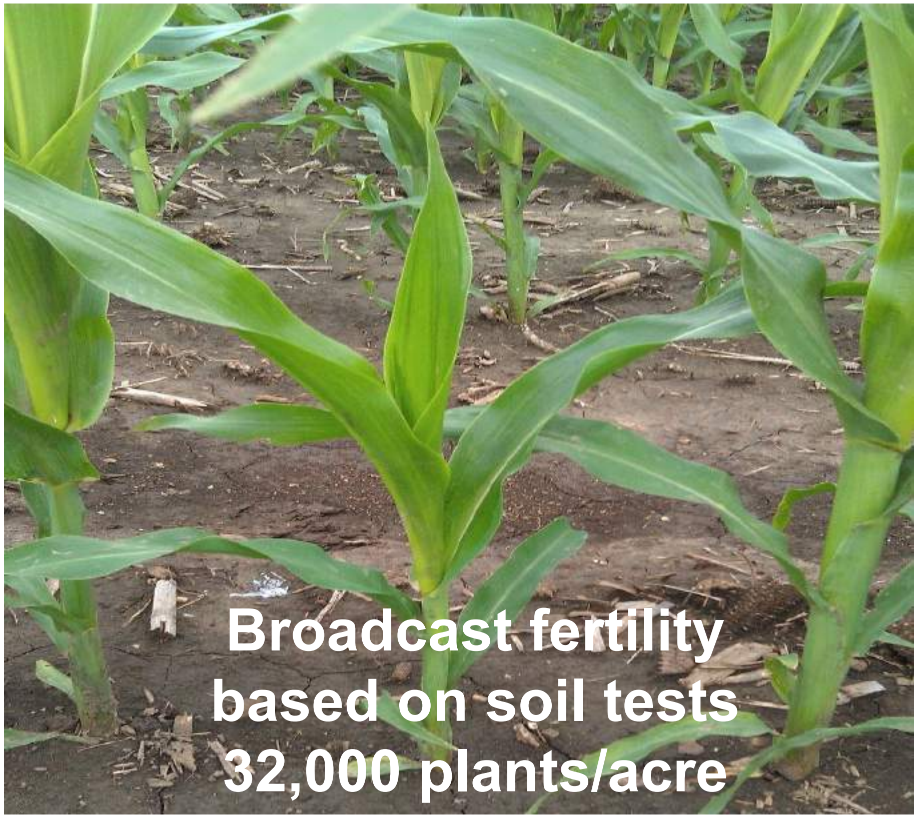
No Corn Plant Left Behind



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

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Key Takeaways

- Increasing plant populations and higher yields necessitate better placement of fertilizers
- Banded fertility ensures key nutrients are placed for best root interception and sets the growth trajectory and potential for higher yields

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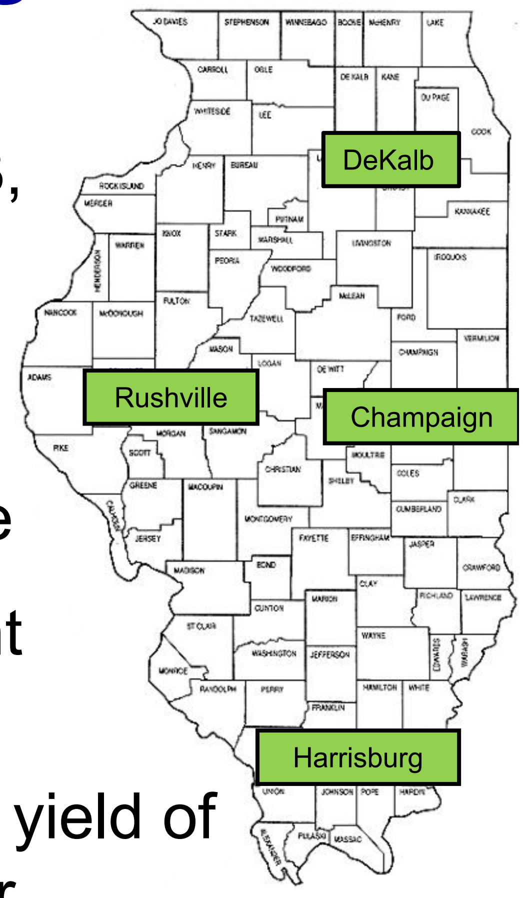
Research Question

- Is the soil P test adequately calibrated to corn yield when a premium P fertilizer is banded directly under the crop row?

Corn Fertility Response Trials

4 sites in Illinois with:

- 22 Evaluations (6 in 2011, 2 in 2012, 8 in 2013, 3 in 2014 and 3 in 2015) at 4 sites
- Banded a premium P fertilizer at planting (250 lbs/acre MicroEssentials-SZ) to provide 30 lbs N, 100 lbs P_2O_5, 25 lbs S, & 2.5 lbs Zn per acre
- Different company seed, standard management and plant population of 32,000 plants/acre
- Measured soil P before planting and compared yield of unfertilized plots to yield with banded P fertilizer



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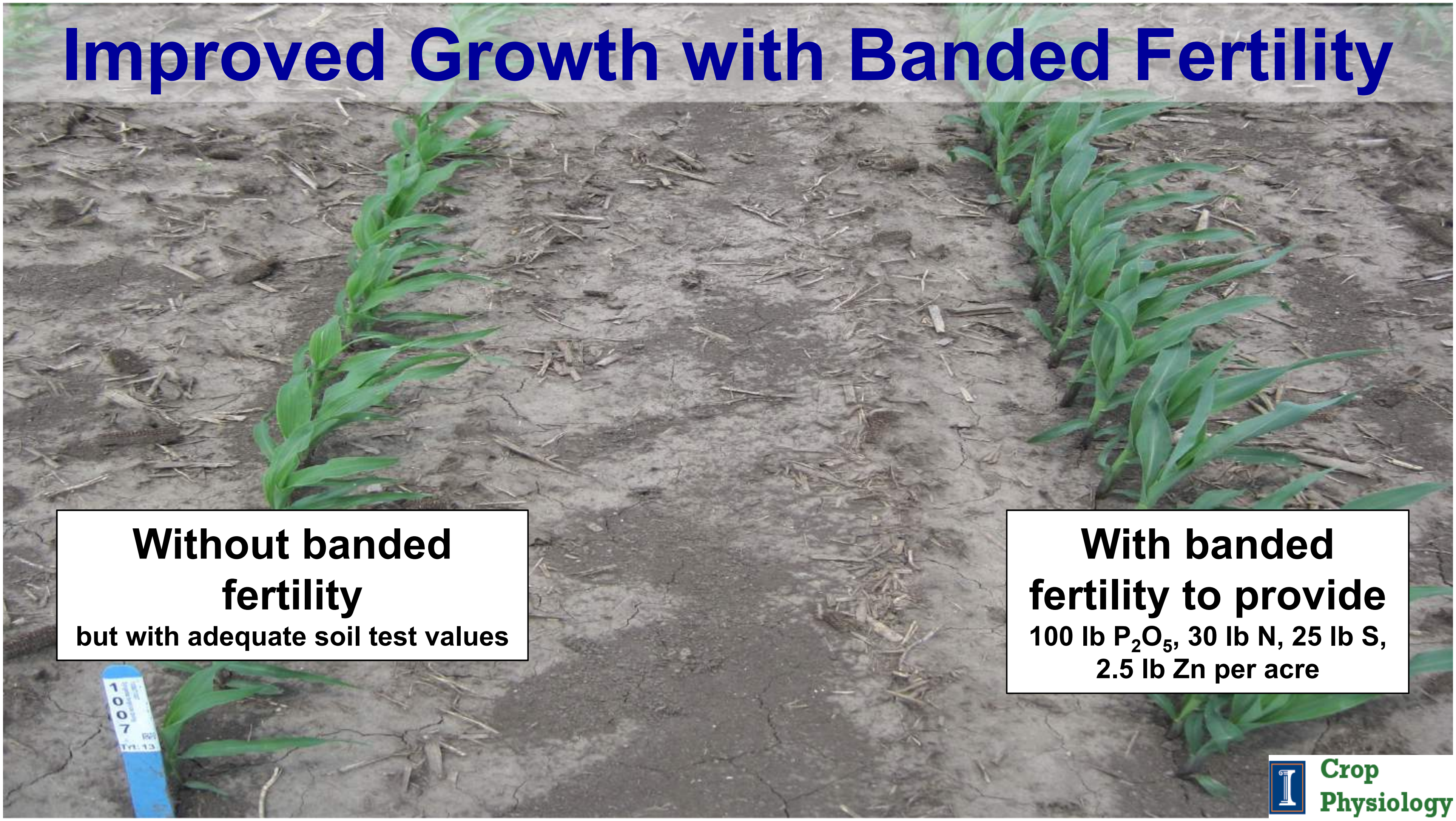
Improved Growth with Banded Fertility



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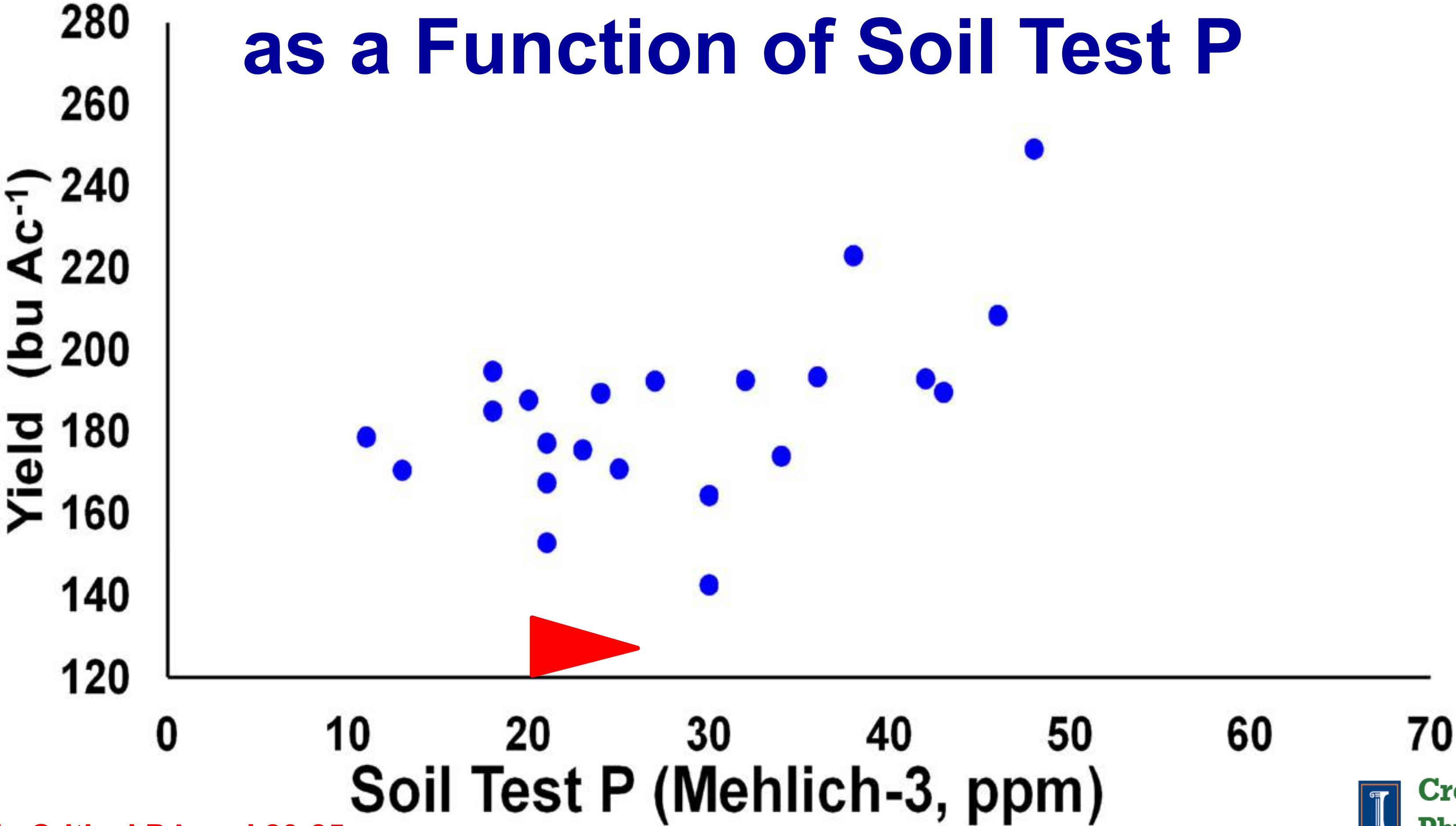
Corn Yield of Plots not Receiving P Fertilizer as a Function of Soil Test P



Illinois Critical P Level 20-25 ppm

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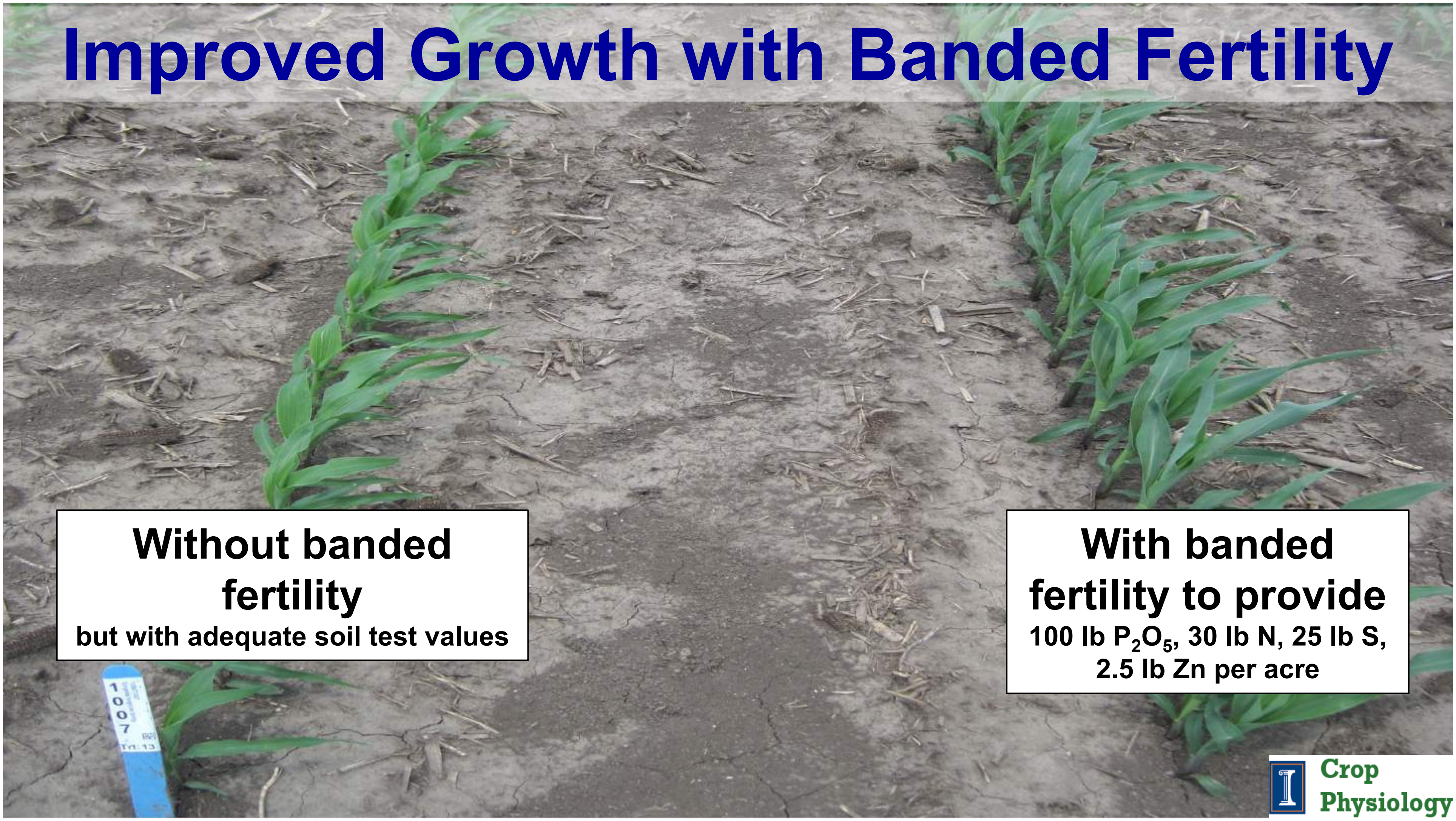
Improved Growth with Banded Fertility
Without banded fertility
but with adequate soil test values
With banded fertility to provide
100 lb P_2O_5, 30 lb N, 25 lb S, 2.5 lb Zn per acre
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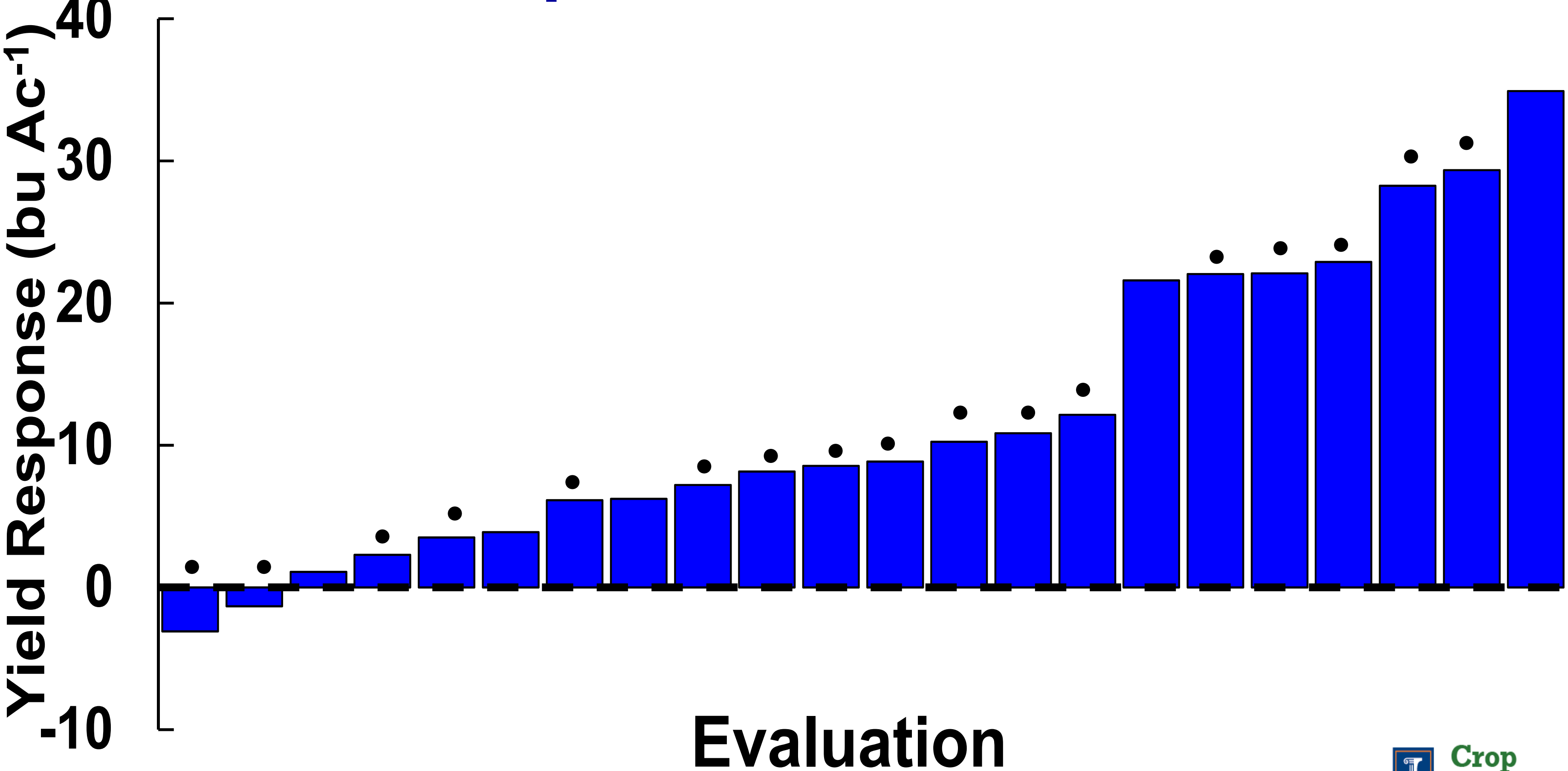
Corn Yield Response from Banded Fertilizer



•Yield response from site with greater than 20 ppm critical soil test

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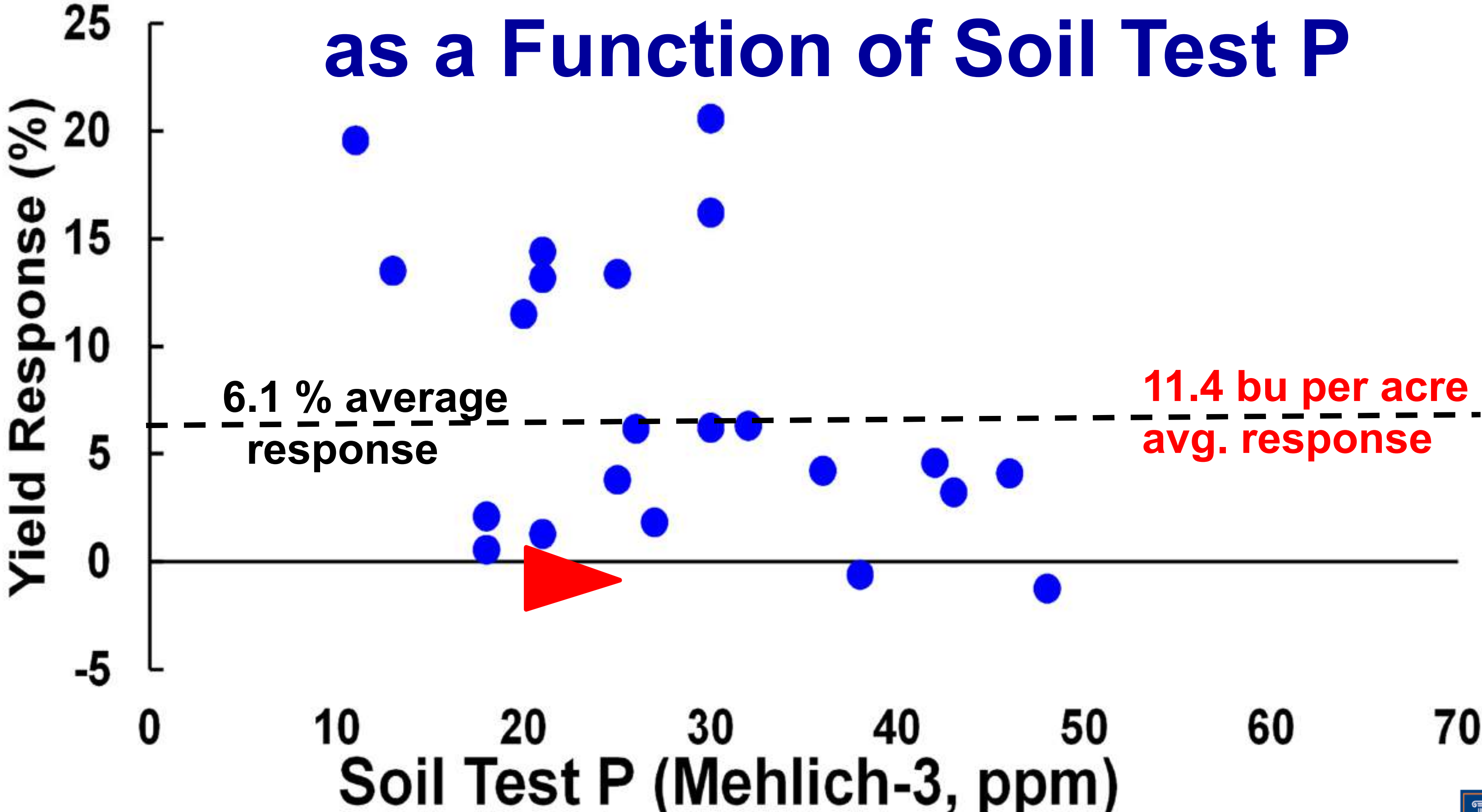
Corn Yield Response to Premium P Fertilizer as a Function of Soil Test P



Illinois Critical P Level 20-25 ppm

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Key Takeaway

- **Soil test P values may not be calibrated for the greater yield potential of modern corn hybrids, especially when banded nutrients are placed directly under the crop row**

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Test Your Knowledge of High Yield Corn

- **Which management factor under the growers control has the biggest impact on corn yield?**

Nitrogen Fertilizer Management

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Test Your Knowledge of High Yield Corn

- Does weather impact nitrogen availability?

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Weather Induced Nitrogen Loss

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Test Your Knowledge of High Yield Corn

- **Does nitrogen predominately move vertically (down) or horizontally (to the side) in the soil?**

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Nitrogen Deficiency to the Row Due to Vertical Soil Movement

180 lbs N preplant (Left) vs 180 lbs preplant + 80 lbs sidedress (Right)

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In-Season Y-Drop N Application

Research Y-Drop Applicator Courtesy of Yield 360

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Mechanical Y-Drop Reseach Applicator

Test Your Knowledge of High Yield Corn

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

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Test Your Knowledge of High Yield Corn

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

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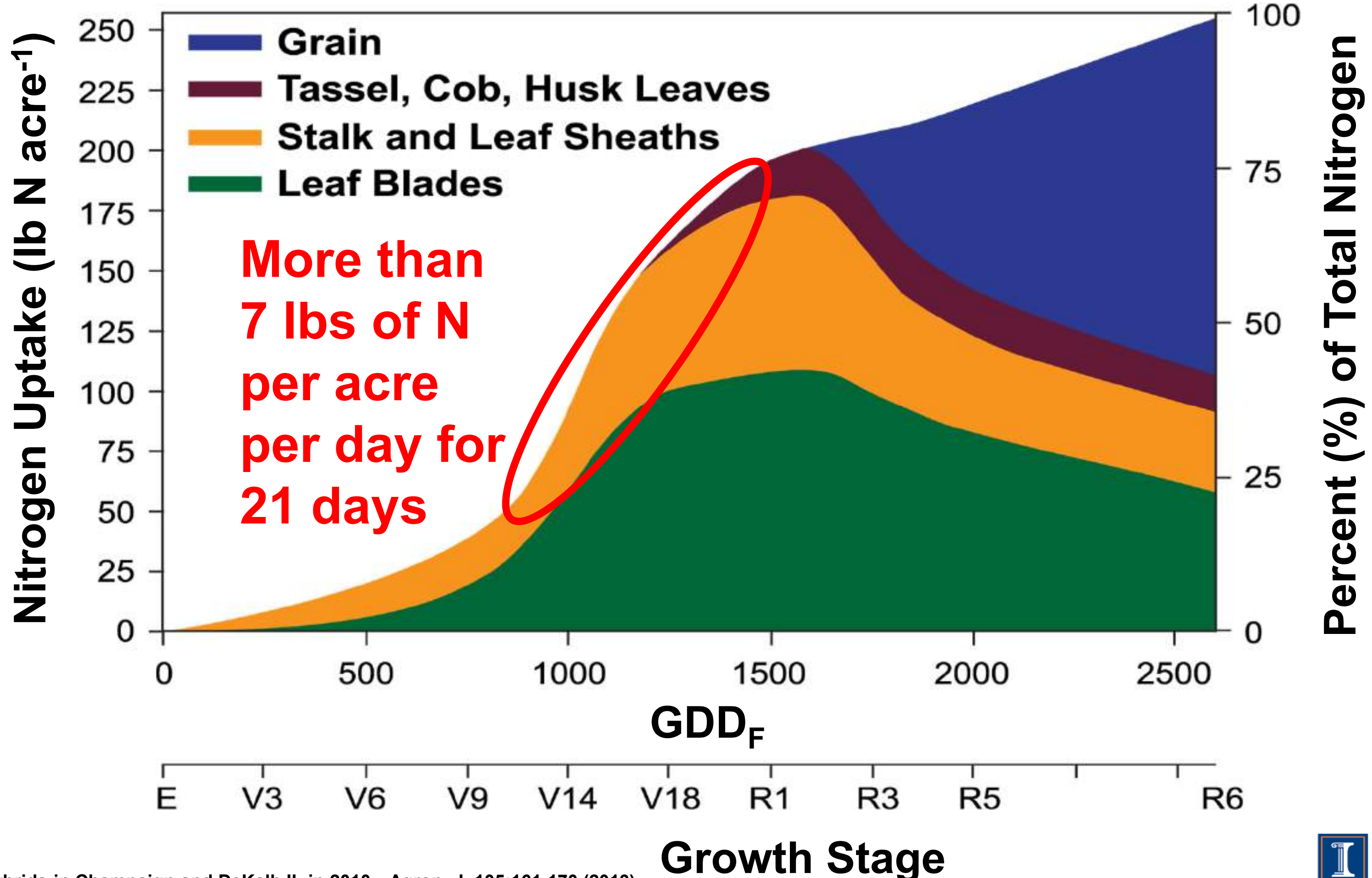
Nitrogen Uptake and Partitioning for 230 Bushel Corn



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

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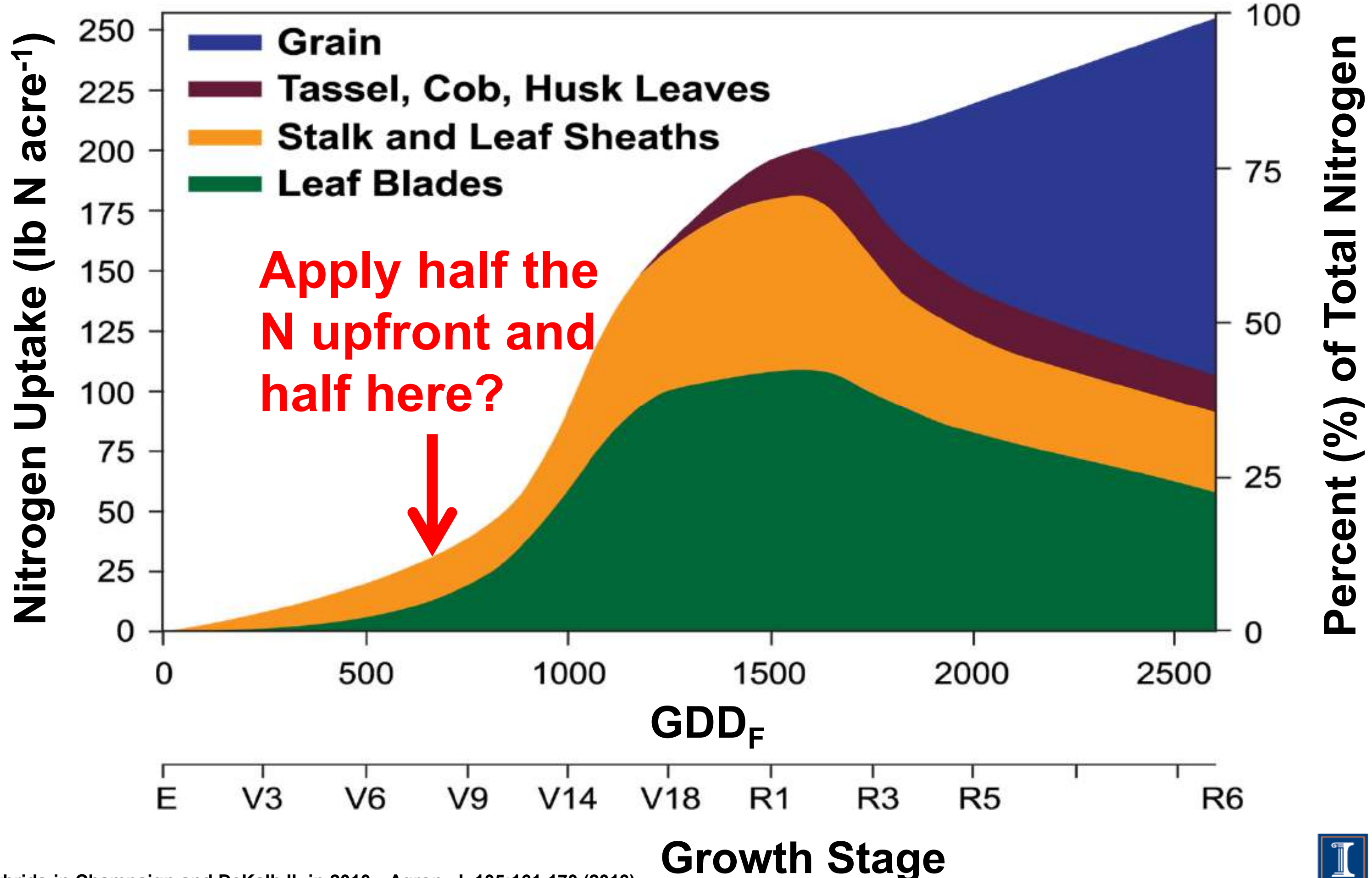
Are Split Applications of Nitrogen Better?



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

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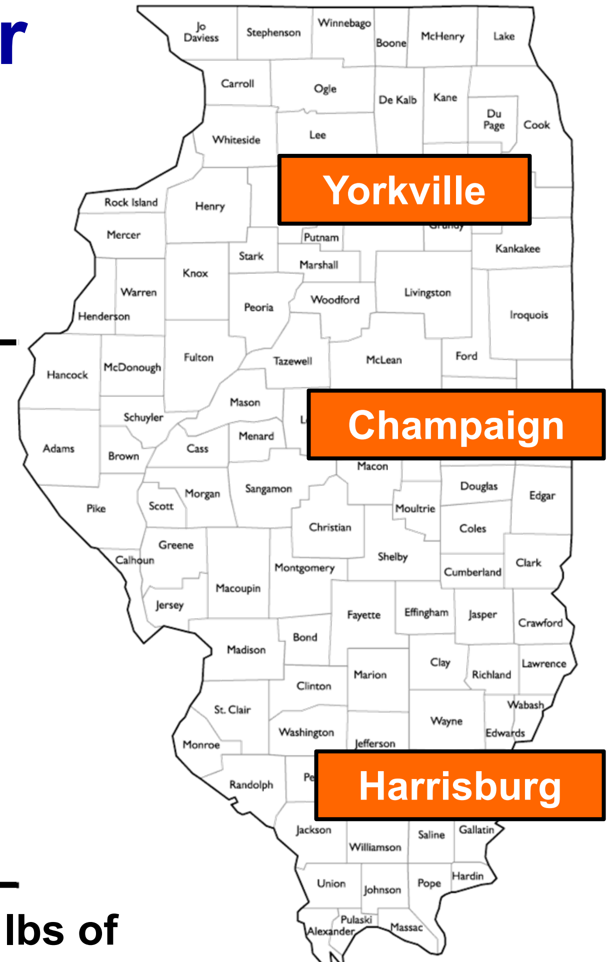
Are Split Applications of N Better than all N at Planting?

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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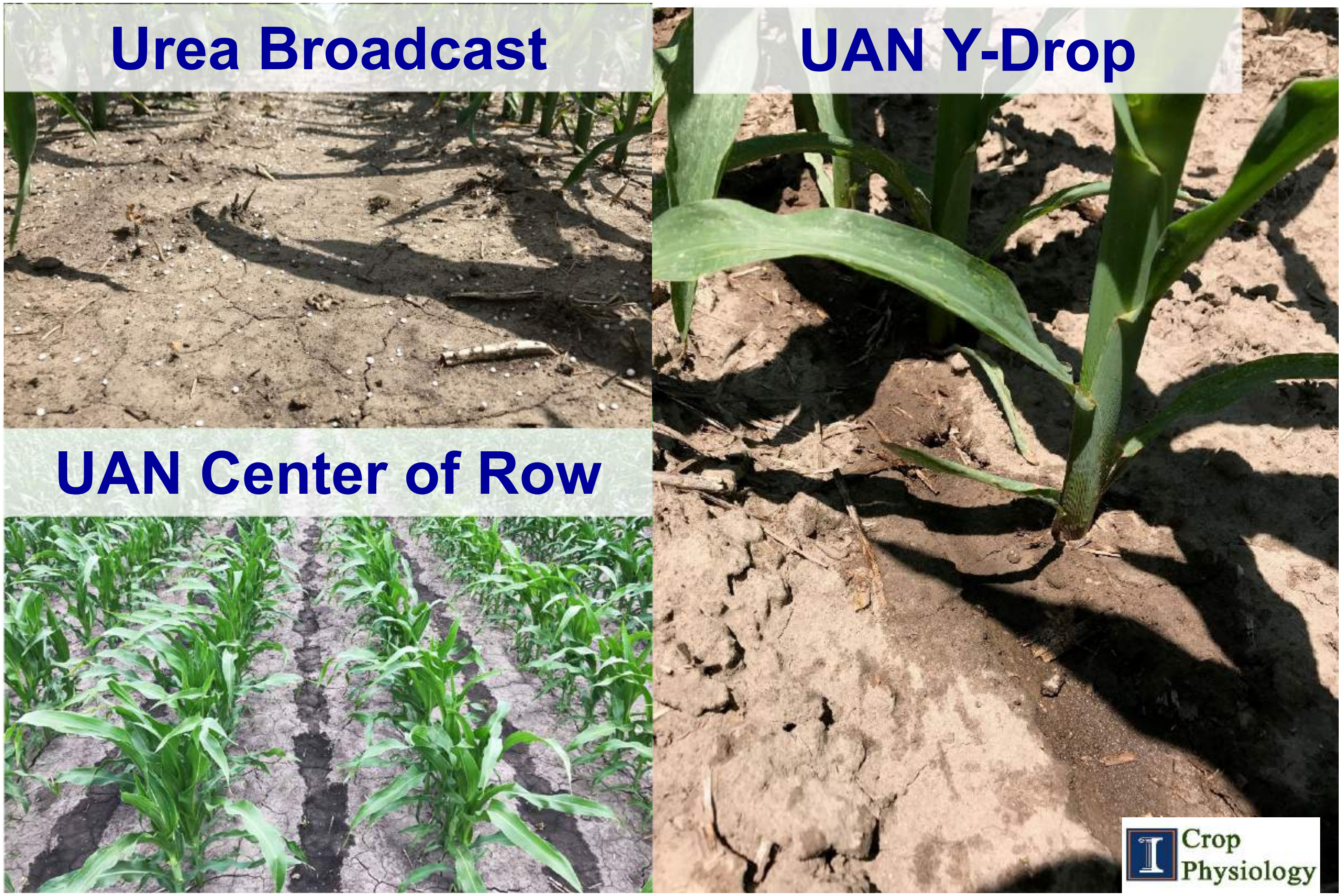
Urea Broadcast
UAN Y-Drop
UAN Center of Row
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Are Split Applications of N Better than all N at Planting?

Planting	Sidedress
No Nitrogen	-
Urea Broadcast	-
Urea Broadcast	Urea Broadcast
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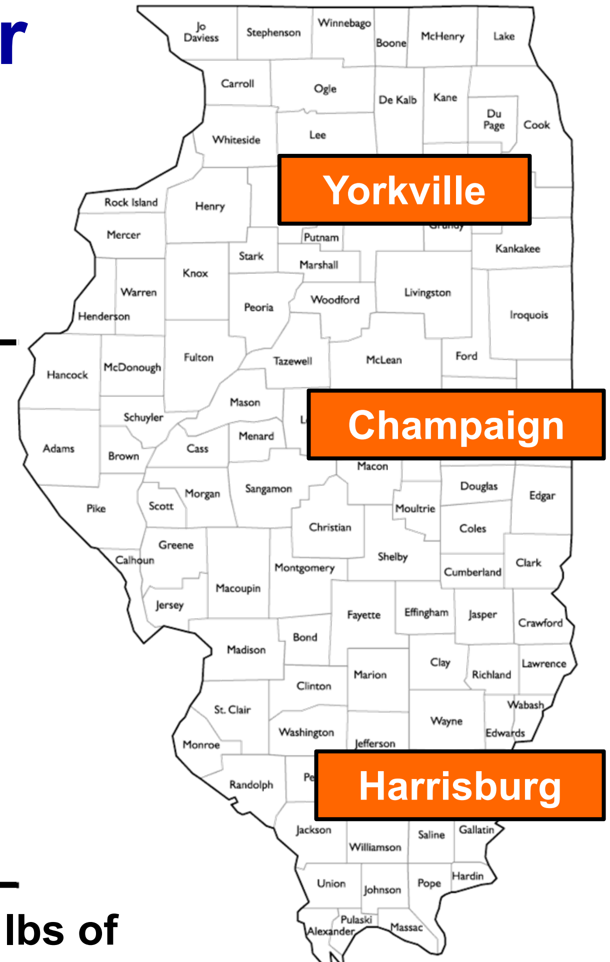

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Differences in Check Plot Yield Per Site

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

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Differences in Check Plot Yield Per Site

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2018 Harrisburg	97
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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

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Test Your Knowledge of High Yield Corn

- Does adequate fertility help other management practices work together (synergistically) to improve yield?

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Standard Practice vs Enhanced System 2013-18

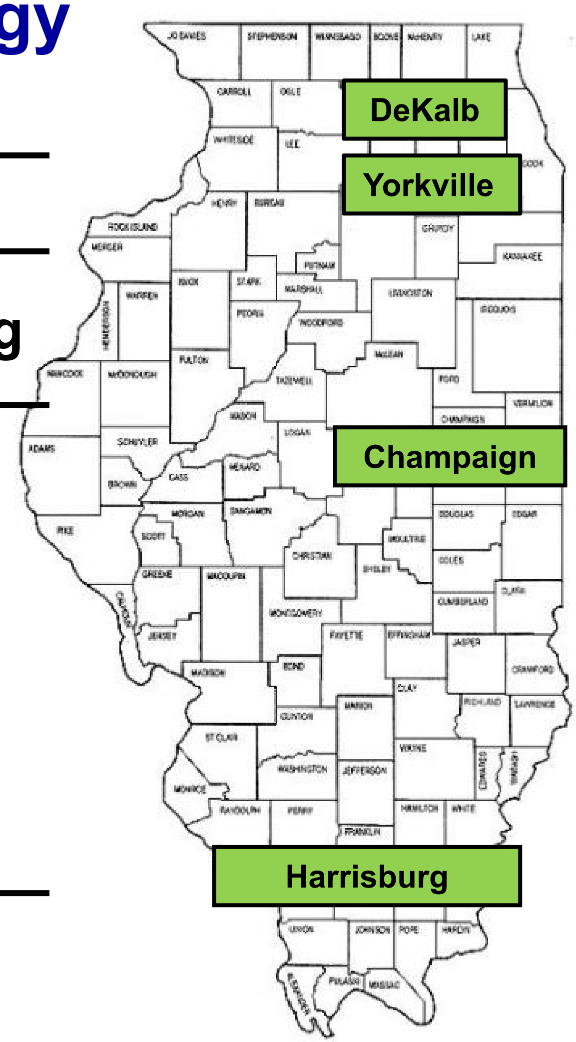
Production Factor	Management System	
	Standard	Enhanced
Fertility	P & K based on soil test, no S or micros	Banded MicroEssentials-SZ for (lbs/acre) 30 N, 100 P_2O_5, 25 S, & 2.5 Zn, and Broadcast Aspire for (lbs/acre) 75 K_2O & 0.6 B
Nitrogen	180 lbs/acre N preplant as UAN	180 lbs/acre UAN preplant + 60 lbs Sidedress (240 lbs total)
Population	32,000 plants/acre	44,000 plants/acre
Fungicide	No fungicide	Headline-AMP, Quilt-Xcel, or Trivapro at flowering
Row Space	30 inches	20 inches

Average Soil Analysis at Crop Physiology Laboratory Research Sites (2013-2018)

	Location		
	DeKalb/ Yorkville	Champaign	Harrisburg
OM (%)	4.5	3.6	2.2
pH	6.3	6.3	6.6
CEC	21.9	19.6	13.2
P (ppm)†	45	38	26
K (ppm)†	197	166	133

† Mehlich 3 extraction

All soils are silt loams or silty clay loams



Standard Management vs Enhanced System

Standard Management **Enhanced System**

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Standard Management vs Enhanced System

Standard Management

Enhanced System

Ears from 1/1000 of an acre

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Corn Yield Response to Management

Year	Standard	Enhanced	Δ
		bushels acre^{-1}	
2013	196	231	+35*
2014	193	238	+45*
2015	189	251	+62*
2016	227	272	+45*
2017	228	288	+60*
2018	245	303	+58*
Average	213	264	+51*

Average of 3 trials each in 2013, 2014, 2015, 2016, and 2 trials in 2017, 2018.
*Significantly different at $P \leq 0.05$.

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Standard Practice vs Enhanced System 2013-18

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Fertility	P & K based on soil test, no S or micros	Banded MicroEssentials-SZ for (lbs/acre) 30 N, 100 P_2O_5, 25 S, & 2.5 Zn, and Broadcast Aspire for (lbs/acre) 75 K_2O & 0.6 B
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Omission-Addition Plot Experimental Design

	TREATMENT	Fertility	Nitrogen	Population	Fungicide	Row Space
		FACTORS				
	ENHANCED	P, S, Zn, K, B	Base + sidedress	44,000	Strobilurin	20 inches
Remove Technology	Fertility	Soil test	Base + sidedress	44,000	Strobilurin	20 inches
	Nitrogen	P, S, Zn, K, B	Base + sidedress	44,000	Strobilurin	20 inches
	Population	P, S, Zn, K, B	Base + sidedress	32,000	Strobilurin	20 inches
	Fungicide	P, S, Zn, K, B	Base + sidedress	44,000	none	20 inches
	Row Space	P, S, Zn, K, B	Base + sidedress	44,000	Strobilurin	30 inches
	STANDARD	Soil test	Base	32,000	none	30 inches
Add Technology	Fertility	P, S, Zn, K, B	Base	32,000	none	30 inches
	Nitrogen	Soil test	Base + Sidedress	32,000	none	30 inches
	Population	Soil test	Base	44,000	none	30 inches
	Fungicide	Soil test	Base	32,000	Strobilurin	30 inches
	Row Space	Soil test	Base	32,000	none	20 inches

Omission-Addition Plot Experimental Design

Standard Practice vs Enhanced System 2013-18

Production Factor	Management System	
	Standard	Enhanced
Fertility	P & K based on soil test, no S or micros	Banded MicroEssentials-SZ for (lbs/acre) 30 N, 100 P_2O_5, 25 S, & 2.5 Zn, <u>and</u> Broadcast Aspire for (lbs/acre) 75 K_2O & 0.6 B
Nitrogen	180 lbs/acre N preplant as UAN	180 lbs/acre UAN preplant + 60 lbs Sidedress (240 lbs total)
Population	32,000 plants/acre	44,000 plants/acre
Fungicide	No fungicide	Headline-AMP, Quilt-Xcel, or Trivapro at flowering
Row Space	30 inches	20 inches

Add One Enhanced Factor to Standard – 2013-18

Add One Enhanced Factor	Yield	Δ
	bushels acre^{-1}	
Standard Management	213	
+Fertility (100 P_2O_5 25 S, 2.5 Zn 75 K_2O, 0.6 B)	225	+12*
+Nitrogen (60 lbs extra N as sidedress)	223	+10*
+Population (44,000 plants/acre)	212	-1
+Fungicide (strobilurin at flowering)	220	+7*
+Row Spacing (20 inch rows)	223	+10*

Average of 3 trials each in 2013, 2014, 2015, 2016, and 2 trials in 2017, 2018.
*Significantly different at $P \leq 0.05$.

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Omission-Addition Plot Experimental Design

	TREATMENT	FACTORS: Fertility	Nitrogen	Population	Fungicide	Row Space
	ENHANCED	P, S, Zn, K, B	Base + sidedress	44,000	Strobilurin	20 inches
Remove Technology	Fertility	**Soil test**	Base + sidedress	44,000	Strobilurin	20 inches
	Nitrogen	P, S, Zn, K, B	**Base + sidedress**	44,000	Strobilurin	20 inches
	Population	P, S, Zn, K, B	Base + sidedress	**32,000**	Strobilurin	20 inches
	Fungicide	P, S, Zn, K, B	Base + sidedress	44,000	**none**	20 inches
	Row Space	P, S, Zn, K, B	Base + sidedress	44,000	Strobilurin	**30 inches**
	STANDARD	Soil test	Base	32,000	none	30 inches
Add Technology	Fertility	**P, S, Zn, K, B**	Base	32,000	none	30 inches
	Nitrogen	Soil test	**Base + Sidedress**	32,000	none	30 inches
	Population	Soil test	Base	**44,000**	none	30 inches
	Fungicide	Soil test	Base	32,000	**Strobilurin**	30 inches
	Row Space	Soil test	Base	32,000	none	**20 inches**

Omit One Factor from Enhanced System – 2013-18

Omit One Enhanced Factor	Yield	Δ
	bushels acre^{-1}	
Enhanced (all five Factors)	264	
-Fertility (P & K from soil test no S, Zn, or B)	244	-20*
-Nitrogen (no extra from sidedress)	254	-10*
-Population (only 32,000 plants/acre)	245	-19*
-Fungicide (no fungicide)	255	-9*
-Row Spacing (30 inch rows)	244	-20*

Average of 3 trials each in 2013, 2014, 2015, 2016, and 2 trials in 2017, 2018.
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Standard vs Enhanced Management 2013-18

	Standard		Enhanced	
Factor	Yield	Δ	Yield	Δ
		bushels acre^{-1}		
None or All	213		264	
Fertility	225	+12*	244	-20*
Nitrogen	223	+10*	254	-10*
Population	212	-1	245	-19*
Fungicide	220	+7*	255	-9*
Row Spacing	223	+10*	244	-20*

Average of 3 trials each in 2013, 2014, 2015, 2016, and 2 trials in 2017, 2018.
*Significantly different at $P \leq 0.05$.

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Key Takeaway

Feeding, protecting and managing more plants is the key to higher yields

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Crop Physiology Laboratory Team

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- **Rodrigo Garrido**
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The Crop Physiology Laboratory
Financial and Product Support for 2019

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- Crystal Green Fertilizer
- Fluid Fertilizer Foundation
- Helena
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- United Prairie
- United Soybean Board
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- Verdesian
- West Central
- WinField United

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Special Thanks to The Fertilizer Institute

For More Information:

Crop Physiology Laboratory

University of Illinois

http://cropphysiology.cropsci.illinois.edu