# Welcome to
# Crop Physiology Day

## Where's the Yield?

# Crop Physiology Field Day Sponsors

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To the Root of Yield

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FS GROWMARK FS

ILLINOIS SOYBEAN ASSOCIATION

STONE SEED

# Crop Physiology Laboratory Team – 2023

**Principal Investigator**
- Dr. Fred Below

**Postdoctoral Research Associate**
- Dr. Connor Sible

**Principal Research Specialist**
- Juliann Seebauer

**Senior Research Specialist**
- Jared Fender

**Ph.D. Students**
- Marcos Loman
- Sam Leskanich

**Master's Students**
- Darby Danzl
- Gabriela Frigo Fernandes
- Miranda Ochs
- Dalton Knerrer

**Visiting Research Scholars**
- Amanda Beckers
- Julia Isaac
- Pieter Schoenmaker


Crop Physiology

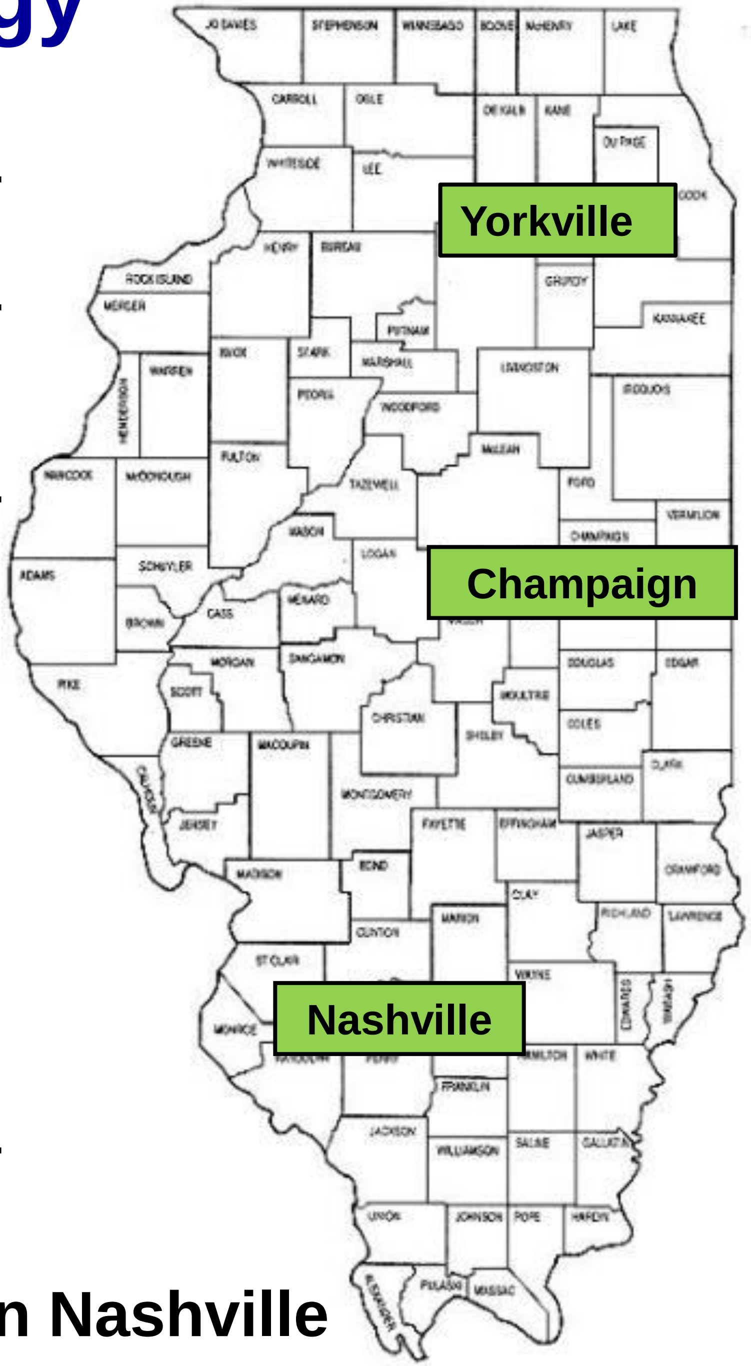
# What Do We Research?

# High Yield Corn and Soybean

Crop Physiology

# Average Soil Analysis at Crop Physiology Laboratory Research Sites in 2023

| | Location | | |
| --- | --- | --- | --- |
| | Nashville | Champaign | Yorkville |
| OM (%) | 2.1 | 3.8 | 6.6 |
| pH | 6.4 | 6.4 | 6.8 |
| CEC | 10.3 | 21.5 | 28.8 |
| P (ppm)† | 16 | 35 | 45 |
| K (ppm)† | 93 | 141 | 200 |




† Mehlich 3 extraction, all soils are silt loams or silty clay loams

Thanks to Stewart Farms in Yorkville and Bartling Farms in Nashville

# Plot Research = Many Trials in a Small Area

Nashville, IL 2020 11 trials in 20 acres

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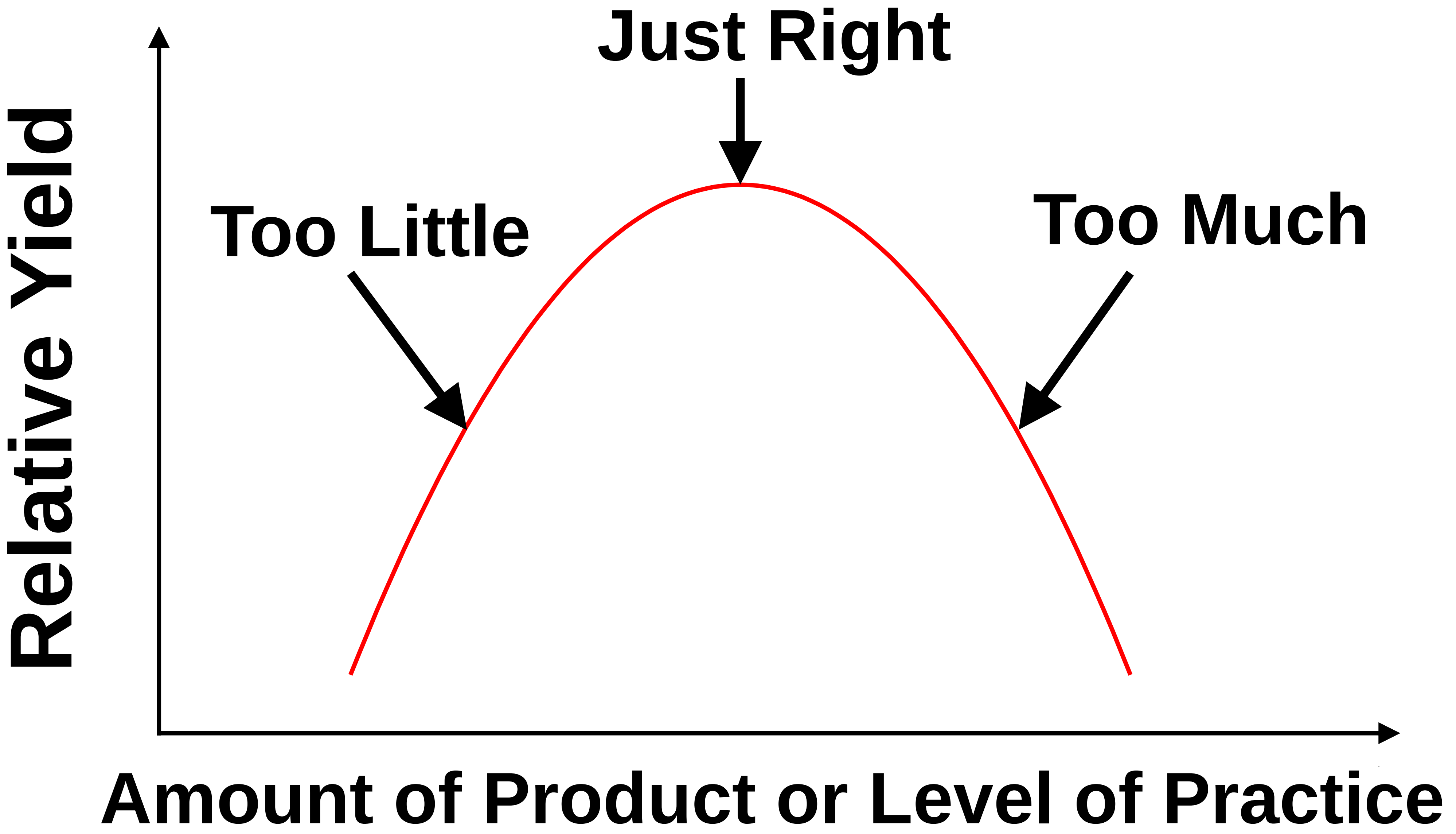
# What Are the Three Ps of Productivity?

- Products
- Practices
- Physiology

Crop Physiology

# Yield Response Follows the Goldilocks Rule



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Illinois Soybean Association

Stone Seed

# The Toys and Tools to Find High Yield


**Jared Fender**

## Crop Physiology Laboratory

Department of Crop Sciences
University of Illinois at Urbana-Champaign


Almaco 4 Row Research Planter
P12573

# Not Your Ordinary 4 Row Planter

Ag Leader®

SkyTrip GPS

Varying Row Spacing Capabilities




# Not Your Ordinary 4 Row Planter

Ag Leader®


- Individual row hydraulic downforce provides the quickest reaction to changing soil conditions
- Each individual row is given varying pressures to maintain uniform seed placement within plots
- Researching narrow row spacings require reactive downforce to overcome compaction from tire tracks

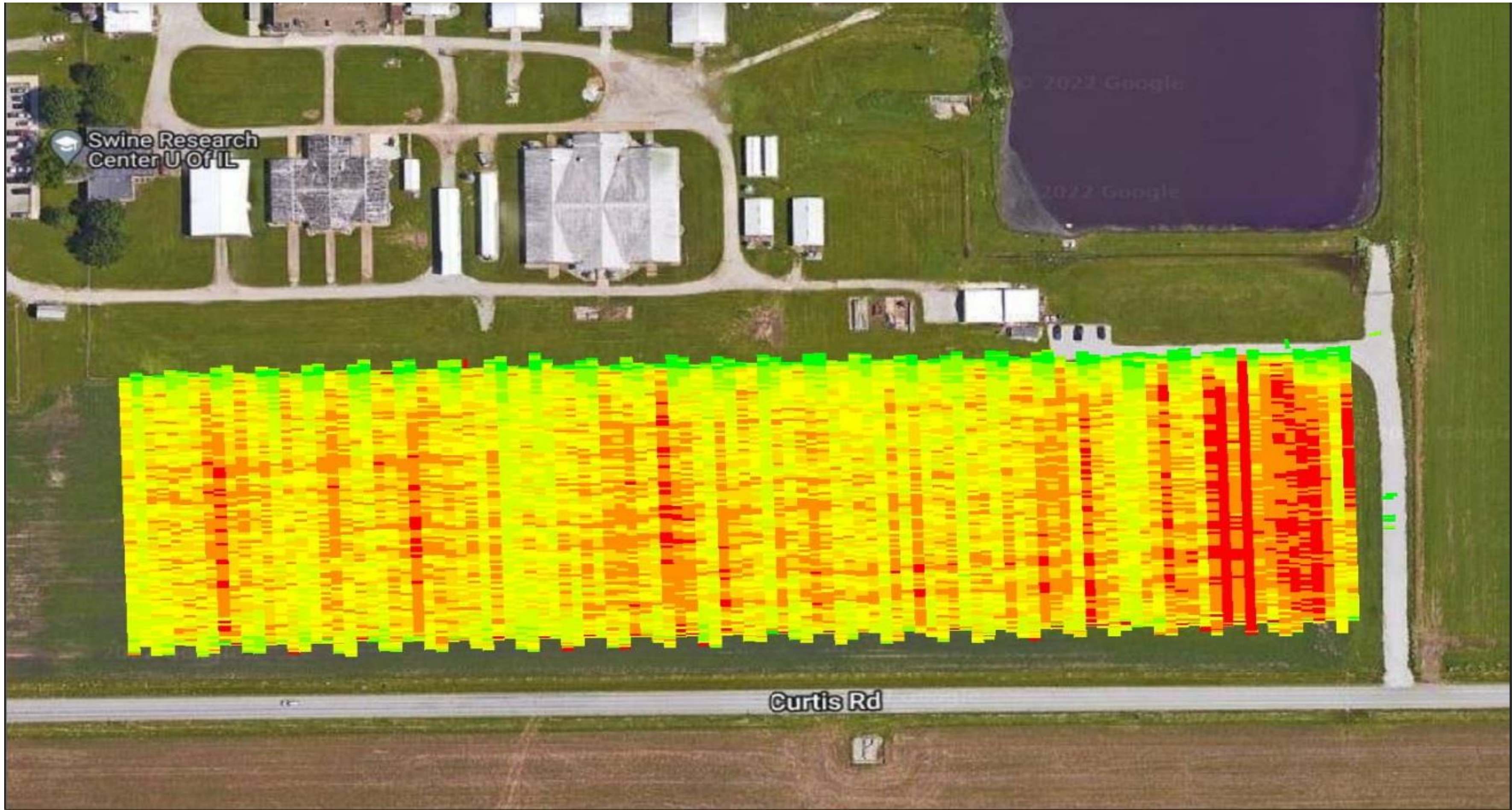
Crop Physiology

# Not Your Ordinary 4 Row Planter

Ag Leader®

Ag Leader®

SMS™

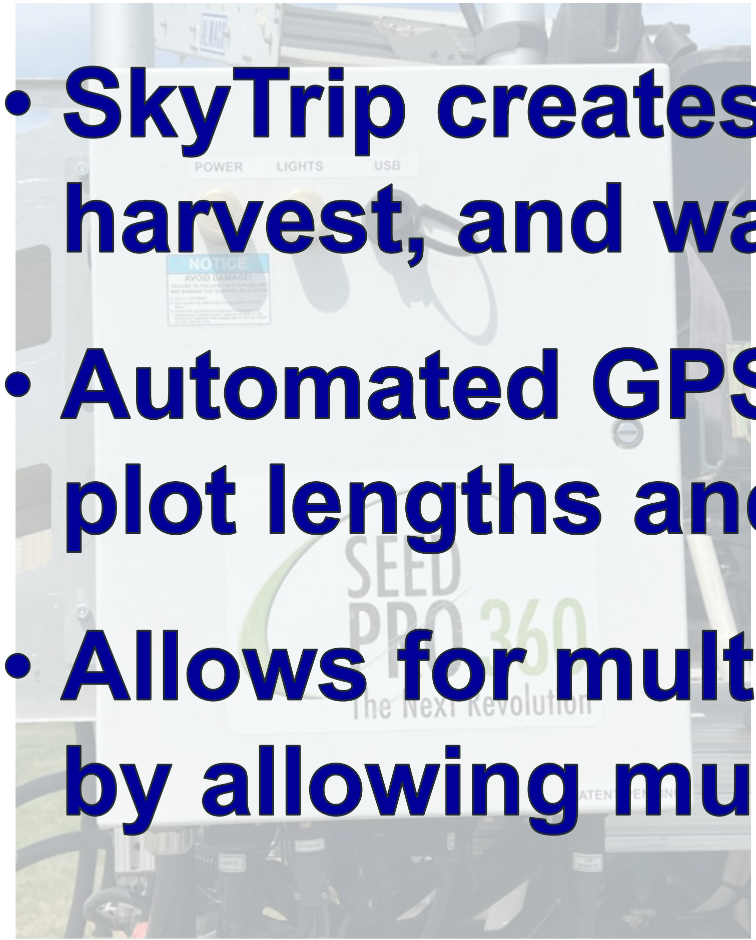



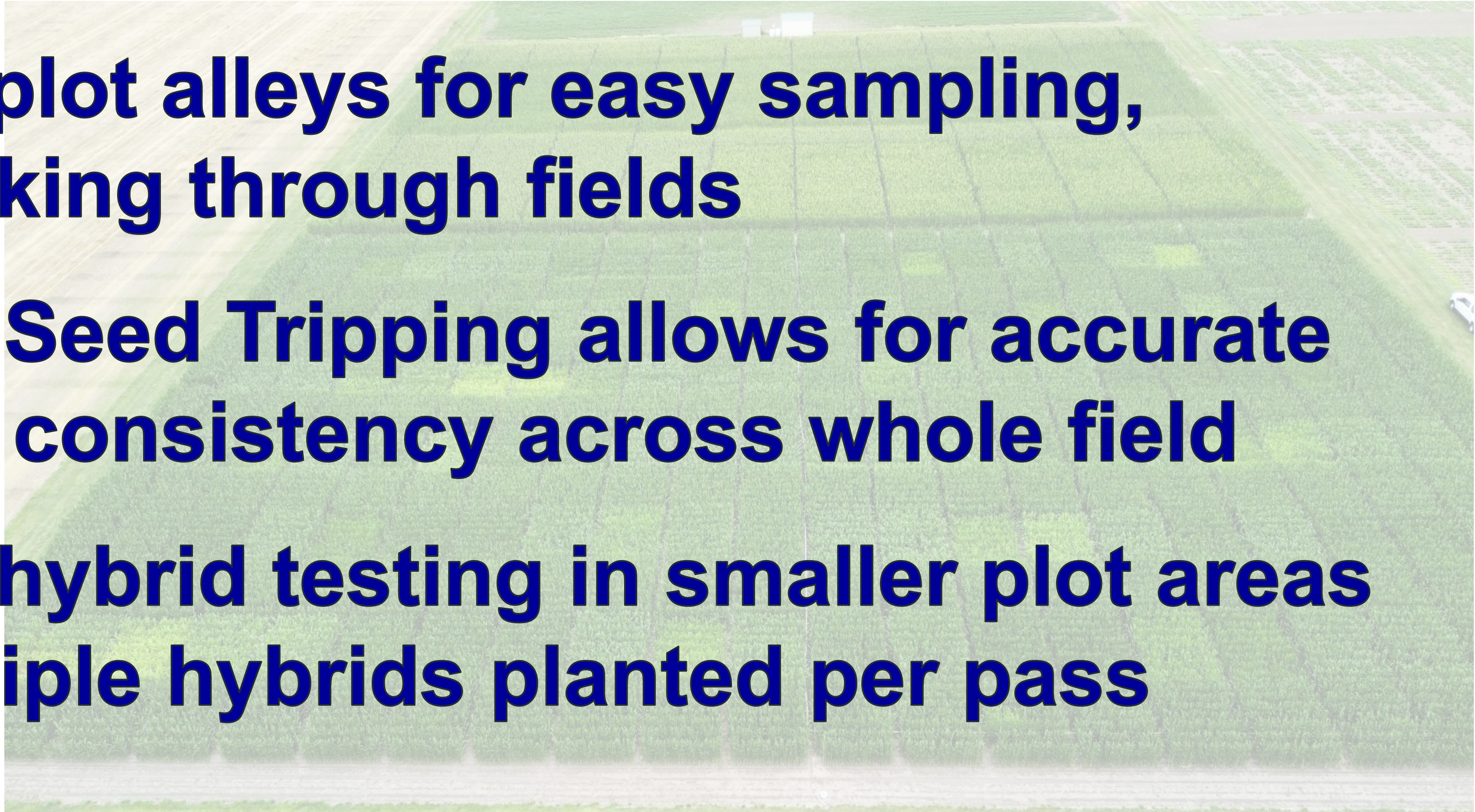
# Not Your Ordinary 4 Row Planter

SkyTrip GPS


# Not Your Ordinary 4 Row Planter

SkyTrip GPS



- **SkyTrip creates plot alleys for easy sampling, harvest, and walking through fields**
- **Automated GPS Seed Tripping allows for accurate plot lengths and consistency across whole field**
- **Allows for multi hybrid testing in smaller plot areas by allowing multiple hybrids planted per pass**

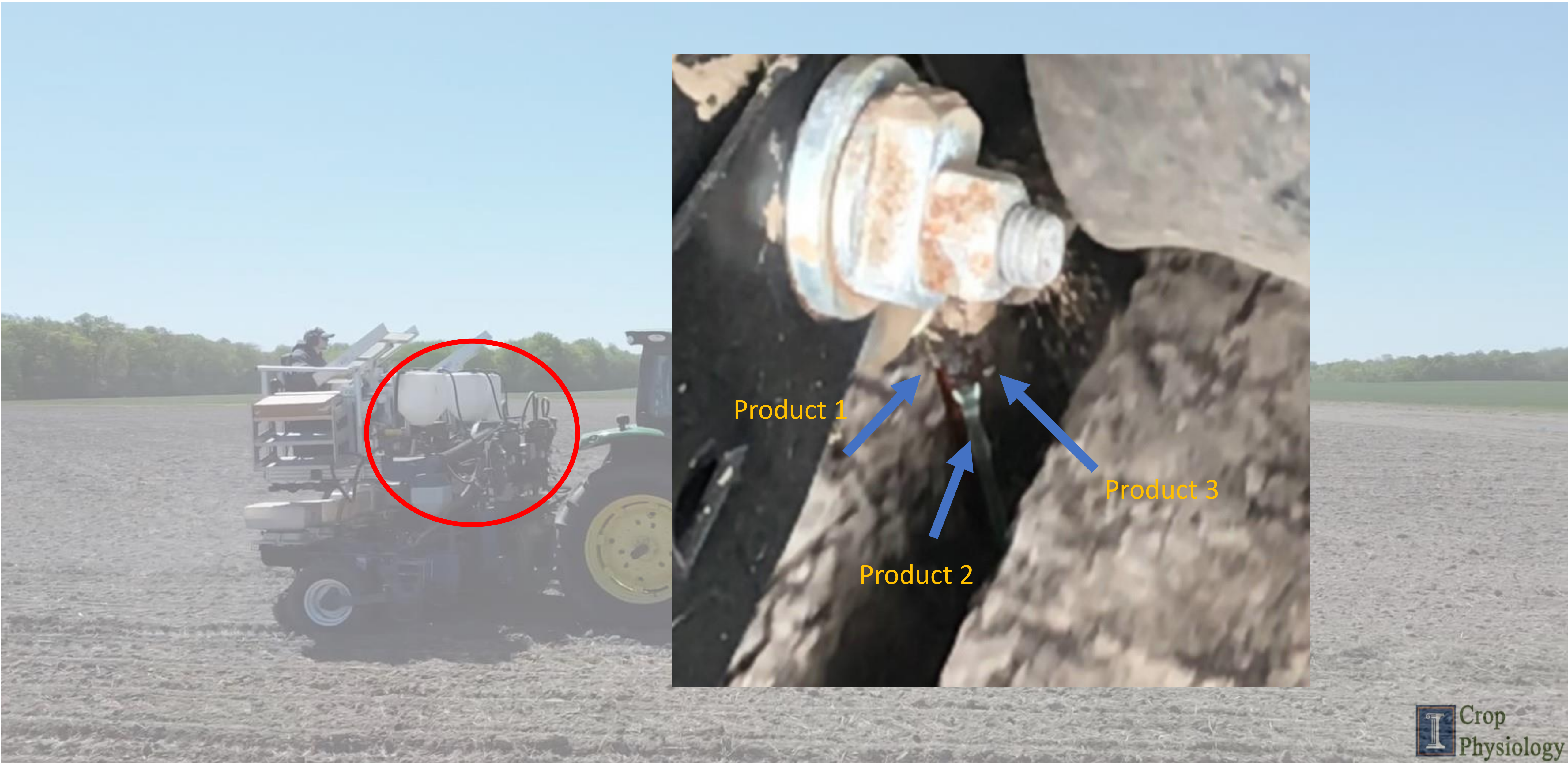
# Not Your Ordinary 4 Row Planter

**30" Row Spacing**


**20" Row Spacing**

# Research Scale Starter System

# All Good Things Come With Limitations




Crop Physiology

# Research Scale Starter System

- **Electric SurePoint Ag pumps allow for fast reactivity of rate changes between plots**
- **3 Products being applied separately prevent precipitation of fertilizers**
- **Allows for multiple product testing within same planter pass, without ‘smearing’ or contamination**

# 5 Row Liquid Fertilizer Toolbar


- **4 Separate Products**
- **5 Separate Tanks**
- **3 LiquiShift Line Sizes Per Product**
- **3 Product Application Points**

SurePoint
Ag Systems

Crop
Physiology

# Any Application Point Is Possible

**Pre-Plant Under The Row**

**Coulter Side-dress Between Row**

**Y-Drop Side-dress On Row**

# 5 Row Liquid Fertilizer Toolbar

- **Various application points allow proving new forms of side-dress products at different timings**
- **4 separate application systems allow for pure products to be applied without worries of precipitation of fertilizer inside of equipment lines**
- **Row spacing and toolbar shifting capabilities allow us to apply pre-plant under the future crop row, 2x2 application, or side-dress in season**

# All Equipment Use the Same GPS and Signal

# End of Year Data Collection

# Almaco R1 Rotary Plot Combine


# Almaco R1 Rotary Plot Combine

- **Rotary threshing system allows for production level threshing, cleaning, and separation of grain from stover in high yield environments (411 bushel per acre CPL record yield)**
- **HarvestMaster H2 weighing system weighs each plot, produces total plot weight, moisture, and test weight on-the-go**
- **Every plot has a sub-sample pulled to analyze later for protein, oil, starch concentrations**
- **Calmer Corn Heads "BT Super Choppers" 12 blade stalk rolls fitted on corn heads for optimal residue sizing for decomposition**


# Even Plot Combines Have Bad Days


# …and Some Technicians Have Worse Days

# Offsite Planting is No Small Feat

# Offsite Planting is No Small Feat


- **78 Tires**
- **12 Graduate Students**
- **5 Trucks and Trailers**
- **3 CDL's**
- **2 Coffee Makers**
- **1 Research Specialist's Devotion**

Crop Physiology

# New Beginnings for CPL

# New Beginnings for CPL

# Key Takeaways

- **All equipment is designed and upgraded to keep pace with ‘industry standards’ in production agriculture**
- **Research equipment is designed for plot integrity, keeping treatments separated**
- **In research, consistency and uniformity is key with equipment**
- **Research equipment may be small, but the equipment is complex**

Crop Physiology

# The Seven Wonders of 300 Bushel Corn


**Fred Below**

**Crop Physiology Laboratory**
**Department of Crop Sciences**
**University of Illinois at Urbana-Champaign**

# The Quest for 300 Bushel Corn

- Monsanto (2007)- US average corn yields will double to 300 bushels per acre by 2030

- World population of 9 billion people by 2037 will require a doubling of grain production

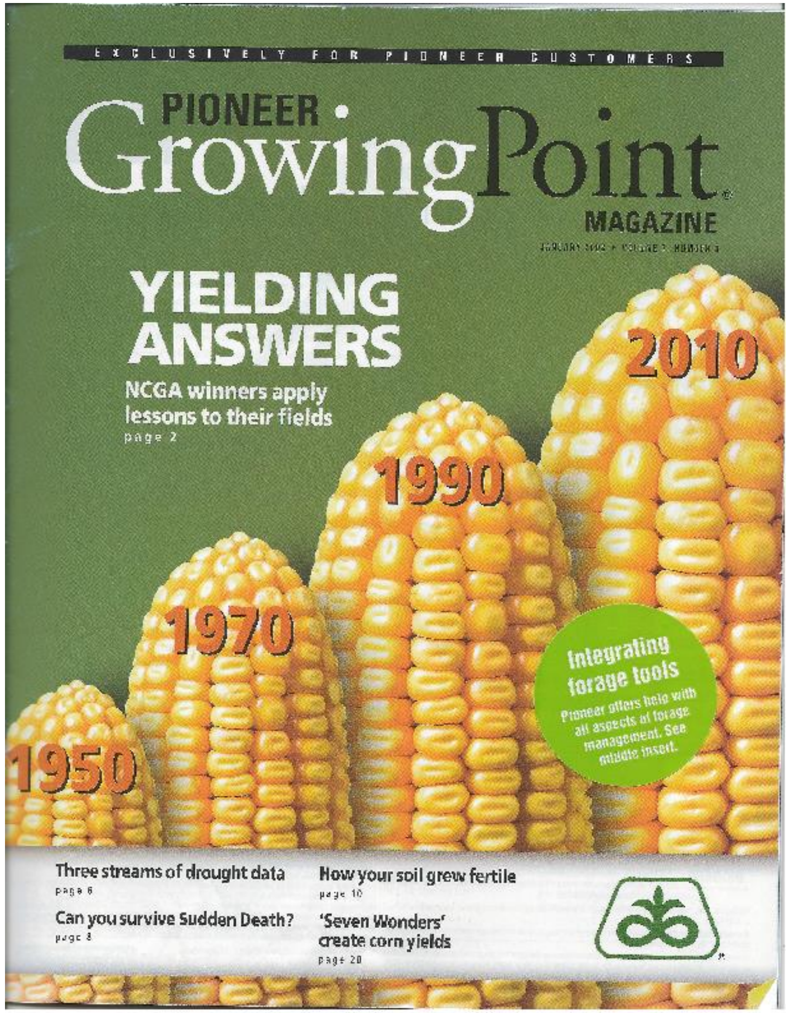
Crop Physiology

# Test Your Knowledge of High Yield Corn

# Where's the Yield?

# The Seven Wonders of the Corn Yield World

## The Relative Importance of Management Factors on Yield




PGP commentary

By Fred E. Below
Department of Crop Sciences
University of Illinois

# 7 WONDERS

## HERE'S A RANKING OF THE TOP 7 FACTORS THAT DETERMINE CORN YIELDS

To help farmers better understand the value of their crop management decisions, I developed the "Seven Wonders of the Corn Yield World." This is a tool to teach farmers (and students) the relative importance of management factors that can impact corn productivity.

The Seven Wonders ranks the top seven factors that can positively impact corn yields. It assigns an average bushel-per-acre value to each wonder. It's based on a compilation of research conducted by the Crop Physiology Laboratory at the University of Illinois over the last 10 years.

Because the bushel-values are averages of ranges, farmers could experience different values. The research for this ranking was conducted mostly in Illinois, so the relative ranking or value of a particular wonder could change slightly with geography.

### Defining a wonder

Some practices are clearly important, but I don't consider them as yield wonders because they are either one-time improvements (tile drainage), they protect rather than increase yield (weed or pest control) or they involve decisions that don't need to be made every year (soil pH and nutrient levels). In my mind, good weed control, along with proper soil pH and adequate levels of phosphorus and potassium, are prerequisites for crop production. They're necessary to allow the seven wonders to express their positive impact on grain yield.

One nuance of the seven wonders is that they can interact with each other to either magnify or lessen a wonder's impact on yield. As a rough rule, the higher the ranking of a particular wonder, the more control it can exert over the wonders below it. Understanding a wonder's ranking, and its interaction with other wonders, gives farmers an opportunity to further increase grain yields through crop management.

### Weather trumps all

Unfortunately, the first wonder of the corn yield world is the one over which farmers have the least control: the weather. Whether in the form of rainfall or temperature, weather is a major determinant of when the crop can be planted. And weather has a huge impact on grain yield.

Even with the other yield wonders optimized and constant, our research shows a 70-plus bushel variation in grain yield due to weather. Weather reacts strongly with other yield wonders, and all farmers realize weather can circumvent their best management plans.

20 PGP magazine / Jan 2008


Each of these seven factors contributes to a variation in corn yields. Here they are, ranked from the greatest to the least impact. All told, these factors add up to 260-bushel potential yields.

Weather especially affects nitrogen (N) fertilization, the No. 2 wonder of the corn yield world. The ability to apply N, its availability or susceptibility to loss and its impact on grain yield are all heavily impacted by weather.

Because N fertilizer increases grain yield by an average of 70 bushels, and since most of the other yield wonders also can impact the availability or the use of N, nitrogen fertilizer management continues to receive considerable attention in the research world.

### The seeds of potential

Nitrogen use also interacts strongly with the third wonder of the corn yield world, hybrid selection. There's considerable interest in improving the efficiency of N use with genetics or biotechnology.

Hybrid selection is probably the most important decision farmers make. Most don't realize the large difference in yield potential among elite commercial hybrids. Arrays of commercial hybrids, grown under conditions where the other wonders are presumed to be optimized, typically exhibit a 50-bushel range in grain yield.

Hybrid selection will become even more important in the future, when biotechnology adds stress and input traits like drought tolerance and improved N use.

The fourth wonder of the corn yield world, previous crop, is becoming more an issue lately as continuous corn acreage has steadily increased. This is despite the 25 bushel-per-acre yield penalty associated with continuous corn and the higher input cost, especially for N.

Previous crop clearly interacts with the first and second wonders. If sufficient N is available in a good growing year, the continuous-corn yield penalty can be reduced or eliminated. While it makes sense that some hybrids might perform better than others under continuous corn, our research has not shown this. We find the best hybrid on a farmer's rotated land is also the best one for continuous-corn ground.

### What's maximum occupancy?

All farmers know the fifth wonder of the corn yield world, plant population, has increased steadily over the last 20 years. What they probably don't know is how well modern hybrids can flex their ear components (such as kernel number and weight) to account for differences in plant stand.

Because of this, we find similar yields between 28,000 and 40,000 plants per acre, although there is a big difference in the size of individual kernels. Thus, most of the 20-bushel yield benefit we see from plant population comes from correcting stands that are too low.

Of course, plant population interacts heavily with weather: High plant populations are particularly susceptible to unfavorable conditions. Contrary to what many people think, however, we don't see an interaction between plant population and N. There's no need for more N fertilizer at higher plant populations.

### To plow or not

The sixth wonder of the corn yield world is tillage, which comes in varying degrees or in differing times. Both degree and timing aspects interact heavily with the other yield wonders. The relative advantages or disadvantages of a particular tillage system or time depend largely on the weather. Tillage also interacts with N availability and hybrid.

The degree and timing of tillage can make a big difference with the previous crop because most of the yield penalty associated with continuous corn is due to the residue. Similarly, the tillage system can have a big impact on plant population. Overall, our research shows a 15-bushel range of yield due to the various tillage systems.

The seventh wonder of the corn yield world is a catch-all that I call chemicals. This includes plant growth regulators and compounds that exert growth-regulator-like effects that lead to a positive change in growth or yield determination.

Late-season leaf-greening from certain foliar fungicides and new technologies that make the plant less sensitive to environmental stresses fit into this category. While the overall average is a positive 10 bushels, the success of these compounds depends highly on the other yield wonders, especially weather and hybrid. This category has the widest range.

### The sum total

They all add up. By optimizing all of the seven wonders, grain yields of 260 bushels should be possible. This total doesn't take into account interactions among the wonders, which in some cases could drive yields even higher. By the same token, a nonoptimized yield wonder lowers yield.

Although I realize the seven wonders concept is a vast oversimplification of all the complicated factors that make a high yielding corn crop, it should give you a better perspective on how your management decisions can impact grain yield.

PGP magazine / Jan 2008 21

January 2008

Crop Physiology

# Test Your Knowledge of High Yield Corn

- How common is 300 bushel per acre corn?

Crop Physiology

# Herman Warsaw Produces Record Corn Yield in 1985

- Herman Warsaw of Saybrook, Illinois produces a world record 370 bushels per acre

Crop Physiology

# Research on Herman Warsaw's Farm

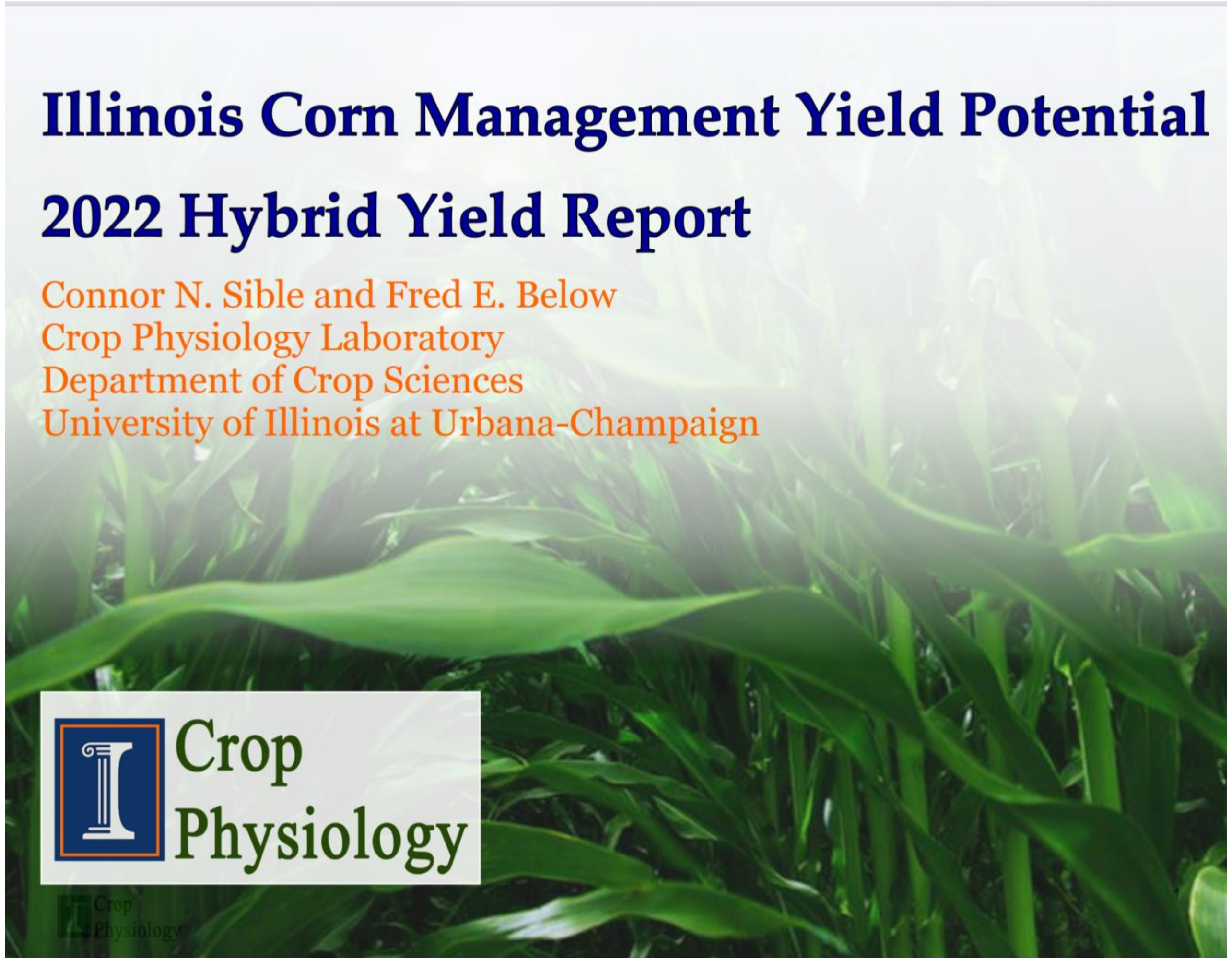
- Our replicated research plots on Mr. Warsaw's farm in 1985 produced 313 bushels per acre

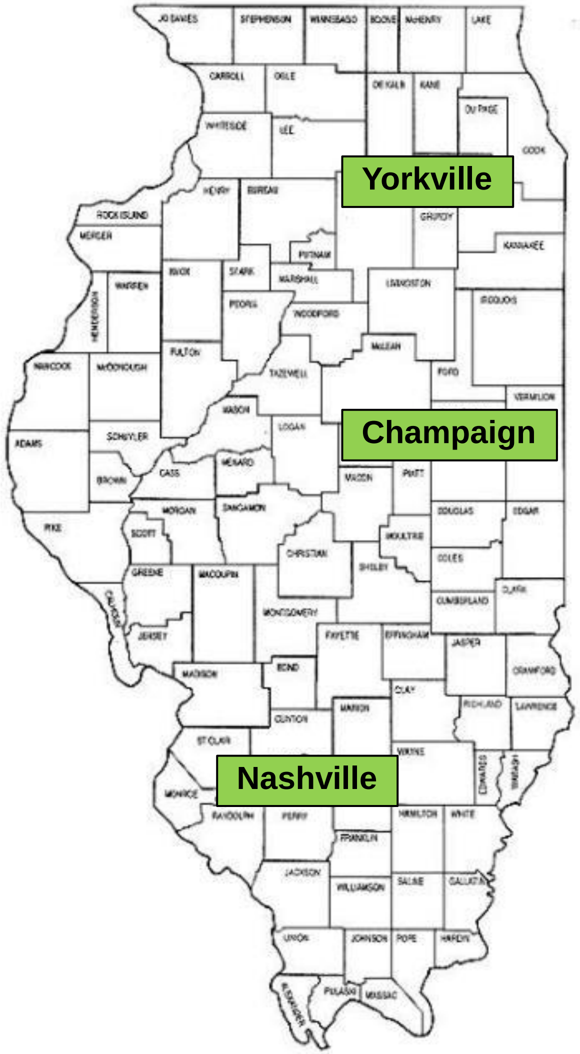
- Did not see 300 bushels again for 30 years

Crop Physiology

# Corn Management Yield Potential

## How Hybrids Respond to Agronomic Management




http://cropphysiology.cropsci.illinois.edu

# Highest Yearly Yields in CPL Research Trials

| Year | Grain Yield | Location |
|---|---|---|
| | bushels/acre | |
| 2015 | 360 | Champaign |
| 2016 | 327 | Yorkville |
| 2017 | 379 | Yorkville |
| 2018 | 322 | Champaign |
| 2019 | 310 | Champaign |
| 2020 | 279 | Nashville |
| 2021 | 363 | Nashville |
| 2022 | 310 | Champaign |

All without irrigation and all replicated plot averages

Crop Physiology

# Highest Yearly Yields in CPL Research Trials

| Year | Grain Yield | Location |
|---|---|---|
| | bushels/acre | |
| 2015 | 360 | Champaign |
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| 2019 | 310 | Champaign |
| 2020 | 279 | Nashville |
| 2021 | 363 | Nashville |
| 2022 | 310 | Champaign |

All without irrigation and all replicated plot averages

Crop Physiology

# Location and Year on Average Grain Yield

| Location | 2020 | 2021 | 2022 |
|---|---|---|---|
| | | bushels acre$^{-1}$ | |
| Yorkville | 205 | - | 256 |
| Champaign | 198 | 278 | 258 |
| Nashville | 172 | 292 | 232 |

Average of 36 hybrids at each location in 2020 and 2021, and 20 in 2022
Yorkville site lost in 2021 to Derecho winds.

Crop Physiology

# Test Your Knowledge of High Yield Corn

- What management factors can lead to 300 bushel per acre corn?

# The Seven Wonders of 300 Bushel Corn

- Ranks, and gives an average bushel per acre value of those seven factors that can have a positive (and sometimes negative) impact on corn yield, and that when summed can lead to 300 bushels

- An update to the previous ‘Seven Wonders of the Corn Yield World’ that summed to 260 bushels

Crop Physiology

# Crucial Prerequisites, but not 300 Bushel Yield Wonders

- Soil Structure and Drainage

**Can soil structure be improved from use of a Cover Crop or by the addition of Carbon?**

# Crucial Prerequisites, but not 300 Bushel Yield Wonders

- Soil Structure and Drainage
- Control of Weeds, Pests, Diseases

Is foliar protection with fungicides (& insecticides) a prerequisite for 300 bushel corn production?

Crop Physiology

# Response to Foliar Protection by Location & Year

| Location | 2020 | 2021 | 2022 |
|---|---|---|---|
| | | Δ bushels $acre^{-1}$ | |
| Yorkville | 4 | - | 5 |
| Champaign | 14 | 13 | 7 |
| Nashville | 26 | 12 | 13 |

**Foliar Protection as Miravis Neo and Warrior II at VT/R1**
**Average of 36 hybrids at each location in 2020 and 2021, and 20 in 2022**
**Yorkville site lost in 2021 to Derecho winds.**

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# Leaf Greening from Strobilurin Fungicides


**Greener leaves 50 days after VT application**

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# Crucial Prerequisites, but not 300 Bushel Yield Wonders

- Soil Structure and Drainage
- Control of Weeds, Pests, Diseases
- Proper soil pH & adequate ‘base’ levels of P & K based on soil tests

**Are Soil Tests Calibrated to 300 Bushels?**

# Test Your Knowledge of High Yield Corn

- When were soil test values calibrated to corn yields?

In the 60's and Early 70's

Crop
Physiology

# Crucial Prerequisites, but not 300 Bushel Yield Wonders

- Soil Structure and Drainage
- Control of Weeds, Pests, Diseases
- Proper soil pH & adequate ‘base’ levels of P & K based on soil tests

Crop Physiology

# Seven Wonders of 300 Bushel Corn

| Rank | Factor | Value |
|---|---|---|
| | | bu/acre |
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |

Given key prerequisites

# Seven Wonders of 300 Bushel Corn

| Rank | Factor | Value (bu/acre) |
|---|---|---|
| 1 | Weather | 90+ |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |

Given key prerequisites

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# Planting Date is Determined by Weather

May 15th, 2019 in Champaign, IL

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# Non-Uniformity of Corn Due to Early Planting

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# Non-Uniformity of Corn Due to Early Planting

Crop Physiology

# Highest Yearly Yields in CPL Research Trials

| Year | Grain Yield | Location |
|---|---|---|
| | bushels/acre | |
| 2015 | 360 | Champaign |
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| 2020 | 279 | Nashville |
| 2021 | 363 | Nashville |
| 2022 | 310 | Champaign |

**All without irrigation and all replicated plot averages**

Crop Physiology

# Highest Yearly Yields in CPL Research Trials

| Year | Grain Yield | Location | Planting |
|---|---|---|---|
| | bushels/acre | | |
| 2015 | 360 | Champaign | May 6 |
| 2016 | 327 | Yorkville | May 20 |
| 2017 | 379 | Yorkville | May 16 |
| 2018 | 322 | Champaign | April 27 |
| 2019 | 310 | Champaign | May 31 |
| 2020 | 279 | Nashville | June 8 |
| 2021 | 363 | Nashville | April 22 |
| 2022 | 310 | Champaign | May 20 |

All without irrigation and all replicated plot averages

Crop Physiology

# Seven Wonders of 300 Bushel Corn

| Rank | Factor | Value bu/acre |
|---|---|---|
| 1 | Weather | 90+ |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |

Given key prerequisites

Crop Physiology

# Negative Weather Events can Seriously Decrease Yield Potential

Crop Physiology

# Negative Weather Events can Seriously Decrease Yield Potential

Crop Physiology

# Negative Weather Events can Seriously Decrease Yield Potential

Crop Physiology

# Negative Weather Events can Seriously Decrease Yield Potential

- Every night in August that the temperature stays above 73 degrees results in a bushel per acre loss in yield

Crop Physiology

# Seven Wonders of 300 Bushel Corn

| Rank | Factor | Value |
|---|---|---|
| | | bu/acre |
| 1 | Weather | 90+ |
| 2 | Fertility | 90 |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |

Given key prerequisites

Crop Physiology

# Test Your Knowledge of High Yield Corn

- Does weather impact nutrient availability?

Crop Physiology

# Weather Induced Nitrogen Loss

Crop Physiology

# Seven Wonders of 300 Bushel Corn

| Rank | Factor | Value |
|---|---|---|
| | | bu/acre |
| 1 | Weather | 90+ |
| 2 | Fertility | 90 |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |

Given key prerequisites

# Nutrition Needed for 300 Bushel Corn

| Nutrient | Required to Produce | Production Coefficient | Removed with Grain | Removal Coefficient |
|---|---|---|---|---|
| | lbs/acre | lbs/bushel | lbs/acre | lbs/bushel |
| N | 333 | 1.11 | 192 | 0.64 |
| $P_2O_5$ | 132 | 0.44 | 105 | 0.35 |
| $K_2O$ | 234 | 0.78 | 78 | 0.26 |
| S | 30 | 0.10 | 18 | 0.06 |
| Zn (oz) | 9.3 | 0.031 | 5.7 | 0.019 |
| B (oz) | 1.5 | 0.005 | 0.3 | 0.001 |

Adapted from Agronomy Journal 105:161-170 (2013)

Crop Physiology

# Test Your Knowledge of High Yield Corn

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

**Better Source, Rate, Time, and Placement**

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# Test Your Knowledge of High Yield Corn

- Why is better placement of fertilizers so important?

Crop Physiology

# Roots Expand Only 6-8 Inches Horizontally
## Roots do Not Cross the Row


Root System at R5, 32,000 plants/acre

Crop Physiology

# Methods for Better Placement of Fertilizers

- Liquid at Planting - In-Furrow or 2 x 2

# Placement with Liquid In-Furrow Starter Fertilizer


Crop Physiology

# Effect of Properly Placed Fertilizer

3 gallons 10-34-0 In-Furrow

No Starter

Crop Physiology

# Methods for Better Placement of Fertilizers

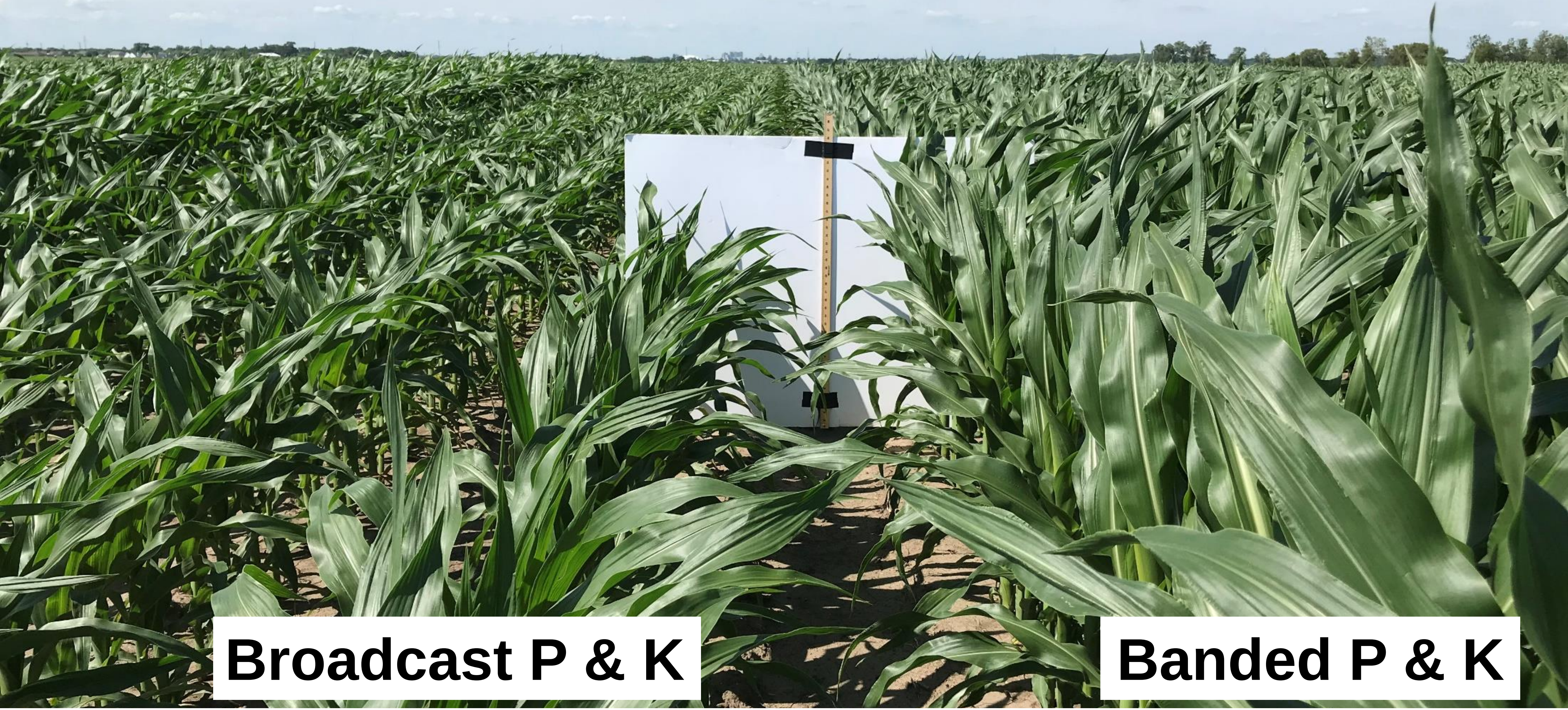
- Liquid at Planting - In-Furrow or 2 x 2
- Banding directly under future crop row

Crop Physiology

# Preplant Banding Application


**Fertilizer is placed 4 to 6 inches deep directly below the future crop row**

# Improved Growth with Banded Fertility




**Same Hybrid – Same Population – Same Planting Date- Same Fertilizer Amounts**

# Methods for Better Placement of Fertilizers

- Liquid at Planting - In-Furrow or 2 x 2
- Banding directly under the future crop
- In season placement adjacent to the crop row  Y-Drop

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# Research Scale Sidedress Toolbar

## Center-Row Coulter or Y-Drop

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# Methods for Better Placement of Fertilizers

- Liquid at Planting - In-Furrow or 2 x 2
- Banding directly under the future crop
- In season placement adjacent to the crop row Dry-Drop

# Surface Banding of Dry Fertilizer – Dry Drop


# Seven Wonders of 300 Bushel Corn

| Rank | Factor | Value |
|---|---|---|
| | | bu/acre |
| 1 | Weather | 90+ |
| 2 | Fertility | 90 |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |

Given key prerequisites

# Seven Wonders of 300 Bushel Corn

| Rank | Factor | Value |
|---|---|---|
| | | bu/acre |
| 1 | Weather | 90+ |
| 2 | Fertility | 90 |
| 3 | Hybrid | 50 |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |

Given key prerequisites

Crop Physiology

# Yield Range Among Hybrids by Location & Year

| Location | 2020 | 2021 | 2022 |
|---|---|---|---|
| | | Δ bushels $acre^{-1}$ | |
| Yorkville | 57 | - | 40 |
| Champaign | 48 | 62 | 49 |
| Nashville | 70 | 61 | 60 |

Averaged over five levels of agronomic management
Average of 36 hybrids at each location in 2020 and 2021, and 20 in 2022
Yorkville site lost in 2021 to Derecho winds.

Crop Physiology

# Not All Hybrids are Not Created Equal - 2022

| Rank | Yield | Rank | Yield | Rank | Yield | Rank | Yield |
|---|---|---|---|---|---|---|---|
| | bu/acre | | bu/acre | | bu/acre | | bu/acre |
| 1 | 284 | 6 | 267 | 11 | 258 | 16 | 247 |
| 2 | 276 | 7 | 264 | 12 | 254 | 17 | 244 |
| 3 | 273 | 8 | 261 | 13 | 254 | 18 | 240 |
| 4 | 270 | 9 | 259 | 14 | 251 | 19 | 237 |
| 5 | 269 | 10 | 258 | 15 | 249 | 20 | 235 |

LSD (0.10) 5

Averaged across management levels at Champaign (Central IL)

Crop Physiology

# Not All Hybrids are Not Created Equal - 2022

| Rank | Yield | Rank | Yield | Rank | Yield | Rank | Yield |
|---|---|---|---|---|---|---|---|
| | bu/acre | | bu/acre | | bu/acre | | bu/acre |
| 1 | 284 | 6 | 267 | 11 | 258 | 16 | 247 |
| 2 | 276 | 7 | 264 | 12 | 254 | 17 | 244 |
| 3 | 273 | 8 | 261 | 13 | 254 | 18 | 240 |
| 4 | 270 | 9 | 259 | 14 | 251 | 19 | 237 |
| 5 | 269 | 10 | 258 | 15 | 249 | 20 | 235 |

LSD (0.10) 5

Averaged across management levels at Champaign (Central IL)

Crop Physiology

# Not All Hybrids are Not Created Equal - 2022

| Rank | Yield | Rank | Yield | Rank | Yield | Rank | Yield |
|---|---|---|---|---|---|---|---|
| | bu/acre | | bu/acre | | bu/acre | | bu/acre |
| 1 | 284 | 6 | 267 | 11 | 258 | 16 | 247 |
| 2 | 276 | 7 | 264 | 12 | 254 | 17 | 244 |
| 3 | 273 | 8 | 261 | 13 | 254 | 18 | 240 |
| 4 | 270 | 9 | 259 | 14 | 251 | 19 | 237 |
| 5 | 269 | 10 | 258 | 15 | 249 | 20 | 235 |

LSD (0.10) 5

Averaged across management levels at Champaign (Central IL)

Crop Physiology

# Full Season Hybrids Tend to Have Highest Yield

| Rank | Yield | Rank | Yield | Rank | Yield | Rank | Yield |
|---|---|---|---|---|---|---|---|
| | bu/acre | | bu/acre | | bu/acre | | bu/acre |
| 114 | 284 | 6 | 267 | 11 | 258 | 114 | 247 |
| 111 | 276 | 7 | 264 | 12 | 254 | 109 | 244 |
| 116 | 273 | 8 | 261 | 13 | 254 | 113 | 240 |
| 115 | 270 | 9 | 259 | 14 | 251 | 110 | 237 |
| 117 | 269 | 10 | 258 | 15 | 249 | 107 | 235 |

LSD (0.10) 5

Averaged across management levels at Champaign (Central IL)

Crop Physiology

# Highest Yearly Yields in CPL Research Trials

| Year | Grain Yield | Location | Planting |
|---|---|---|---|
| | bushels/acre | | |
| 2015 | 360 | Champaign | May 6 |
| 2016 | 327 | Yorkville | May 20 |
| 2017 | 379 | Yorkville | May 16 |
| 2018 | 322 | Champaign | April 27 |
| 2019 | 310 | Champaign | May 31 |
| 2020 | 279 | Nashville | June 8 |
| 2021 | 363 | Nashville | April 22 |
| 2022 | 310 | Champaign | May 20 |

All without irrigation and all replicated plot averages

Crop Physiology

# Highest Yearly Yields in CPL Research Trials

| Year | Grain Yield | Location | Planting | Maturity |
|---|---|---|---|---|
| | bushels/acre | | | days |
| 2015 | 360 | Champaign | May 6 | 118 |
| 2016 | 327 | Yorkville | May 20 | 110 |
| 2017 | 379 | Yorkville | May 16 | 117 |
| 2018 | 322 | Champaign | April 27 | 113 |
| 2019 | 310 | Champaign | May 31 | 115 |
| 2020 | 279 | Nashville | June 8 | 120 |
| 2021 | 363 | Nashville | April 22 | 118 |
| 2022 | 310 | Champaign | May 20 | 116 |

All without irrigation and all replicated plot averages

Crop Physiology

# Test Your Knowledge of High Yield Corn

- **What is the next major innovation in corn hybrid technology?**

Crop Physiology

# What is SMART Corn?

- **Shorter statured corn that has a number of environmental, management, and physiological, advantages compared to conventional tall corn**

Crop Physiology

# What is SMART Corn?

- Shorter statured corn that has a number of environmental, management, and physiological, advantages compared to conventional tall corn

Crop Physiology

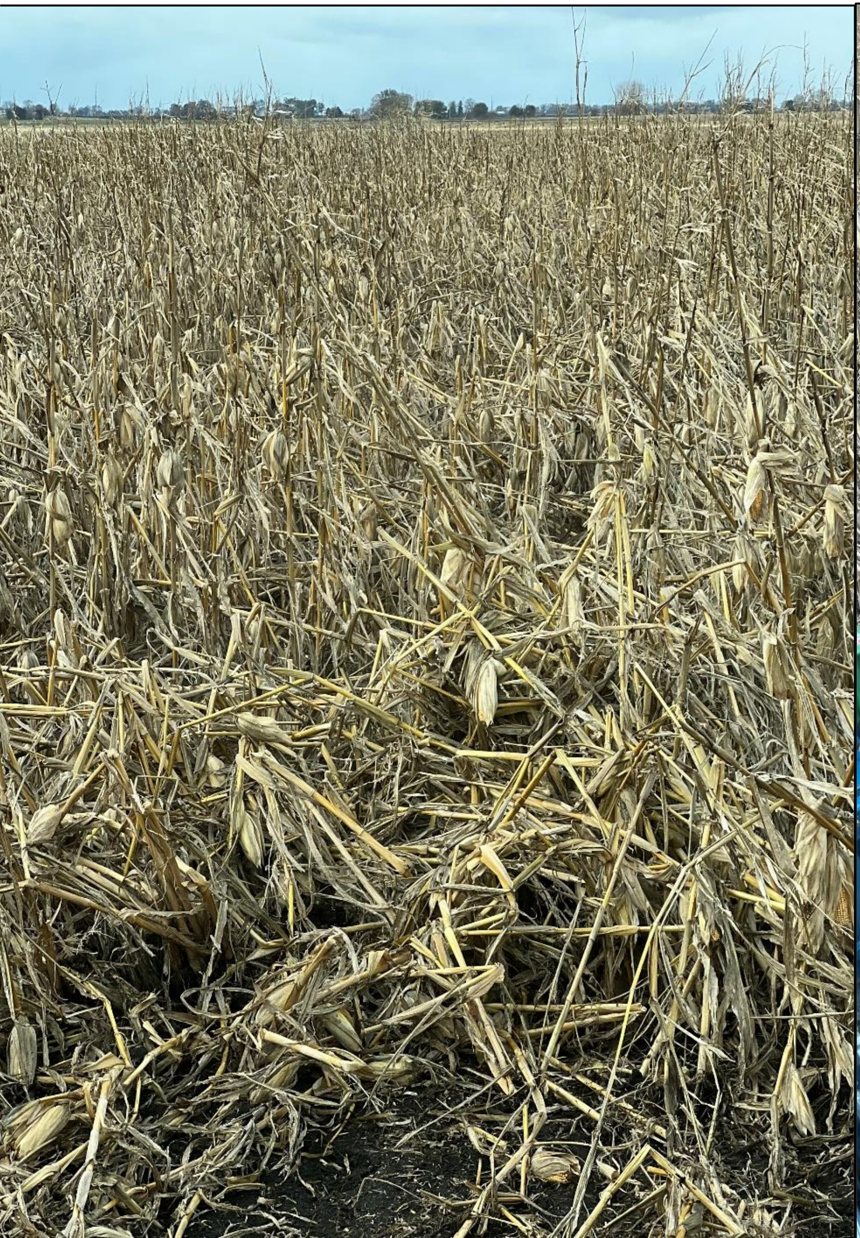
# Negative Weather Events can Seriously Decrease Yield Potential

Crop Physiology

# Is Short Corn the Solution To Wind Damage?


# Tall vs Short Corn Wind Damage at Yorkville 2021

# Wind Damage at Yorkville Hindered Harvest



# Short Corn Easily Harvestable at Yorkville

# What is SMART Corn?

- Shorter statured corn that has a number of environmental, management, and physiological, advantages compared to conventional tall corn

Crop Physiology

# Short Corn Allows for In-Season Applications

# What is SMART Corn?

- Shorter statured corn that has a number of environmental, management, and physiological, advantages compared to conventional tall corn

Crop Physiology

# Test Your Knowledge of High Yield Corn

- How is the growth and physiology of short corn different than tall corn?

Crop Physiology

# Difference in Mid Vegetative Height



V11 Growth Stage, 42,000 plants/acre 200 lbs N/acre
Champaign, IL June 18th, 2018

Crop Physiology

# Change in Partitioning of Dry Weight in Favor of Leaves and Developing Ears


| Hybrid Stature | Plant Part Weight at Flowering | | | |
|---|---|---|---|---|
| | Stalk | Leaves | Repro | Total |
| | —— grams/plant (% of total) —— | | | |
| Tall | 46 (36) | 53 (41) | 29 (23) | 128 |
| Short | 30 (26) | 51 (44) | 35 (30) | 116 |

**Reproductive Parts Include Tassel and Ear Shoots**

Averaged Across Planting Density, 3 Nitrogen Rates, 4 Hybrids, and two years

Crop Physiology

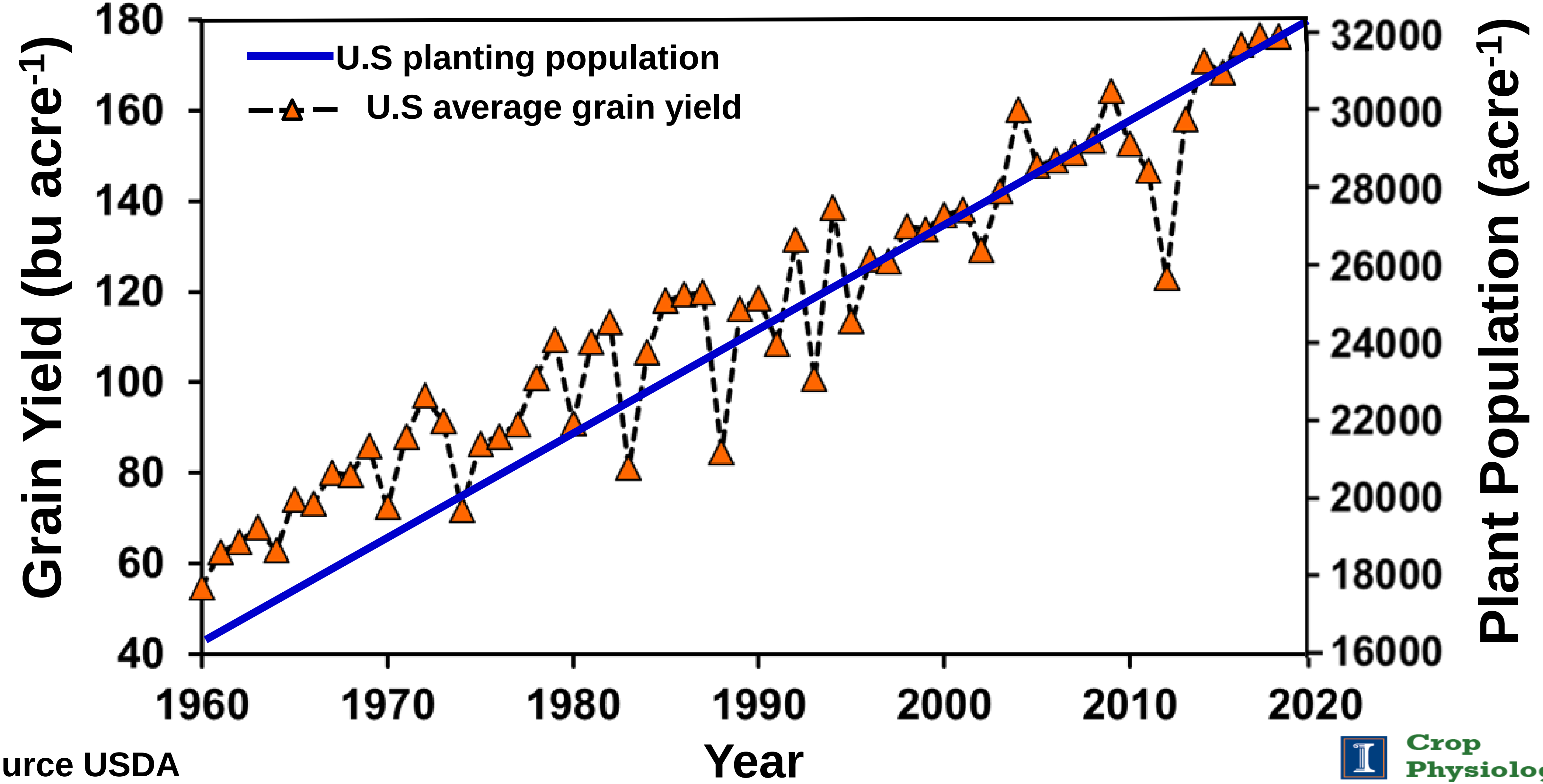
# Seven Wonders of the 300 Bushel Corn

| Rank | Factor | Value |
|---|---|---|
| | | bu/acre |
| 1 | Weather | 90+ |
| 2 | Fertility | 90 |
| 3 | Hybrid | 50 |
| 4 | Plant Population | 25 |
| 5 | | |
| 6 | | |
| 7 | | |

Given key prerequisites

Crop Physiology

# How Have Corn Yields Increased?




Source USDA

Crop Physiology

# Corn Yield is a Product Function of Yield Components

**Yield = (plants/acre) x**

**(kernels/plant) x**

**(weight/kernel)**

Crop Physiology

# Corn Yield is a Product Function of Yield Components

Plants/acre

Kernels/plant

Weight/kernel

Crop Physiology

# Which Yield Component Do Growers Have the Most Control Over?

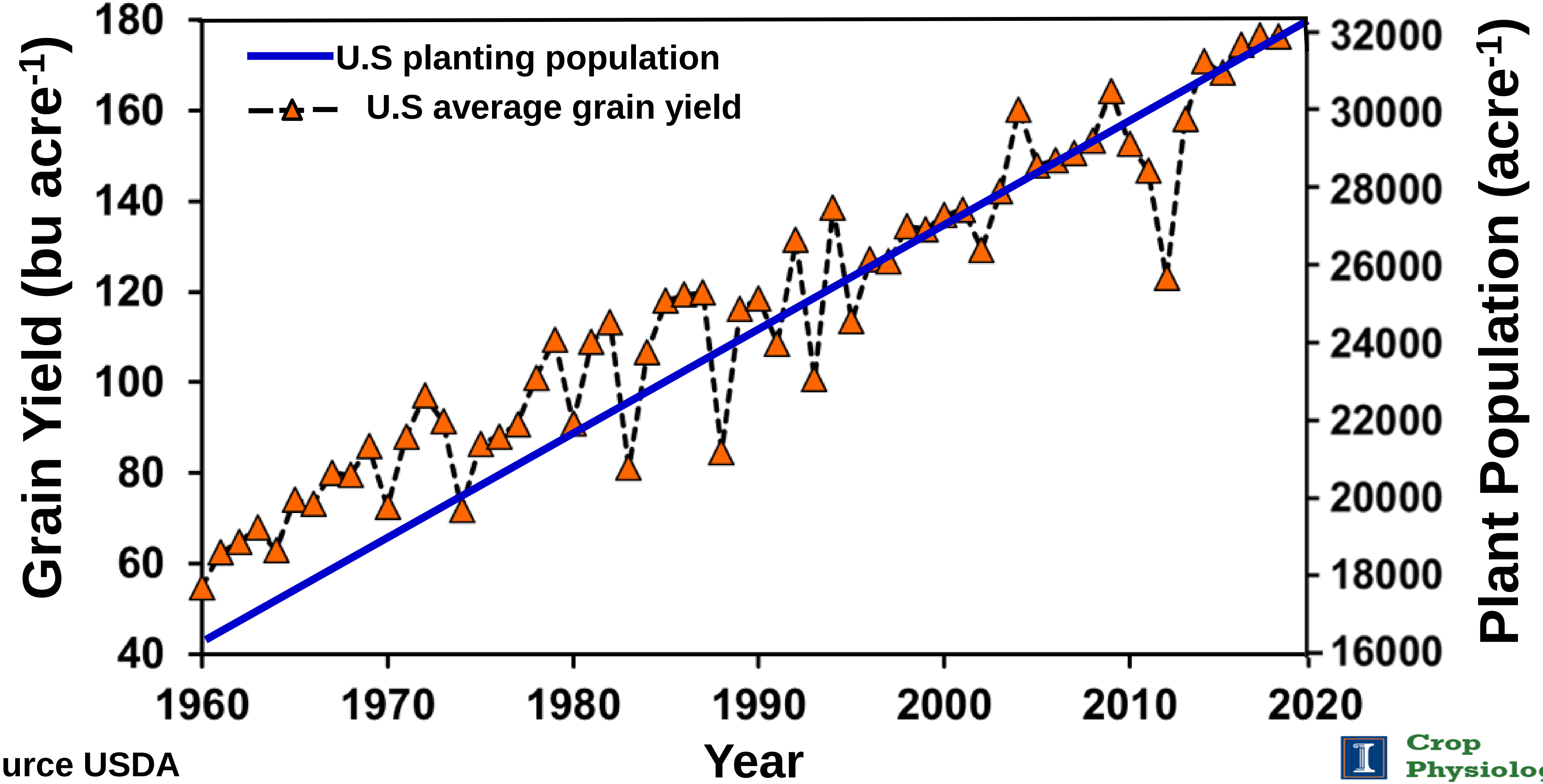
Plants/acre

Kernels/plant

Weight/kernel

Crop Physiology

# Population Increases 400 Plants per Acre per Year




Source USDA

Crop Physiology

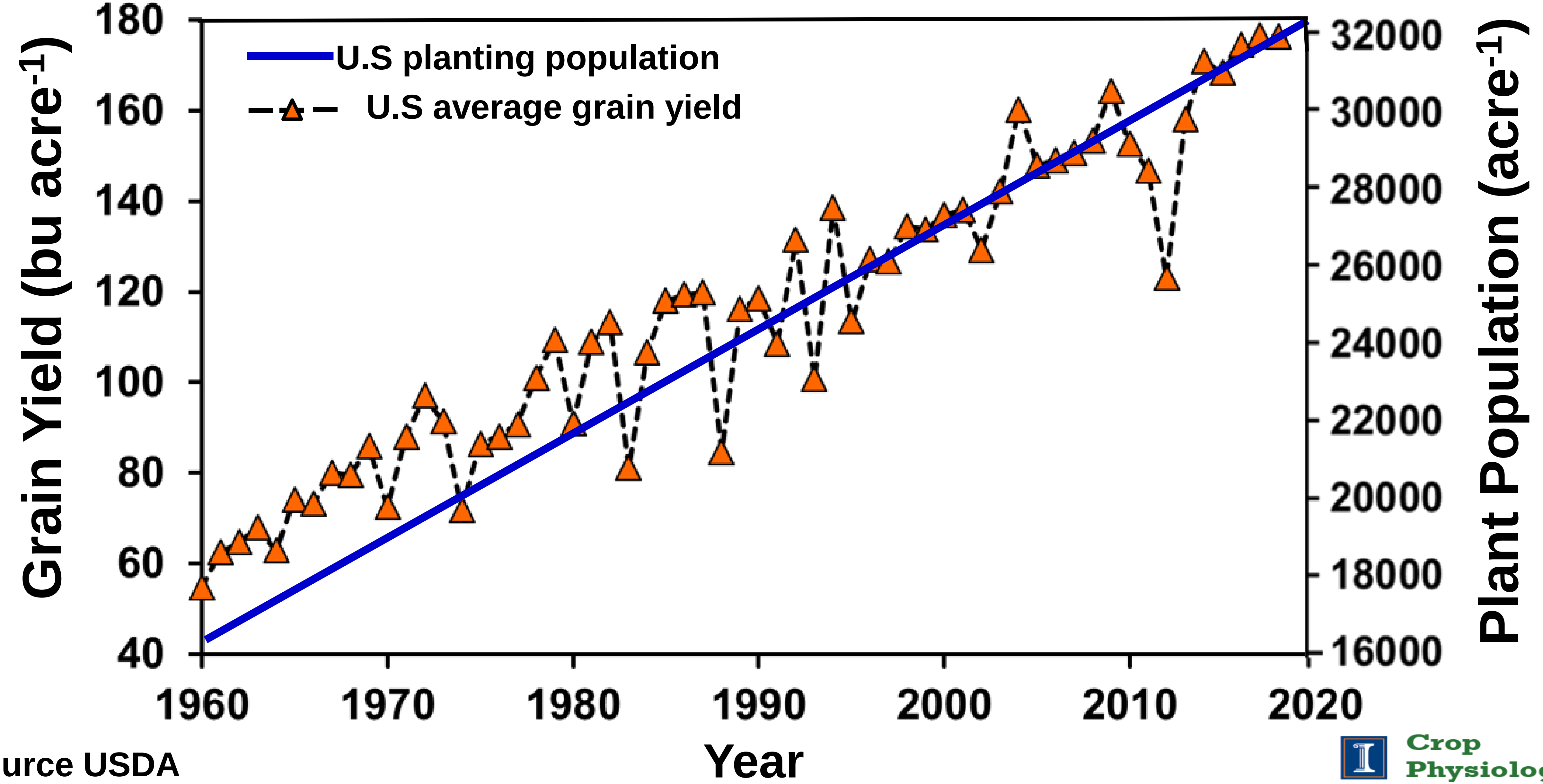
# Test Your Knowledge of High Yield Corn

- What is the maximum population that corn plants can tolerate in a 30 inch row spacing?

38,000 plants per acre

Crop Physiology

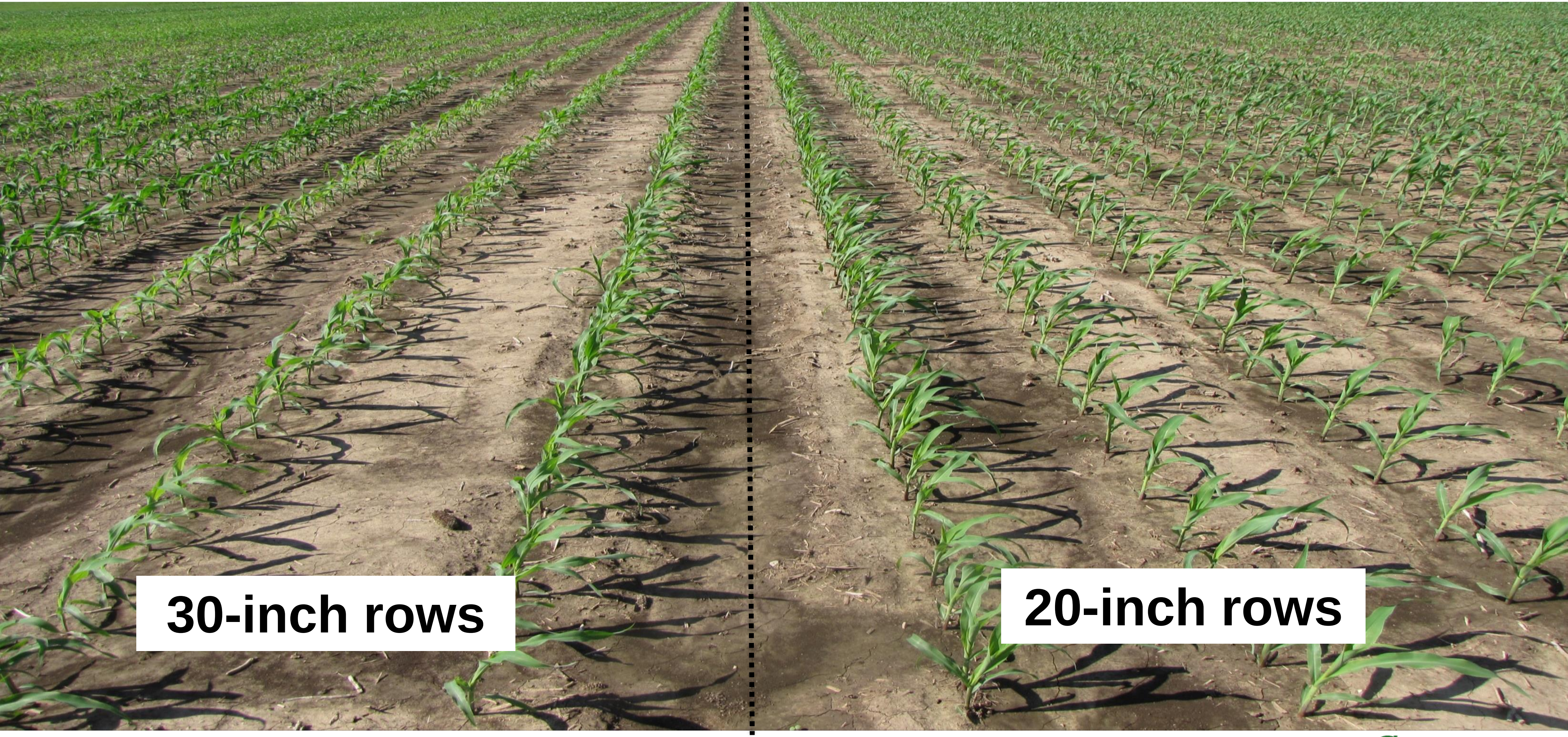
# Population Increases 400 Plants per Acre per Year




Source USDA

Crop Physiology

# Is the Future of Corn Higher Populations in Narrow Rows?




Both at 44,000 plants/acre

Crop Physiology

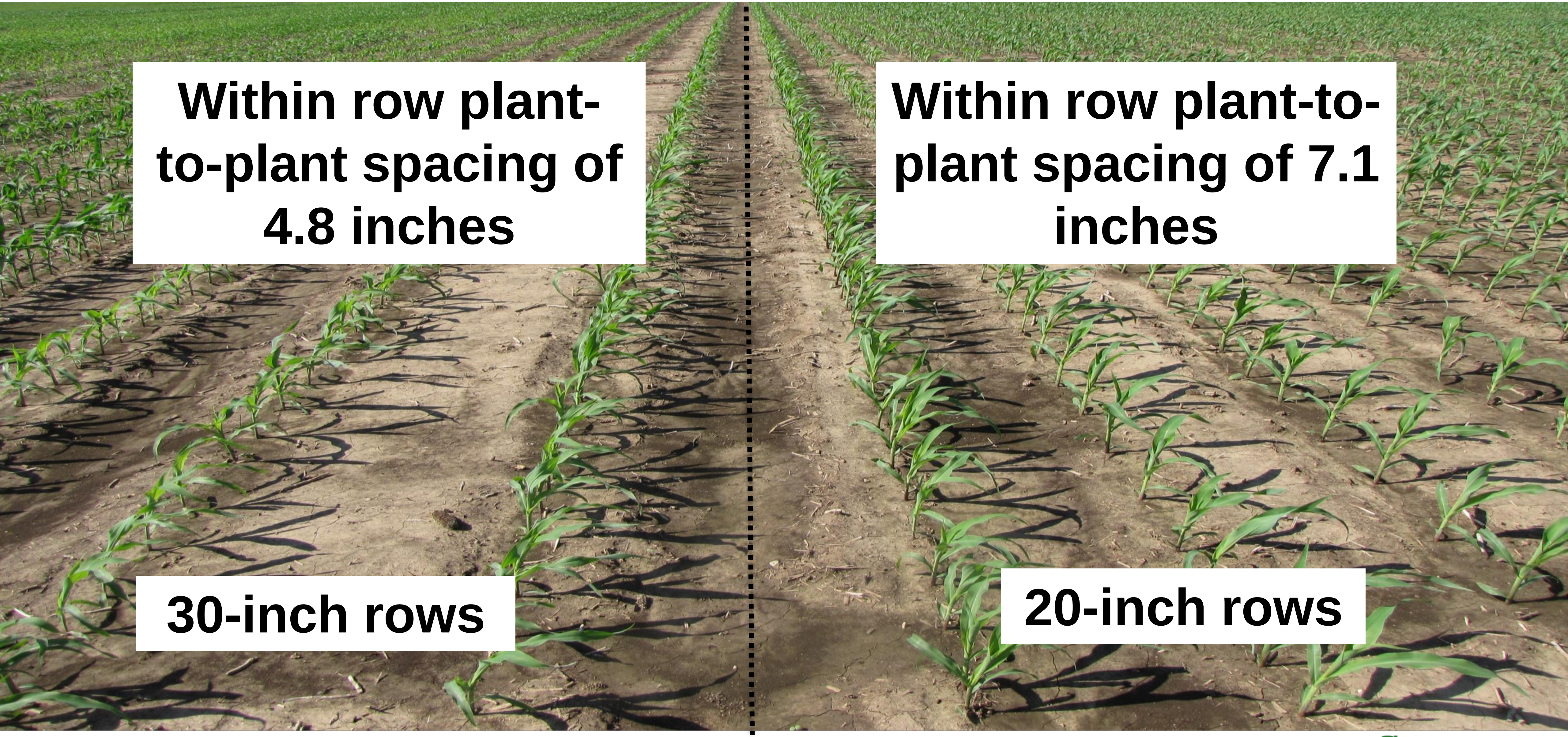
# Narrow Row Spacing Intercepts More Light



**Both at 44,000 plants/acre**

Crop Physiology

# Narrow Rows Can Support Higher Plant Populations




Both at 44,000 plants/acre

Crop Physiology

# Response to 20 Inch Rows by Location & Year

| Location | 2020 | 2021 | 2022 |
|---|---|---|---|
| | | Δ bushels acre$^{-1}$ | |
| Yorkville | -7 | - | 16 |
| Champaign | 3 | 23 | 15 |
| Nashville | 36 | 9 | 7 |

**Compared to the same plant population and management in 30 inch rows**
**Average of 36 hybrids at each location in 2020 and 2021, and 20 in 2022**
**Yorkville site lost in 2021 to Derecho winds.**

Crop Physiology

# Highest Yearly Yields in CPL Research Trials

| Year | Grain Yield | Location | Planting | Maturity |
|---|---|---|---|---|
| | bushels/acre | | | days |
| 2015 | 360 | Champaign | May 6 | 118 |
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| 2020 | 279 | Nashville | June 8 | 120 |
| 2021 | 363 | Nashville | April 22 | 118 |
| 2022 | 310 | Champaign | May 20 | 116 |

All without irrigation and all replicated plot averages

Crop Physiology

# Highest Yearly Yields Are Always in Narrow Rows

| Year | Grain Yield | Location | Planting | Maturity |
|---|---|---|---|---|
| | bushels/acre | | | days |
| 2015 | 360 | Champaign | May 6 | 118 |
| 2016 | 327 | Yorkville | May 20 | 110 |
| 2017 | 379 | Yorkville | May 16 | 117 |
| 2018 | 322 | Champaign | April 27 | 113 |
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All without irrigation and all replicated plot averages

Crop Physiology

# Seven Wonders of the 300 Bushel Corn

| Rank | Factor | Value<br>bu/acre |
| --- | --- | --- |
| 1 | Weather | 90+ |
| 2 | Fertility | 90 |
| 3 | Hybrid | 50 |
| 4 | Plant Population | 25 |
| 5 | Crop Rotation | 20 |
| 6 | | |
| 7 | | |

Given key prerequisites

Crop Physiology

# Seven Wonders of the 300 Bushel Corn

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| 1 | Weather | 90+ |
| 2 | Fertility | 90 |
| 3 | Hybrid | 50 |
| 4 | Plant Population | 25 |
| 5 | Crop Rotation | 20 |
| 6 | Tillage/No-Tillage | 15 |
| 7 | | |

Given key prerequisites

Crop Physiology

# Tillage or No-Tillage Affects the Residue

Crop Physiology

# Seven Wonders of the 300 Bushel Corn

| Rank | Factor | Value<br>bu/acre |
| --- | --- | --- |
| 1 | Weather | 90+ |
| 2 | Fertility | 90 |
| 3 | Hybrid | 50 |
| 4 | Plant Population | 25 |
| 5 | Crop Rotation | 20 |
| 6 | Tillage/No-Tillage | 15 |
| 7 | Biologicals | 10 |

Given key prerequisites

Crop Physiology

# Potential Value of Biologicals?

- **Relieve plant stress**
- **Improve nutrient availability or use**
- **Large versatility for use and possibility for multiple product applications**

Crop Physiology

# Versatile Ways to Use Biologicals

- Seed Treatments
- In-Furrow (with starter fertilizer)
- Foliar - Vegetative Stages (with post herbicide)
- Foliar – Reproductive Stages (with fungicide/insecticide application)
- On dry fertilizers
- On crop residues

# Seven Wonders of the 300 Bushel Corn

| Rank | Factor | Value bu/acre |
|---|---|---|
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| 3 | Hybrid | 50 |
| 4 | Plant Population | 25 |
| 5 | Crop Rotation | 20 |
| 6 | Tillage/No-Tillage | 15 |
| 7 | Biologicals | 10 |
| | TOTAL | 300 bu |

Given key prerequisites

Crop Physiology

# To Produce 300 Bushel Corn Yields?

- **Must have the prerequisites, soil structure, drainage, season long weed control & foliar protection**
- **Optimize each of the seven wonders, and their positive interactions**

# Getting to the Root of High Yield

Samuel Leskanich

Crop Physiology Laboratory
Department of Crop Sciences
University of Illinois at Urbana-Champaign

Crop Physiology

# Above-Ground Plant Architecture Hasn’t Always Worked in Determining Yield Potential

**Bigger Hybrids ≠ Bigger Yields**

**Next Step is to Start Looking Dr. Below-Ground**

Crop Physiology

# Do You Pay for Roots in Yield?

Crop Physiology

# Root Digging/ Washing

Crop Physiology


Crop
Physiology


Crop
Physiology

# Corn Root Observation Platform (CROP)

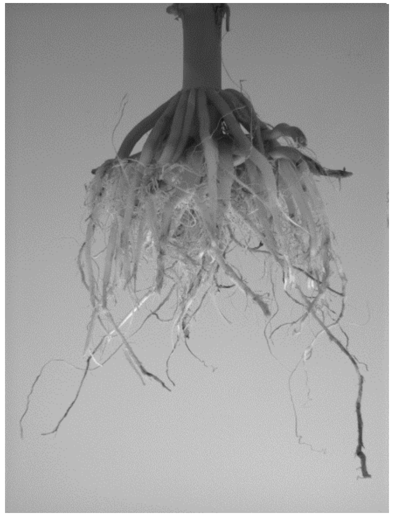
Crop Physiology

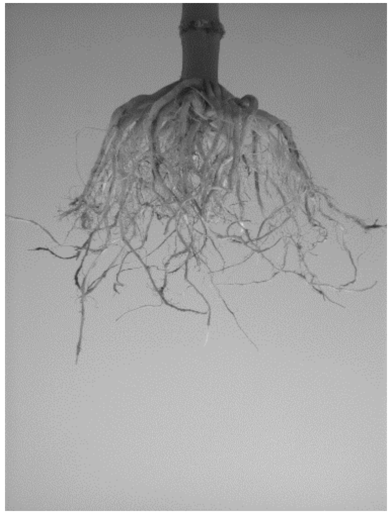
# Managements that Modify Roots

- **Hybrid**
- Population
- Fertility
- Fungicide
- Biologicals

Crop Physiology

# Not All Hybrids are Created Equal


12U17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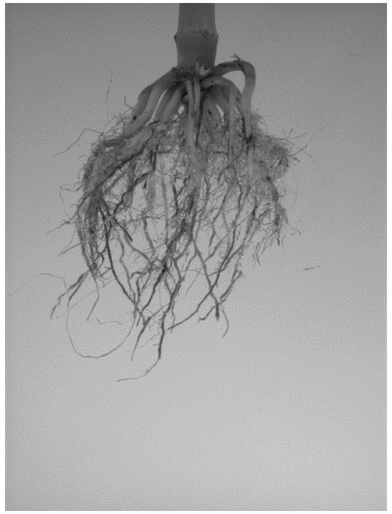

10L16


13Z50


10D21


11A33

## Small Rooted Hybrids

## Large Rooted Hybrids

## Racehorse
## “Offensive”

## Workhorse
## “Defensive”

Crop Physiology

# Racehorse
## "Offensive"

**Top-End Yield Potential…**

**But Crashes Under Stress**

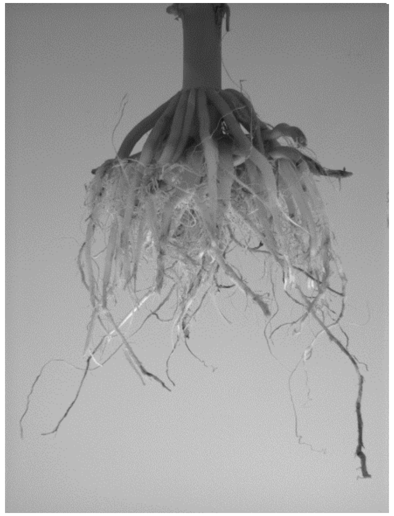
# Workhorse
## "Defensive"

**Handles Stress Really Well…**

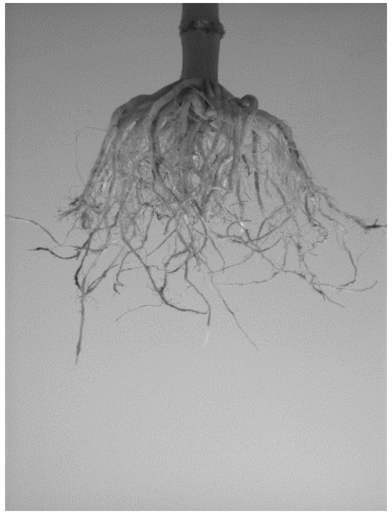
**But Might Have a Capped Top-End Yield**

Crop Physiology

# Not All Hybrids are Created Equal



12U17



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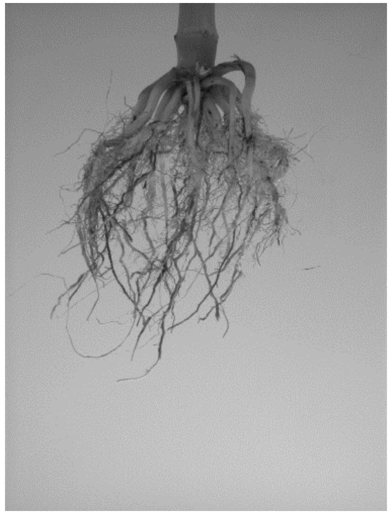

10L16

13Z50

10D21

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## Small Rooted Hybrids

## Large Rooted Hybrids

## Racehorse
## “Offensive”

## Workhorse
## “Defensive”

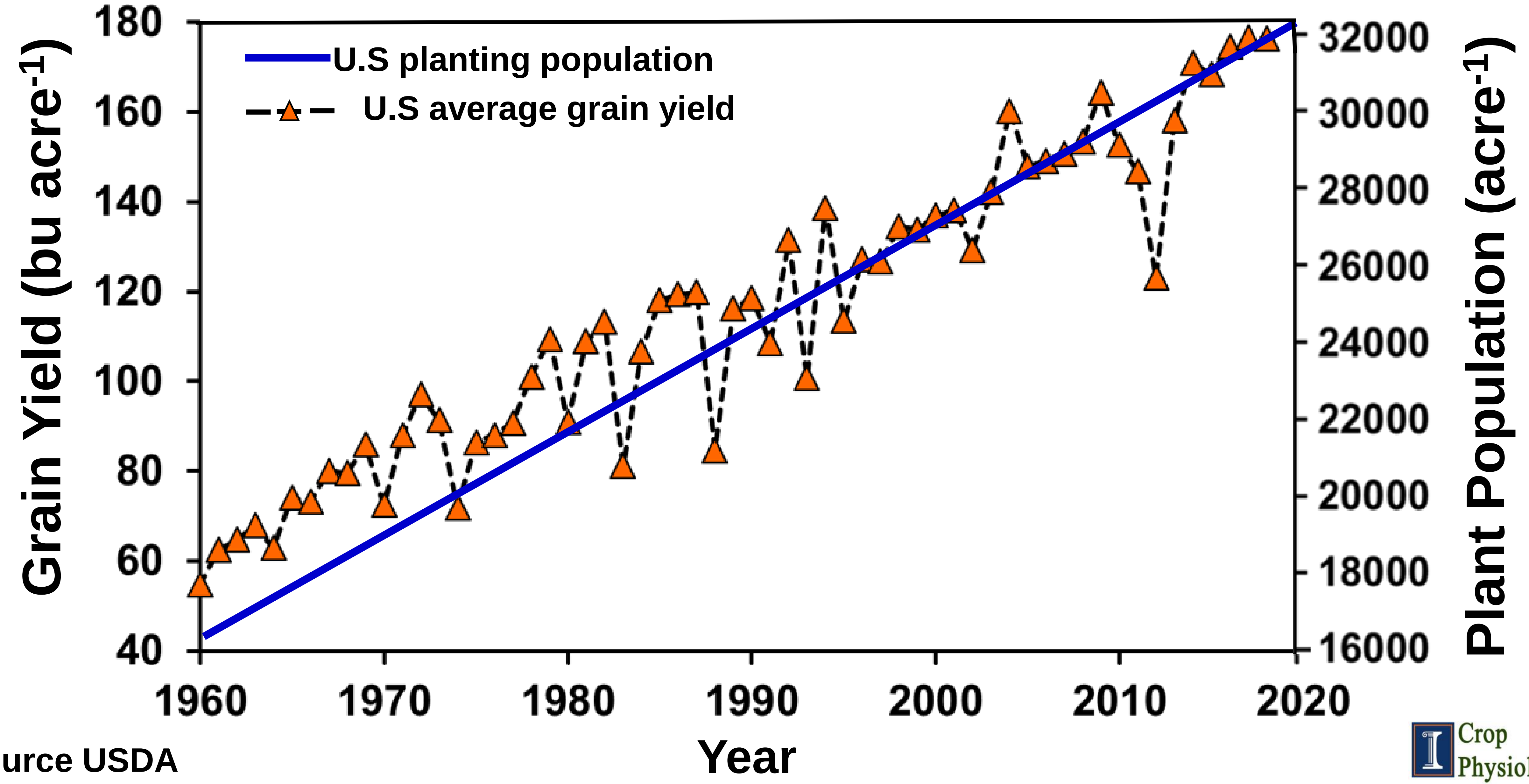
Crop Physiology

# Managements that Modify Roots

- **Hybrid**
- **Population**
- Fertility
- Fungicide
- Biologicals

Crop Physiology

# Trends in Corn Yield and Plant Population




Source USDA

Crop Physiology

# 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**

Crop Physiology

# Increasing Plant Population = Smaller Roots

**30,000 plants/acre** | **36,000 plants/acre** | **42,000 plants/acre**

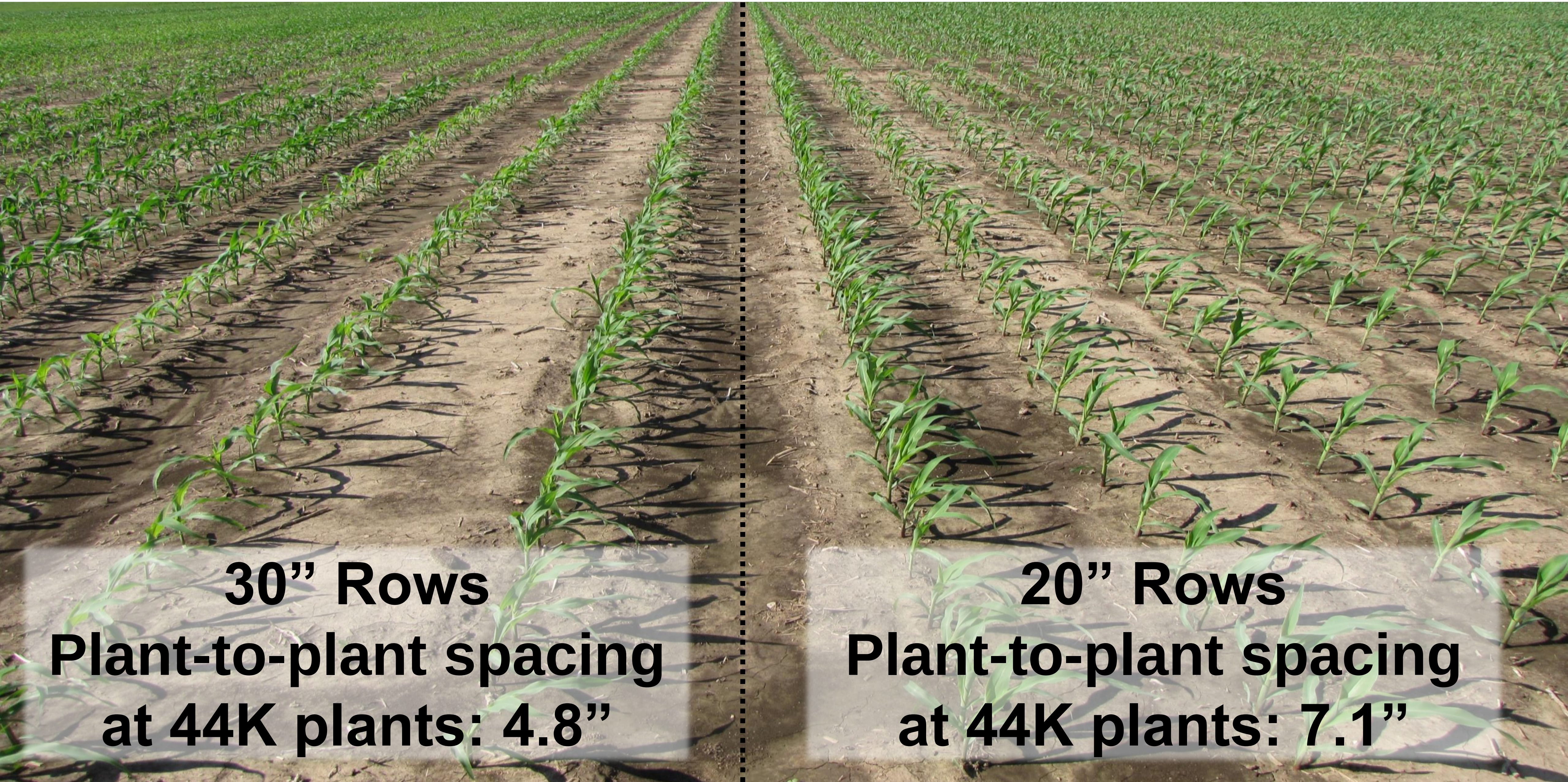


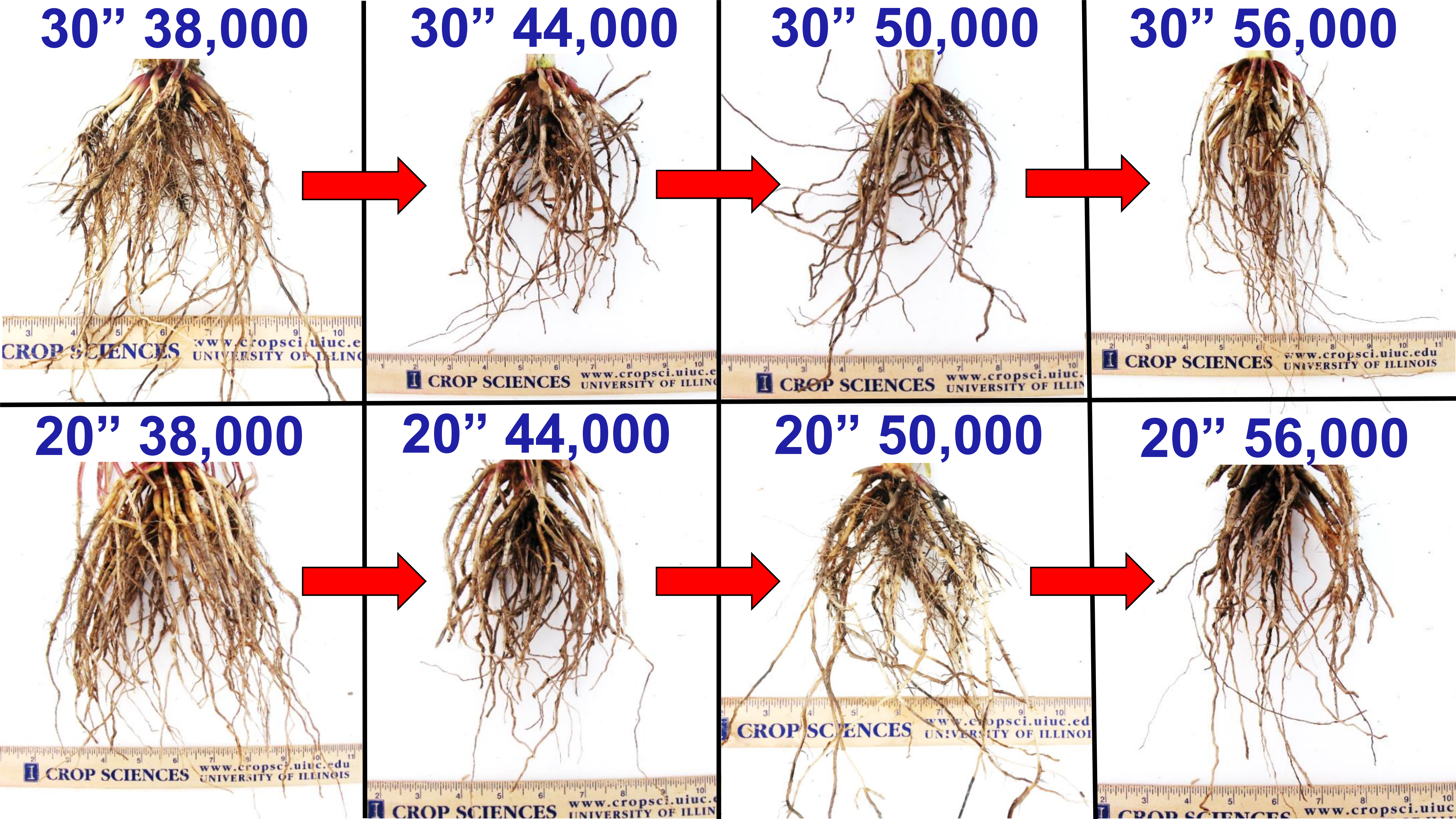

**2.5% decrease in root mass per 1,000 plant increase in population**

All pictures shown are G13Z50

Crop Physiology

# How Can We Alleviate Population Stress?




30” 38,000
30” 44,000
30” 50,000
30” 56,000
20” 38,000
20” 44,000
20” 50,000
20” 56,000
CROP SCIENCES
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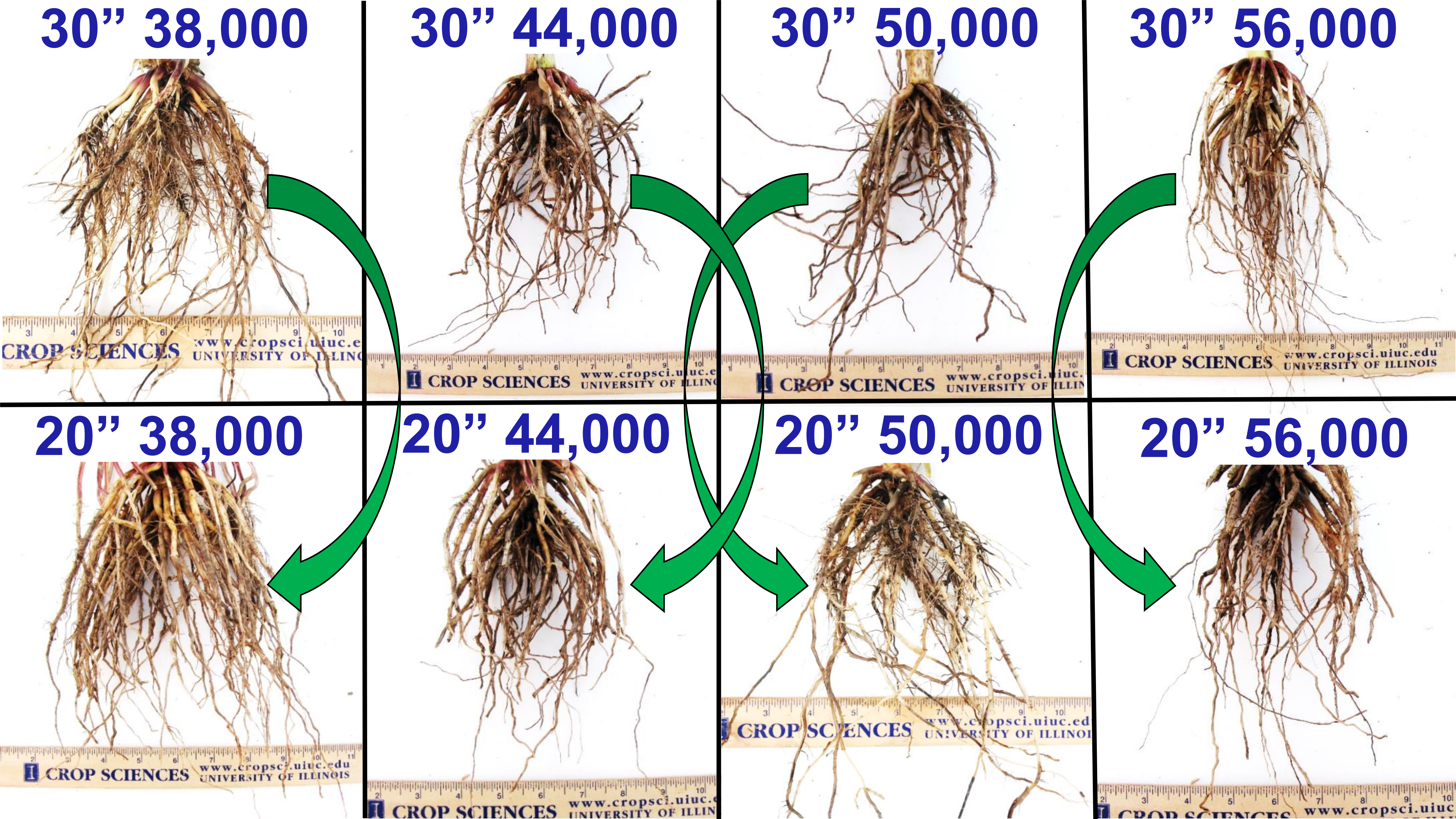
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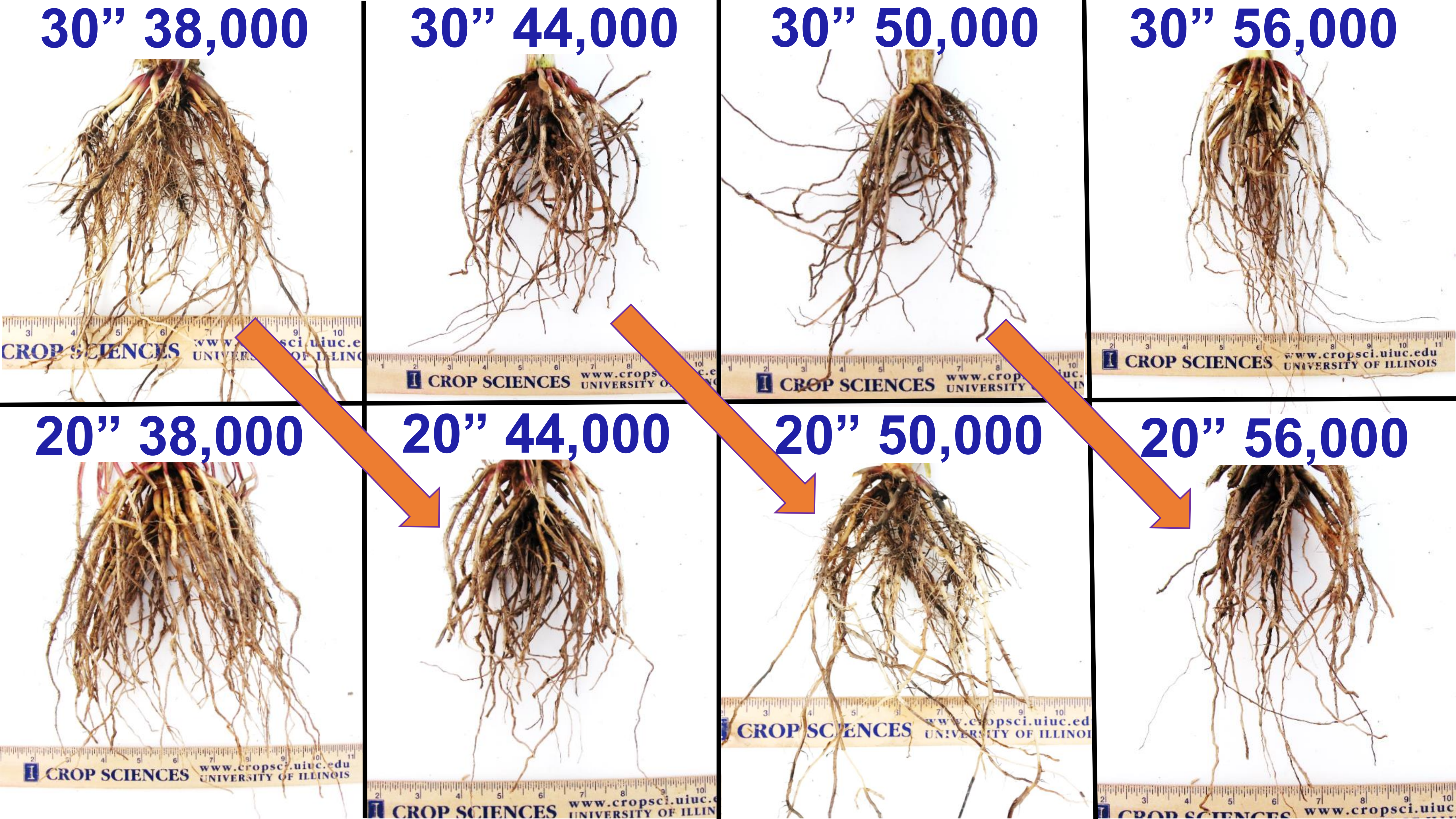
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CROP SCIENCES
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# Row Spacing & Plant Population on Individual Plant Root Dry Weight

| Row Spacing | Plant Population (plants/acre) | | | |
|---|---|---|---|---|
| | 38,000 | 44,000 | 50,000 | 56,000 |
| | grams/root | | | |
| 30” | 12.2 → | 10.2 → | 8.6 → | 6.8 |
| 20” | 14.6 → | 12.5 → | 10.3 → | 8.6 |

LSD (0.05) Spacing x Planting Density = 0.6
Averaged across six hybrids, two locations and two years
Agronomy Journal 112:2456-2465 (2020)

Crop Physiology

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Crop Physiology

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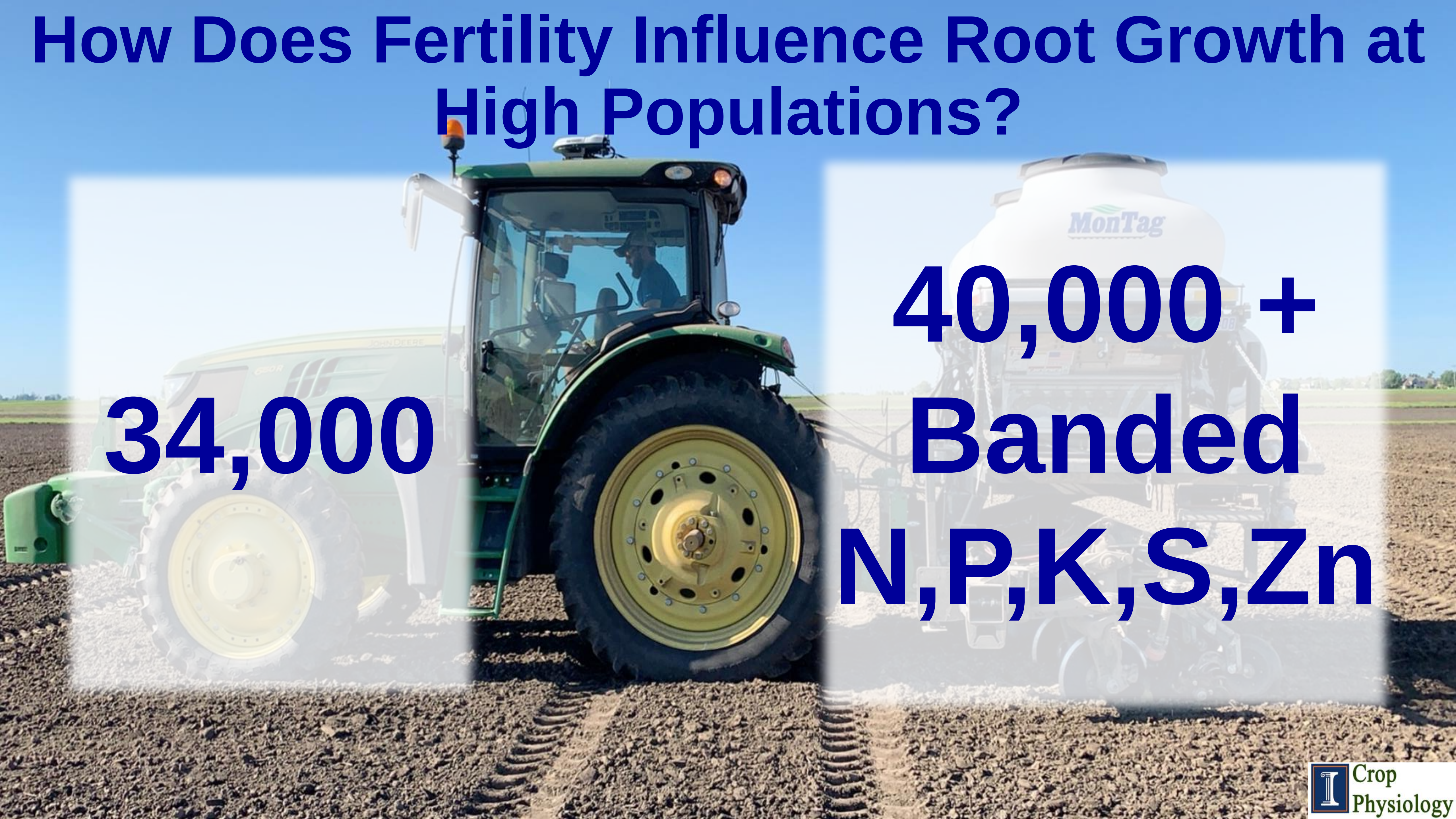
Agronomy Journal 112:2456-2465 (2020)

Crop Physiology

# Managements that Modify Roots

- Hybrid
- Population
- Fertility
- Fungicide
- Biologicals

Crop Physiology


How Does Fertility Influence Root Growth at High Populations?
34,000
40,000 +
Banded
N,P,K,S,Zn
MonTag
Crop Physiology

# How Does Fertility Influence Root Growth at High Populations?

**Small Rooted "Offensive"**

**Large Rooted "Defensive"**

Crop Physiology

# G10L16 (Offensive)

## 34,000 plants/acre


## 40,000 plants/acre + Banded Fertility


Crop Physiology

# G13Z50 (Defensive)

**34,000 plants/acre**


**40,000 plants/acre + Banded Fertility**


Crop Physiology

# Effect of Hybrid and Management on Grain Yield Averaged over 2021 & 2022

| Hybrid | 34,000 | | 40,000 + Banded Fertility | |
|---|---|---|---|---|
| | bu/acre | | | |
| Defensive | 220[d] | +23 | 243[b] | |
| | +9 | | | +18 |
| Offensive | 229[c] | +32 | 261[a] | |
| Average | 225 B | +27 | 252 A | |

Banded Fertility (lbs/acre) = 84 N, 80 $P_2O_5$, 60 $K_2O$, 20 S, 2 Zn

Crop Physiology

Effect of Hybrid and Management on Grain Yield Averaged over 2021 & 2022

40,000 + Banded

# “You Pay for Roots in Yield”

| | | | |
|---|---|---|---|
| Average | 225 B | +27 | 252 A |

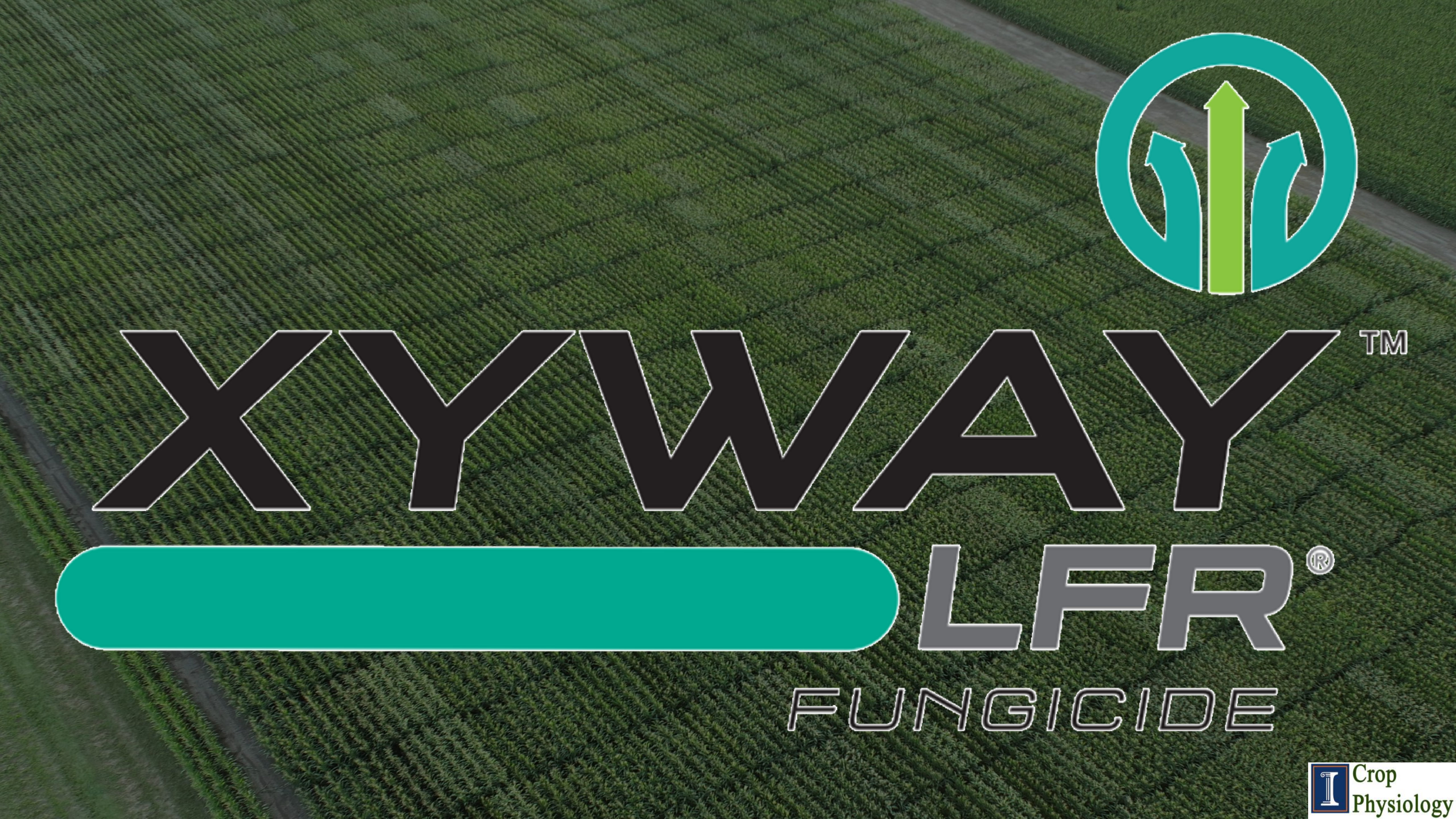
Banded Fertility (lbs/acre) = 84 N, 80 $P_2O_5$, 60 $K_2O$, 20 S, 2 Zn

Crop Physiology

# Managements that Modify Roots

- Hybrid
- Population
- Fertility
- Fungicide
- Biologicals

Crop Physiology


XYWAY™
LFR®
FUNGICIDE
Crop Physiology

# 2022 Xyway Effect on Offensive Hybrid

## No Xyway


## Xyway 2x0


## Xyway In-Furrow


G10L16

Crop Physiology

# 2022 Xyway Effect on Defensive Hybrid

## No Xyway


## Xyway 2x0

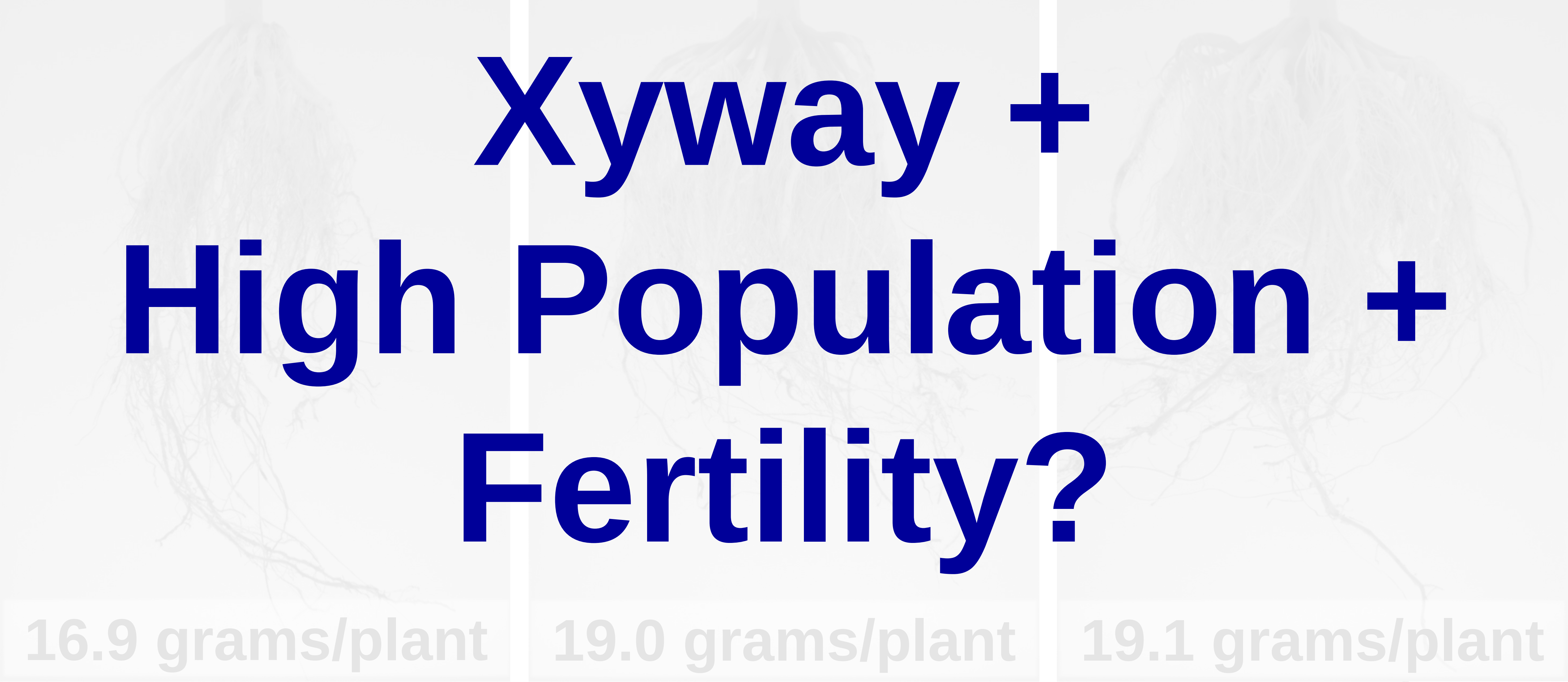

## Xyway In-Furrow


G13Z50

Crop Physiology

# 2022 Xyway Effect on Defensive Hybrid

No Xyway | Xyway 2x0 | Xyway In-Furrow



# Xyway +
# High Population +
# Fertility?

16.9 grams/plant | 19.0 grams/plant | 19.1 grams/plant

G13Z50

# Corn Root Observation Platform (CROP)

Crop Physiology

# 2022 Treatment Effect on Relative Root Area

| | Xyway Placement | | |
|---|---|---|---|
| Management | None | 2x0 | In-Furrow |
| | cm²/root | | |
| 34,000 plants/acre | 130[c] | 145[b] ↑ | 162[a] ↑ |
| 40,000 plants/acre + Banded Fertility | 155[ab] | 163[a] | 161[a] |

Banded Fertility (lbs/acre) = 84 N, 80 $P_2O_5$, 60 $K_2O$, 20 S, 2 Zn

Crop Physiology

# Managements that Modify Roots

- Hybrid
- Population
- Fertility
- Fungicide
- Biologicals

# N-Fixing Bacteria


Crop Physiology

# Root Biomass – 2 Site-Years in 2021-2022

| | Planting Population | | |
|---|---|---|---|
| Treatment | 30,000 | 36,000 | 42,000 |
| | grams/root | | |
| None | 19.4 | 15.7 | 14.0 |
| Proven 40 | 18.9 | 16.8 ↑ | 16.0* ↑ |
| GRAP NOD AL | 19.2 | 17.1 ↑ | 13.6 |

Champaign, IL 2021 & 2022
* Denotes statistically significant response to N-fixing bacteria compared to UTC within the same planting density.
LSD (0.10) Planting Density x In-Furrow Treatment = 1.6

Crop Physiology

# Arbuscular Mycorrhizal Fungi (AMF)

Crop Physiology

# Influence of 10-34-0 and *MycoApply* on Grain Yield of Corn Grown at Champaign, IL in 2021

| In-Furrow Treatment | Grain Yield | |
| --- | --- | --- |
| | bushels/acre | |
| UTC | 270 | |
| 10-34-0 | 277 | +7 |
| 10-34-0 + *MycoApply* | 283 | +13 |
| LSD (0.10) | 12 | |

All plots received 180 lbs N/acre as UAN pre-plant broadcast; 10-34-0 applied in-furrow at planting at 5 gal/acre

Crop Physiology

# Take Home Message

**Simple Management Practices to Increase Yield Have Substantial Effects on Rooting Characteristics**

**Take These Changes into Account When Making Production Decisions**

Crop Physiology

# Managements that Modify Roots

- Hybrid
- Population
- Fertility
- Fungicide
- Biologicals

Crop Physiology

# Take Home Message

**If you manage your crop properly, then you can benefit from your roots without paying for them in yield.**

Crop Physiology

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- Stoller
- syngenta

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- GROWMARK FS
- Illinois Soybean Association
- Stone Seed

# Feed The Plant Not the Soil for High Yield

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**Crop Physiology Laboratory**
**Department of Crop Sciences**
**University of Illinois, Urbana-Champaign**

Crop Physiology

# Presentation Outline

- Current fertilization guidelines for Illinois and potential problems.
- CPL approach to P and K fertilization.
- Importance of fertilizer placement, timing, and source.
- The rate of phosphorus uptake for corn and soybean.

Crop Physiology

# Fertilizer Recommendation Philosophies

**Sufficiency Level of Available Nutrient** – fertilize the crop according to a calibrated soil test and the response expected. No fertilizer application at or above critical soil test value.

**Build-Up and Maintenance** – fertilize the soil according to a calibrated soil test to raise nutrient availability up to a critical soil test value then adjust the rate to maintain soil test values above the critical level (crop removal or no fertilizer).

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Crop Physiology

# 2009 Illinois Agronomy Handbook

- **Based on the Build-Up and Maintenance philosophy.**

## Phosphorus

**Build-Up + Maintenance → < 22 ppm**
**Maintenance → 22 – 32 ppm**
**Don't Fertilize → > 32 ppm**

## Potassium

**Build-Up + Maintenance → < 150 ppm**
**Maintenance → 150 – 200 ppm**
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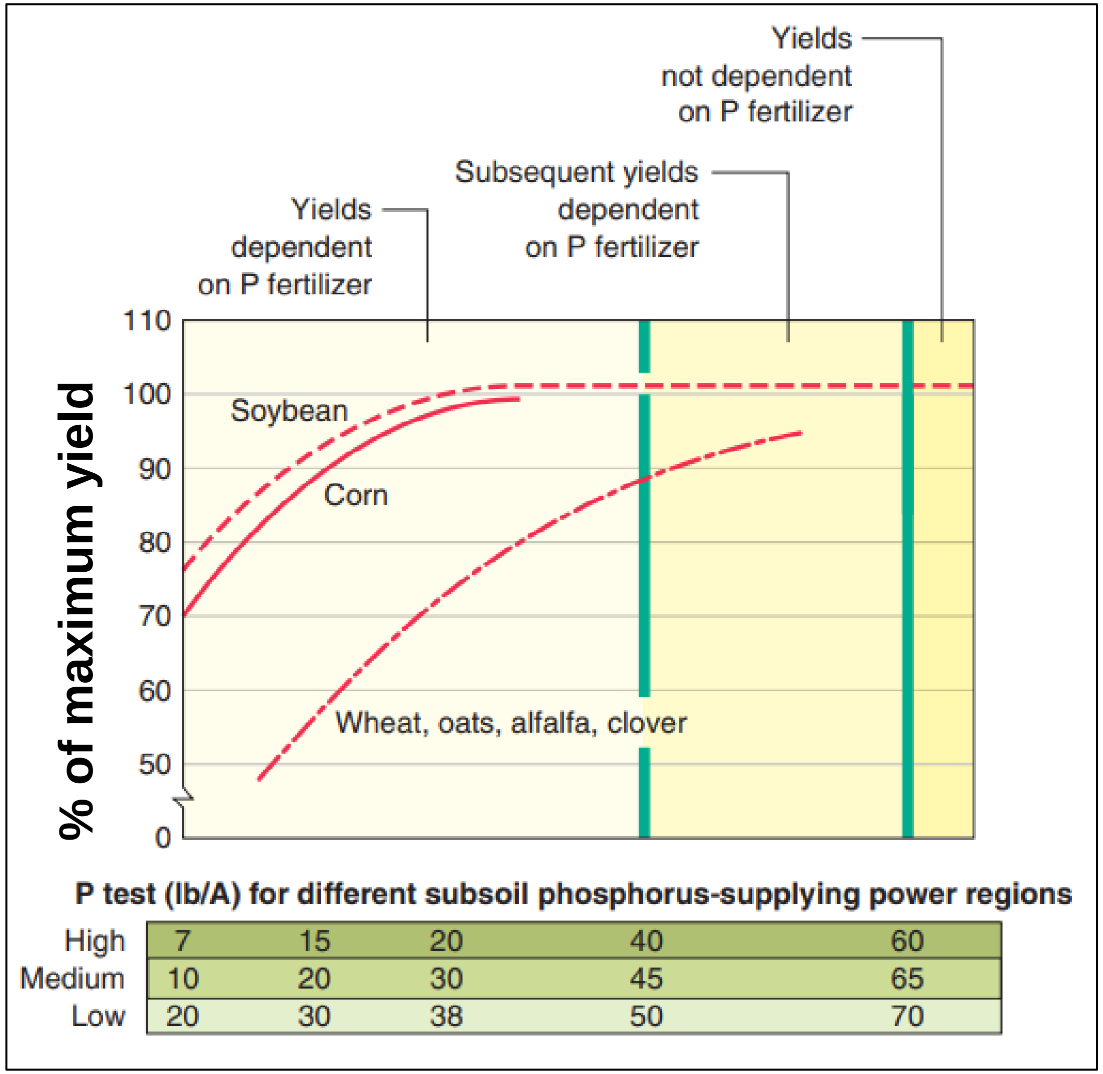


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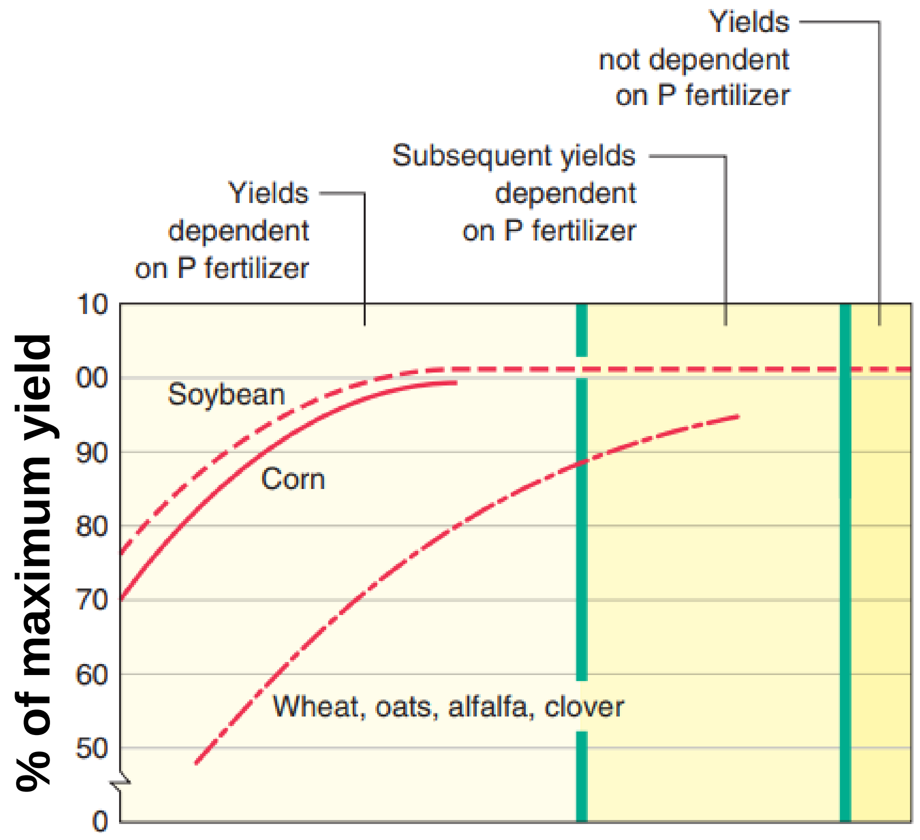
# Are current soil test correlation/calibration for Illinois outdated?

- P and K recommendation values are based on work conducted during the 1960's, relying on historical 'book values' of uncertain origin as their foundation.

**<u>"a different era of agricultural production in Illinois"</u>**




**P test (lb/A) for different subsoil phosphorus-supplying power regions**

| | | | | | |
|---|---|---|---|---|---|
| High | 7 | 15 | 20 | 40 | 60 |
| Medium | 10 | 20 | 30 | 45 | 65 |
| Low | 20 | 30 | 38 | 50 | 70 |

Crop Physiology

# Are current soil test correlation/calibration for Illinois outdated?

- P and K
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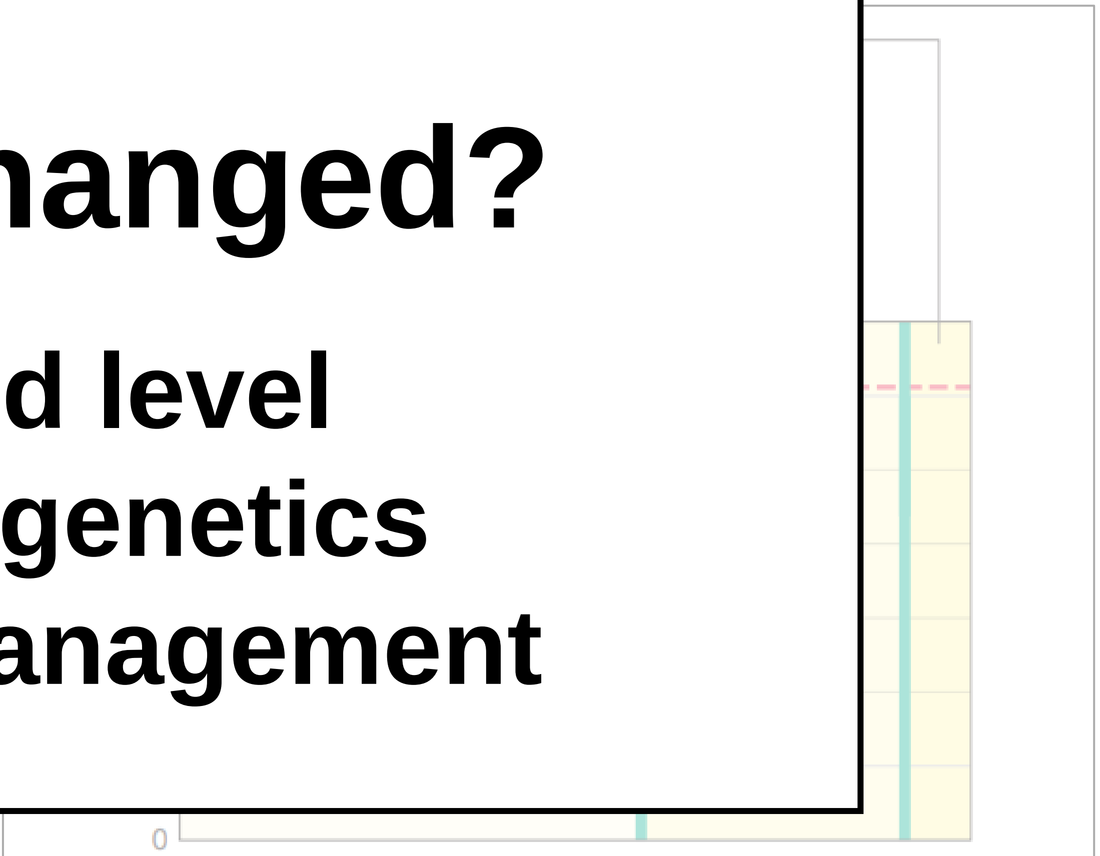
## What changed?

- Yield level
- Crop genetics
- Crop management

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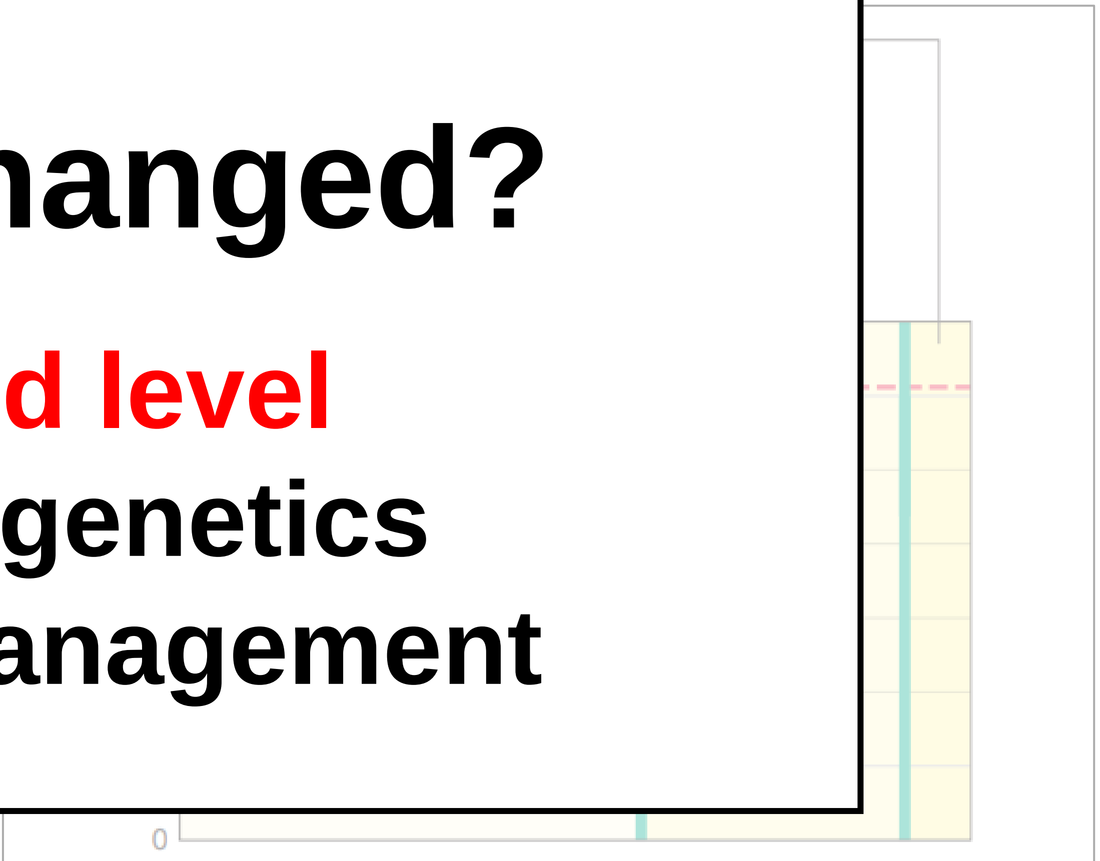


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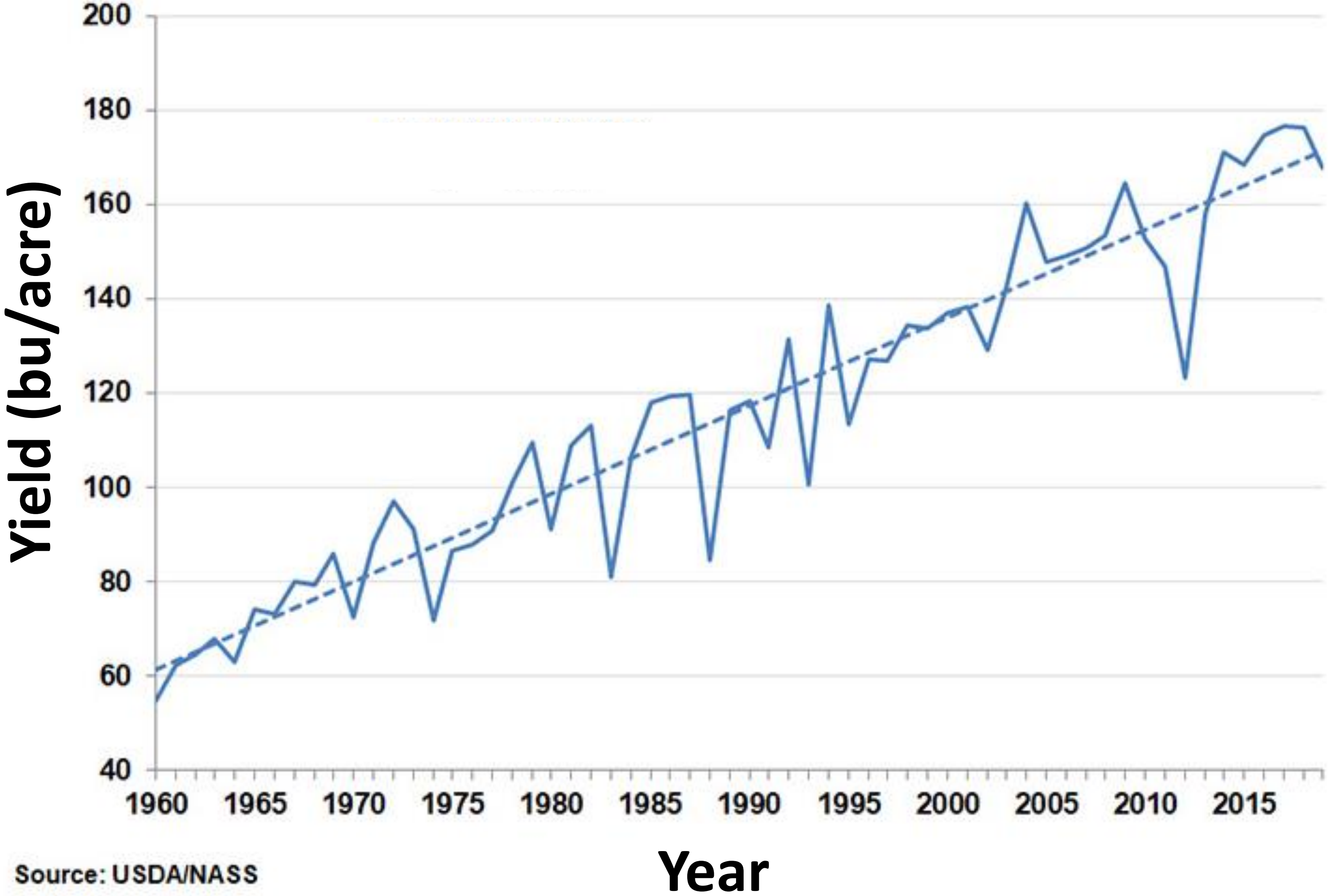
# US Average Corn Yield (1960-2019)

## 1960's vs 2019 = > 100 bu/A difference

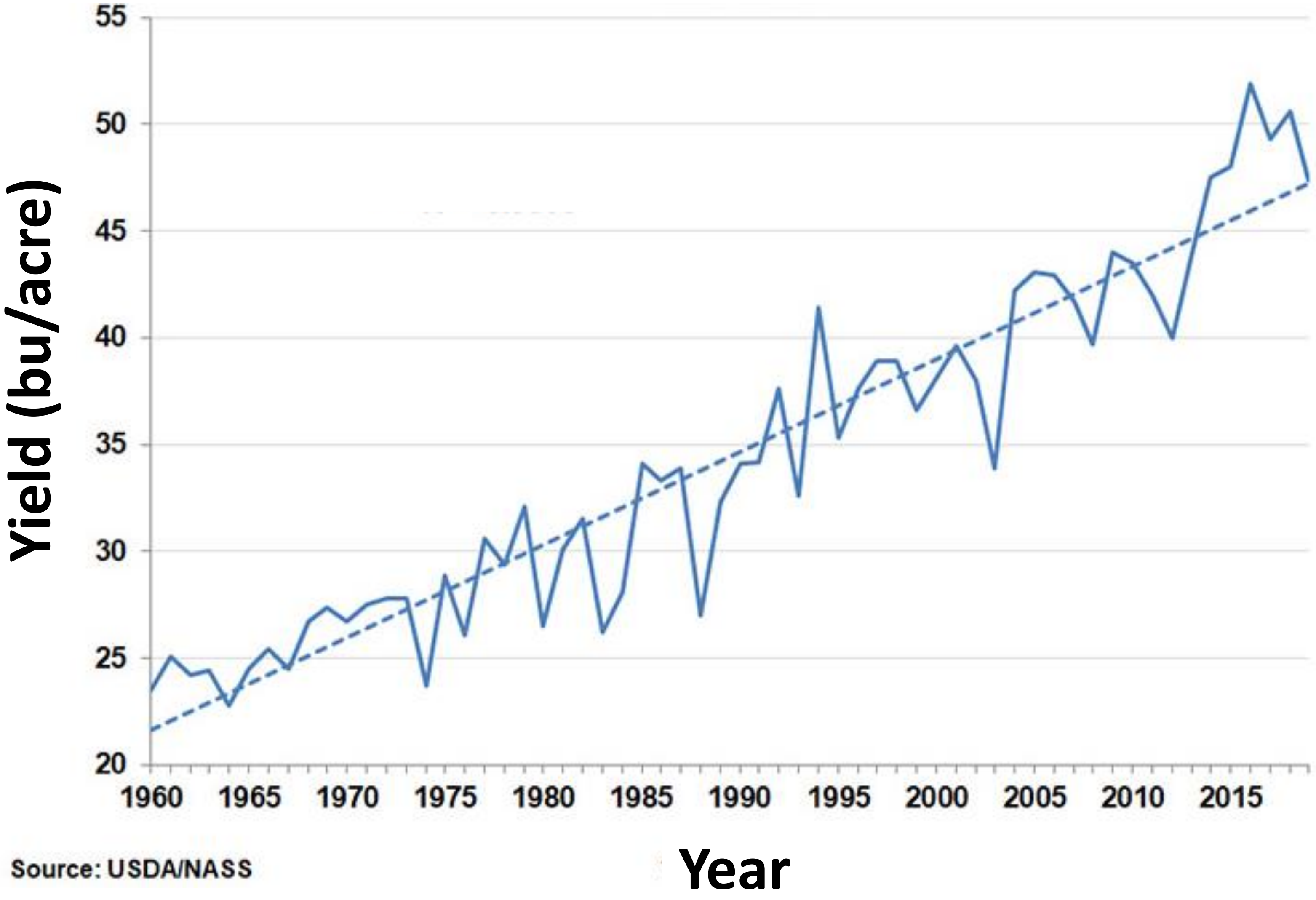



Source: USDA/NASS

Crop Physiology

# US Average Soybean Yield (1960-2019)

## 1960's vs 2019 = > 25 bu/A difference




Source: USDA/NASS

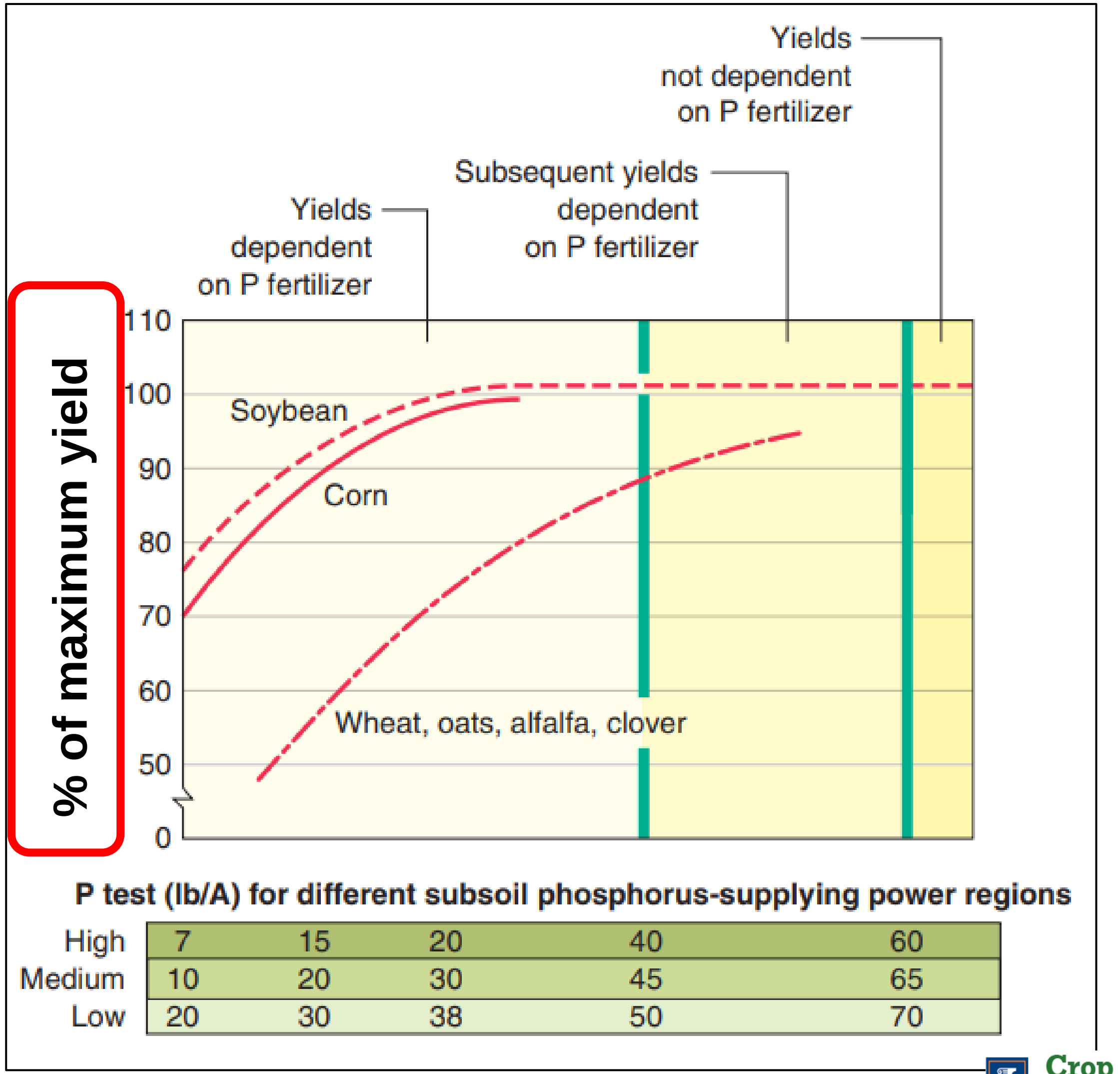
Crop Physiology

# Are current soil test correlation/calibration for Illinois outdated?

## Yield level

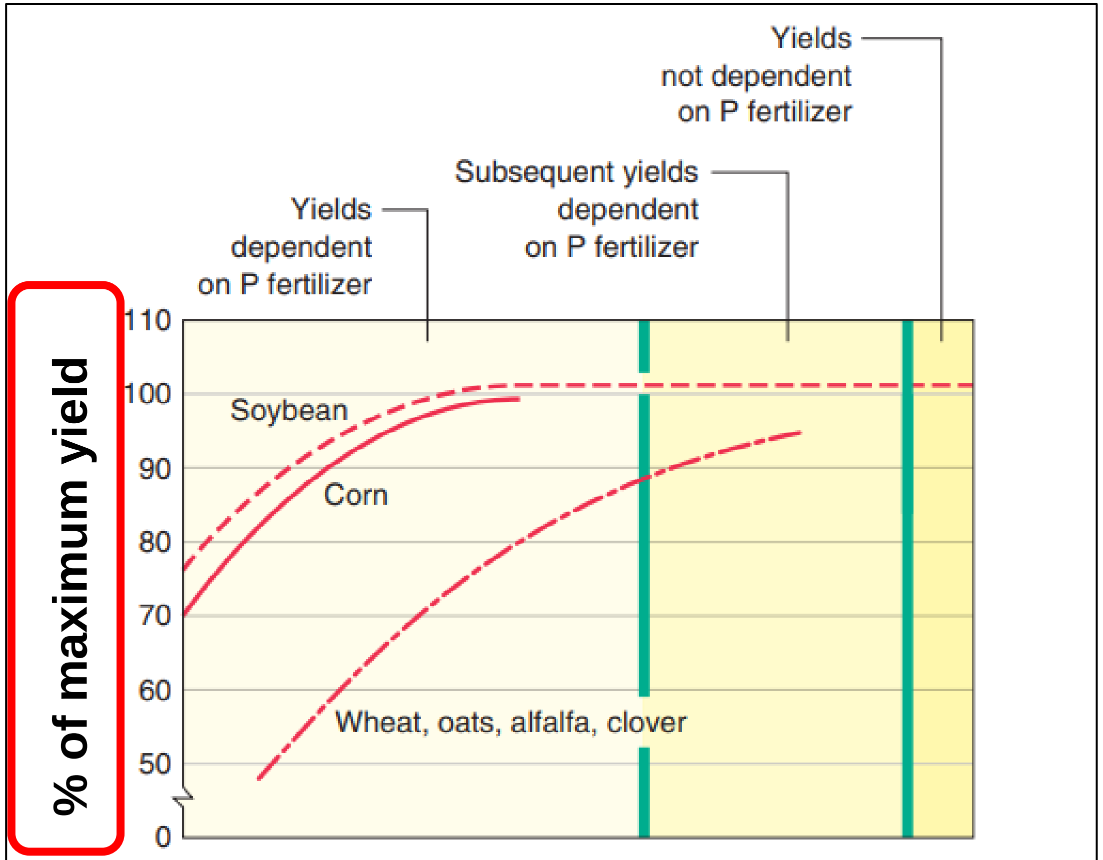
- Soil test correlations are based on percentage of **maximum projected yield** and are used to estimate a critical soil test value (CSTV)

- Above the CSTV, **no yield increase** is expected from fertilization with the nutrient of interest.



# Are current soil test correlation/calibration for Illinois outdated?

**What is the maximum yield used in these correlation curves?**

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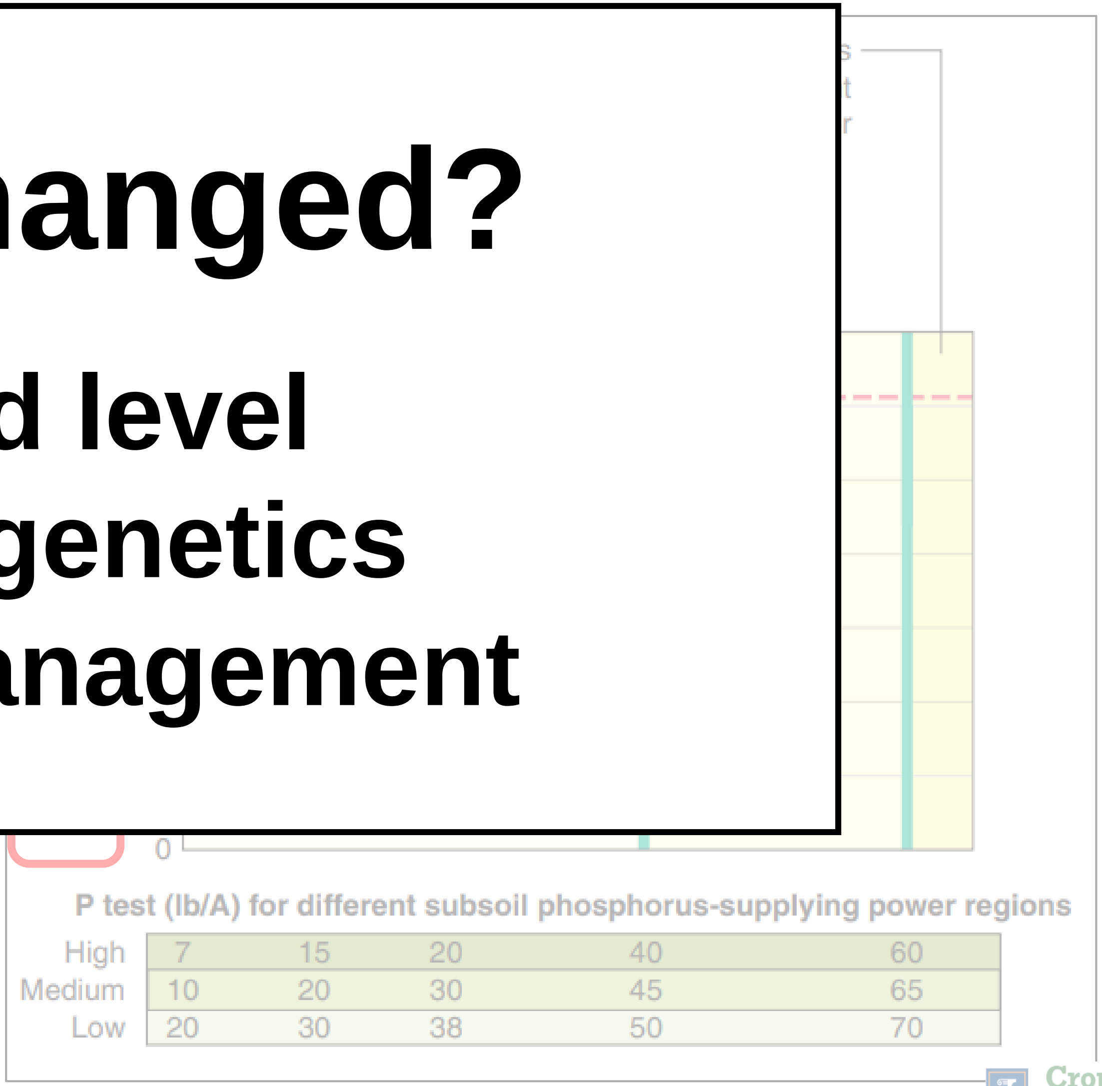


## What changed?

- Yield level
- Crop genetics
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Crop Physiology

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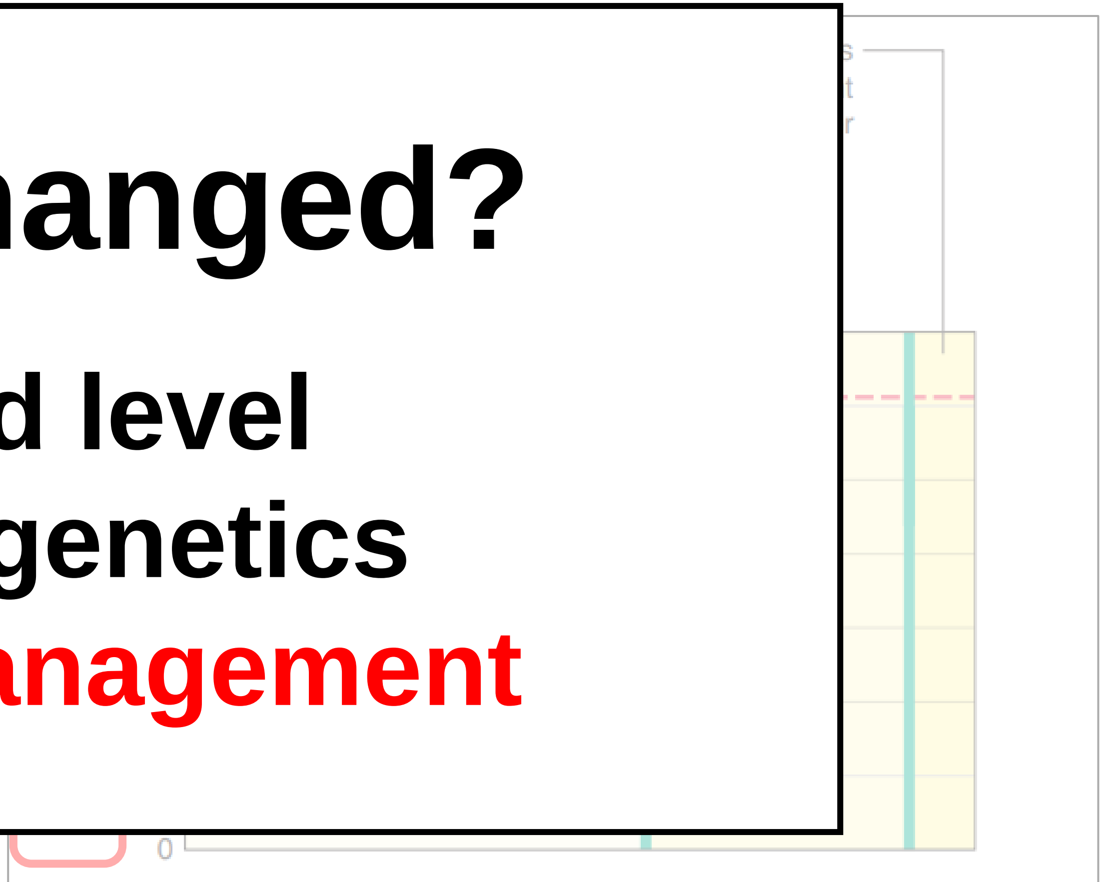

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# Are current soil test correlation/calibration for Illinois outdated?

## Crop Management

- Row spacing and population (root size)
- Fertilizer sources and placement
- Field cultivation (moldboard plow)

# Are Critical Soil Test Values in Central Illinois Accurate?

**Phosphorus**

**Build-Up + Maintenance → < 22 ppm**
**Maintenance → 22 – 32 ppm**
**Don’t Fertilize → > 32 ppm**

**Potassium**

**Build-Up + Maintenance → < 150 ppm**
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# Are Critical Soil Test Values

Ph

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Do

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Bu

Mai

Don’t Fertilize → > 200 ppm

**The CPL routinely observes yield gains with P and K fertilization when soil test levels are above the critical soil test value**

Crop Physiology

# P Fertilizer Study Treatments

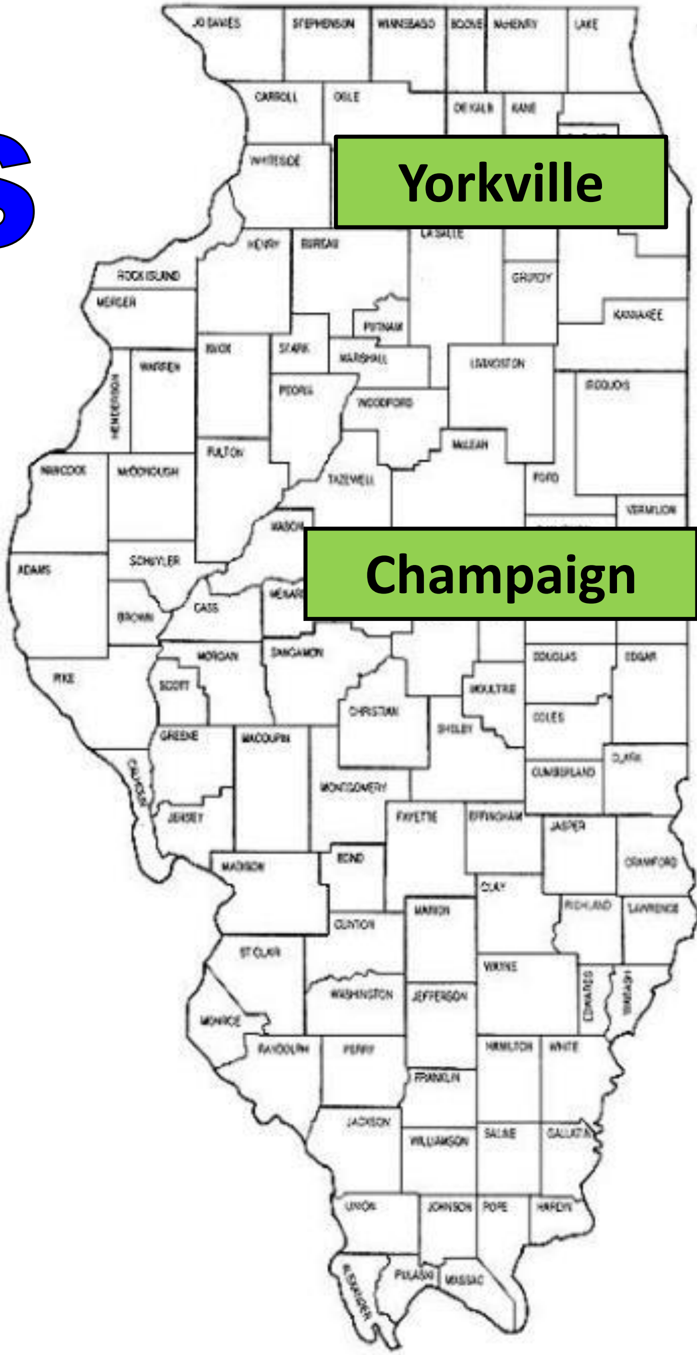
| Treatment |
| --- |
| No Phosphorus Control |
| In-furrow APP (5gal) |
| DAP 100lbs $P_2O_5$/A |
| P Source 2 |
| P Source 3 |
| P Source 4 |
| P Source 5 |
| In-furrow APP (5gal) + P Source 4 |
| In-furrow APP (5gal) + P Source 5 |

- Total P rates per treatment = 100lbs $P_2O_5$/A | DAP and P sources broadcast-applied.
- 5 gal of APP = 20lbs $P_2O_5$/A

Crop Physiology

# Trial Soil Analysis

| Location | OM | CEC | pH | P | K |
|---|---|---|---|---|---|
| | % | meq/100g | units | —— ppm —— | |
| Yorkville | 5.7 | 33.3 | 6.2 | 40 | 165 |
| Champaign | 3.7 | 22.2 | 6.3 | 51 | 162 |



# Impact of P Fertilizer on Corn Grain Yield

## (Northern Illinois - 2019)

| Treatment | Grain Yield |
|---|---|
| | bu/acre |
| No Phosphorus Control | 226 |
| In-furrow APP (5gal) | |
| DAP 100lbs $P_2O_5$/A | |
| P Source 2 | |
| P Source 3 | |
| P Source 4 | |
| P Source 5 | |
| In-furrow APP (5gal) + P Source 4 | |
| In-furrow APP (5gal) + P Source 5 | |
| LSD(.10) | 8 |

- Total P rates per treatment = 100lbs $P_2O_5$/A | 5 gal APP = 20lbs $P_2O_5$/A

# Impact of P Fertilizer on Corn Grain Yield

## (Northern Illinois - 2019)

| Treatment | Grain Yield | |
|---|---|---|
| | bu/acre | |
| No Phosphorus Control | 226 | ΔUTC |
| In-furrow APP (5gal) | 237 | +11 |
| DAP 100lbs $P_2O_5$/A | 240 | +14 |
| P Source 2 | 236 | +10 |
| P Source 3 | 239 | +13 |
| P Source 4 | 240 | +14 |
| P Source 5 | 238 | +12 |
| In-furrow APP (5gal) + P Source 4 | 237 | +11 |
| In-furrow APP (5gal) + P Source 5 | 242 | +16 |
| LSD(.10) | 8 | |

- Total P rates per treatment = 100lbs $P_2O_5$/A | 5 gal APP = 20lbs $P_2O_5$/A

# Impact of P Fertilizer on Corn Grain Yield

## (Central Illinois - 2019)

| Treatment | Grain Yield |
|---|---|
| | bu/acre |
| No Phosphorus Control | 241 |
| In-furrow APP (5gal) | |
| DAP 100lbs $P_2O_5$/A | |
| P Source 2 | |
| P Source 3 | |
| P Source 4 | |
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Crop Physiology

# Impact of P Fertilizer on Corn Grain Yield

## (Central Illinois - 2019)

| Treatment | Grain Yield | |
|---|---|---|
| | bu/acre | |
| No Phosphorus Control | 241 | ΔUTC |
| In-furrow APP (5gal) | 251 | +10 |
| DAP 100lbs $P_2O_5$/A | 246 | +5 |
| P Source 2 | 253 | +12 |
| P Source 3 | 241 | ±0 |
| P Source 4 | 252 | +11 |
| P Source 5 | 259 | +18 |
| In-furrow APP (5gal) + P Source 4 | 258 | +17 |
| In-furrow APP (5gal) + P Source 5 | 253 | +12 |
| LSD(.10) | 7 | |

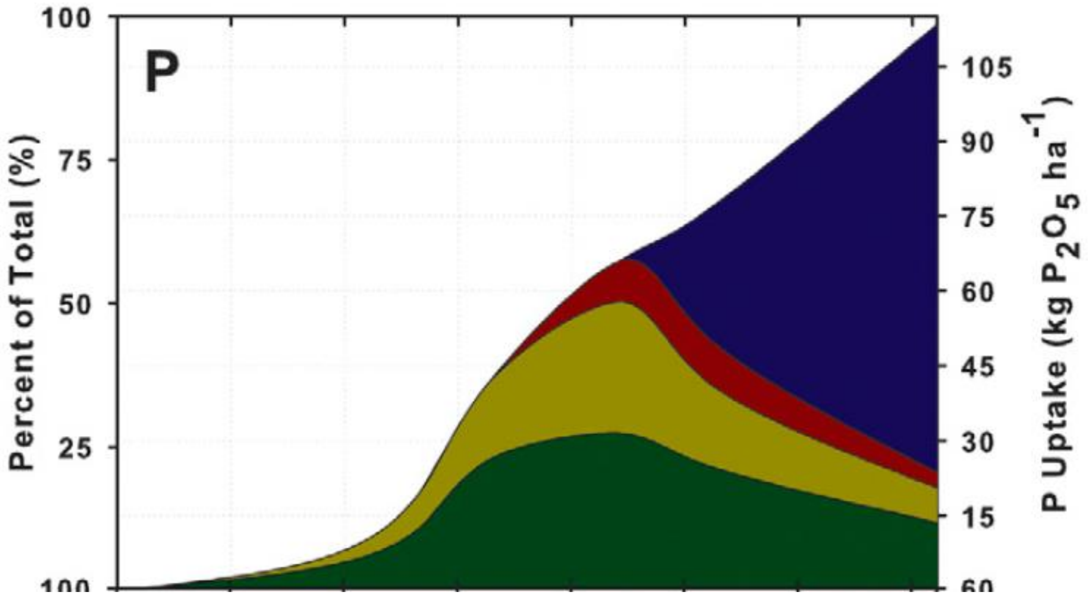
- Total P rates per treatment = 100lbs $P_2O_5$/A | 5 gal APP = 20lbs $P_2O_5$/A

Crop Physiology

# Soil Test x Crop Requirement

**According to the soil test, the soil had 2x more P and K available than required for 230 bu/A corn. However, yield still increases with fertilization. Are fertilizer nutrients better?**

| Soil Test | |
|---|---|
| $P_2O_5$ | $K_2O$ |
| --- lbs/A --- | |
| 210 | 400 |




Crop Physiology

# Soil Test x Crop Requirement

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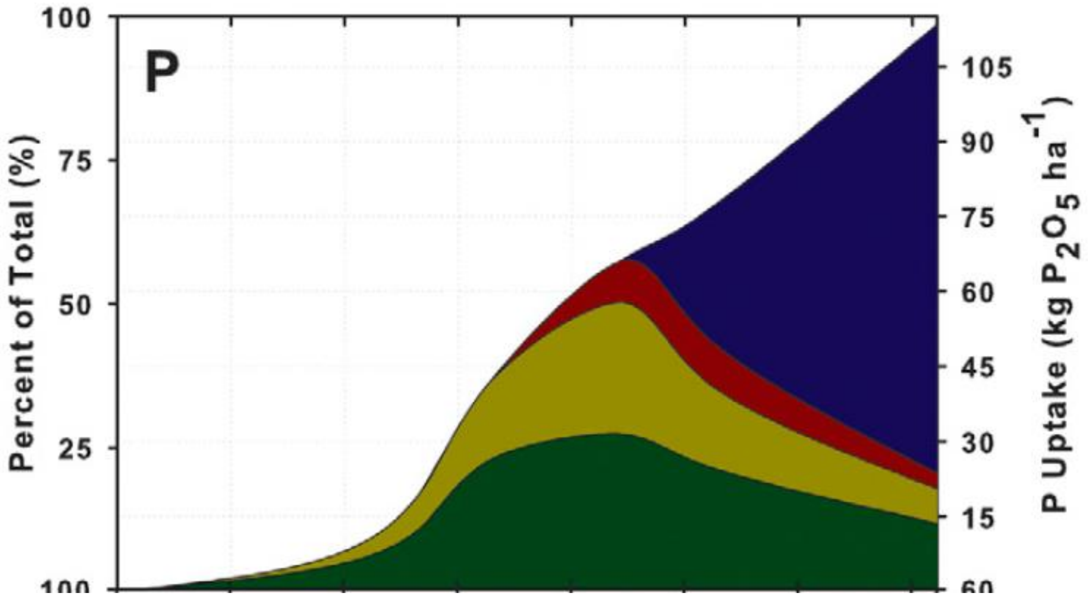


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# Why fertilize if the soil has more than the plant needs?

# Why fertilize if the soil has more than the plant needs?

**Soil nutrient release rate**

**x**

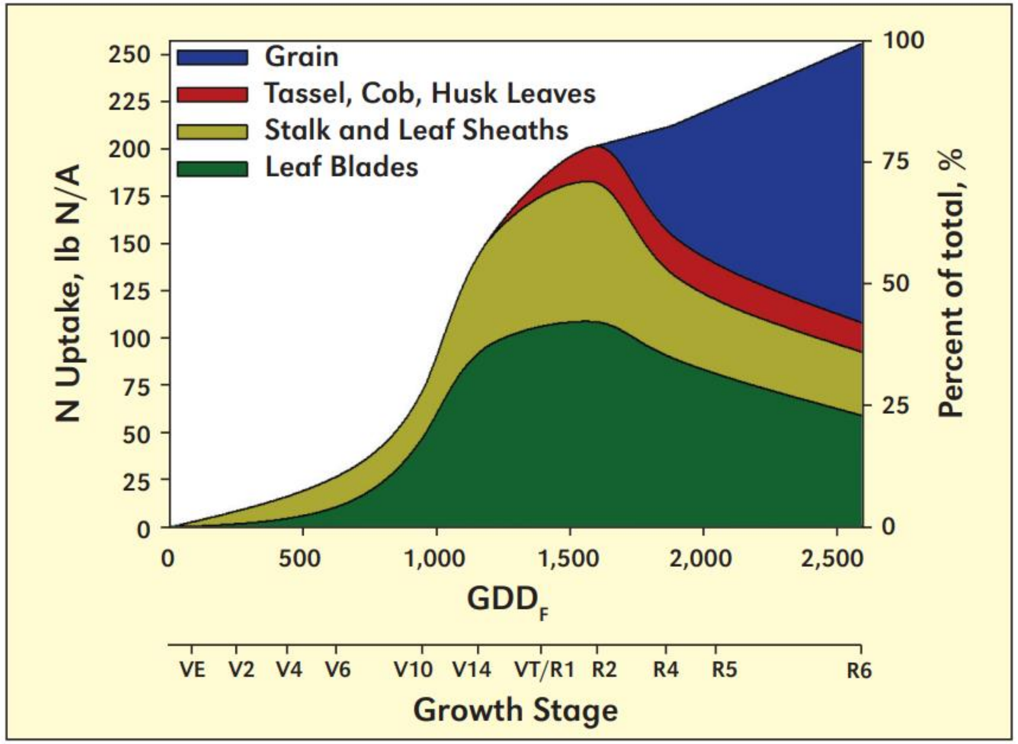
**Plant uptake rate**

Crop Physiology

# Why fertilize if the soil has more than the plant needs?

**The soil may have the <u>total</u> quantity required for high yields, however there are <u>temporal</u> and <u>spatial</u> components related to plant nutrient demand and soil nutrient availability.**

**<u>- Temporal:</u> nutrients are required at different rates during the crop growing season.**

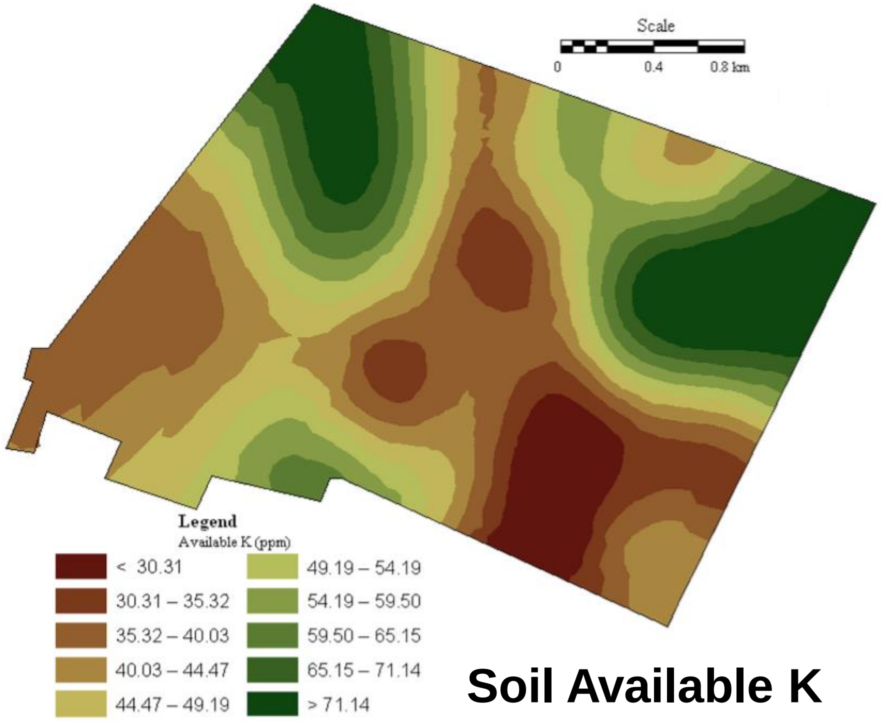


# Why fertilize if the soil has more than the plant needs?

**The soil may have the <u>total</u> quantity required for high yields, however there are <u>temporal</u> and <u>spatial</u> components related to fertility demand and availability.**

**<u>- Temporal:</u> nutrients are required at different rates during the crop growing season.**

**<u>- Spatial:</u> the availability of immobile nutrients is highly restricted to the rhizosphere zone. Fertility varies across the field and by depth. The soil test only reflects the "average" nutrient availability.**




Soil Available K

# Our Approach for P and K Fertilization

- Fertilize based on removal, to avoid depletion of soil nutrients.
- Provide enough fertility during initial growth stages to set a high yield potential.
- Sustain the yield potential by fertilizing timely and near the root zone, in order to maximize nutrient concentration at the rhizosphere at peak uptake timings.

Crop Physiology

# Our Approach for P and K Fertilization

- Fertil… …etion of soil n…
- Provi… …wth stage…
- Susta… …mely and near the root zone, in order to maximize nutrient concentration at the rhizosphere at peak uptake timings.

**- Placement**

**- Timing/source**

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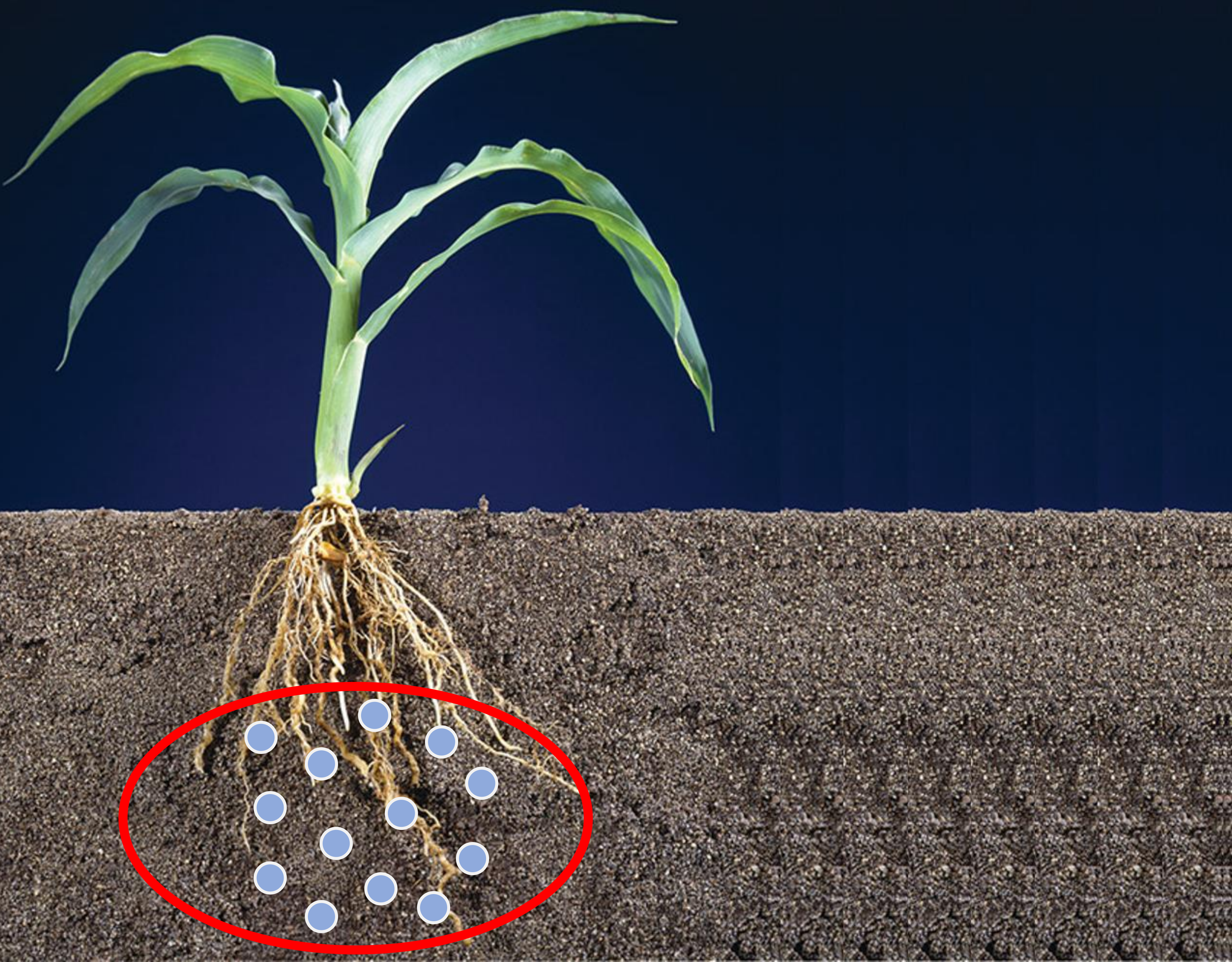
# Placement - Broadcast Application

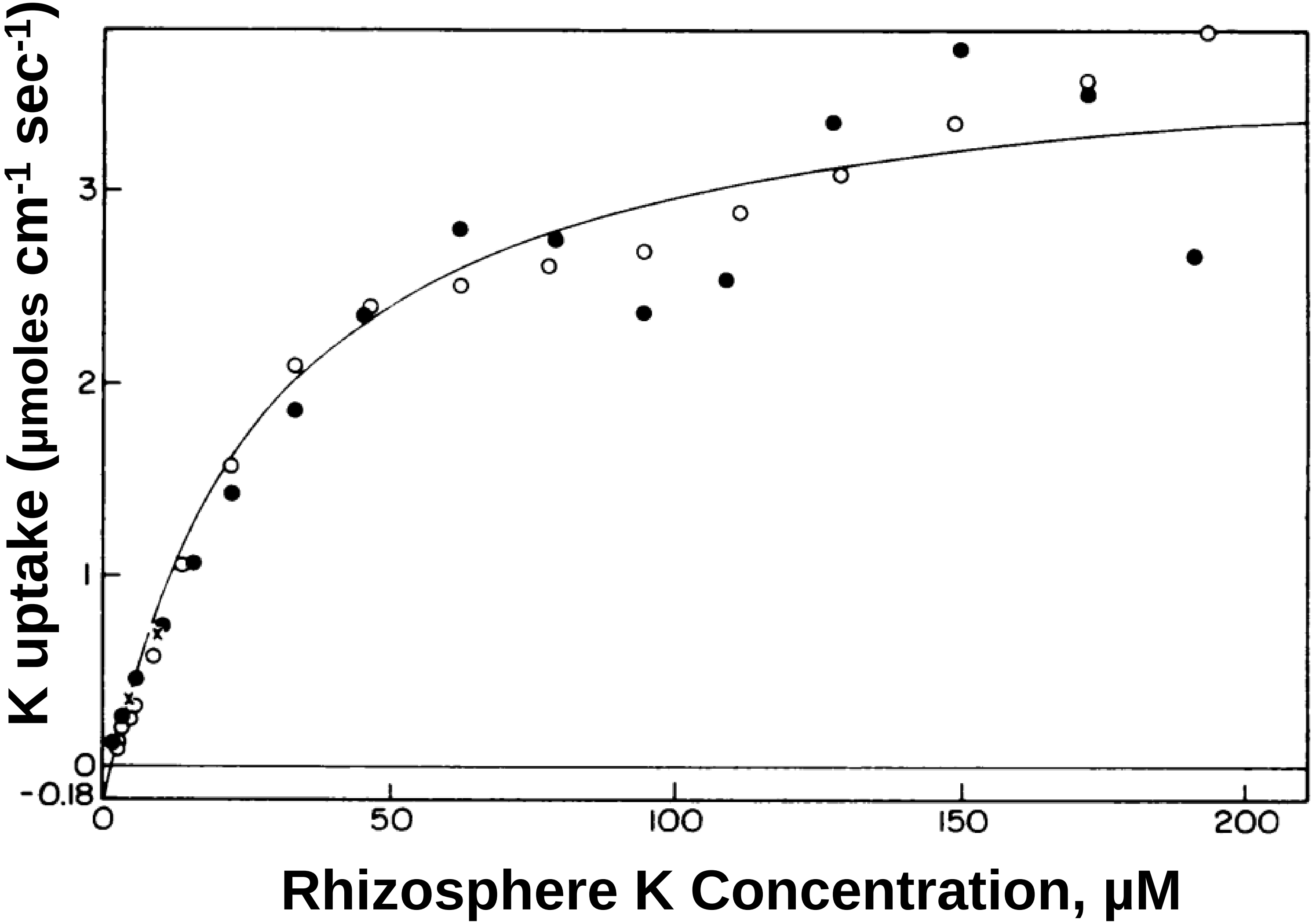
# Placement - Subsurface Banded Fertilizer

5 - 15X greater concentration in the rhizosphere



# Importance of Placement

# Feed the Plant not the Soil!




## Concentrating nutrients around the rhizosphere

- higher uptake rate
- higher NUE
- higher yields

# Importance of Timing/Source

**Nutrients are required at different rates during the crop growing season.**

**Make sure you have nutrients at the highest availability during the phases of high uptake rate**

## Phases of High Uptake Rate?

# Corn and Soybean Daily Nutrient Uptake Rate

**- Using data from Bender et al. publications, I calculated the daily uptake of soil nutrients over the season for corn and soybean.**

Soil Fertility & Crop Nutrition

## Nutrient Uptake, Partitioning, and Remobilization in Modern Soybean Varieties

Ross R. Bender, Jason W. Haegele, and Frederick E. Below*

ABSTRACT

The absence of recent data regarding the nutritional needs of modern soybean [*Glycine max* (L.) Merr.] production systems necessitates a greater comprehensive understanding of nutrient uptake, partitioning, and remobilization. The objective of this study was to evaluate macro- and micronutrient accumulation and partitioning in current soybean cultivars. Across 3 site-years, plants were sampled at seven growth stages and divided into four plant tissue fractions for quantification of nutrient uptake. Accumulation

, 371 g Mn, 325 g B, 849 g

espectively. Supplemental

dex. Nutrients with high

N (73%), Cu (62%), and S

at K and Fe were acquired

ually distributed between

nutrient accumulation in

Published November 27, 2012

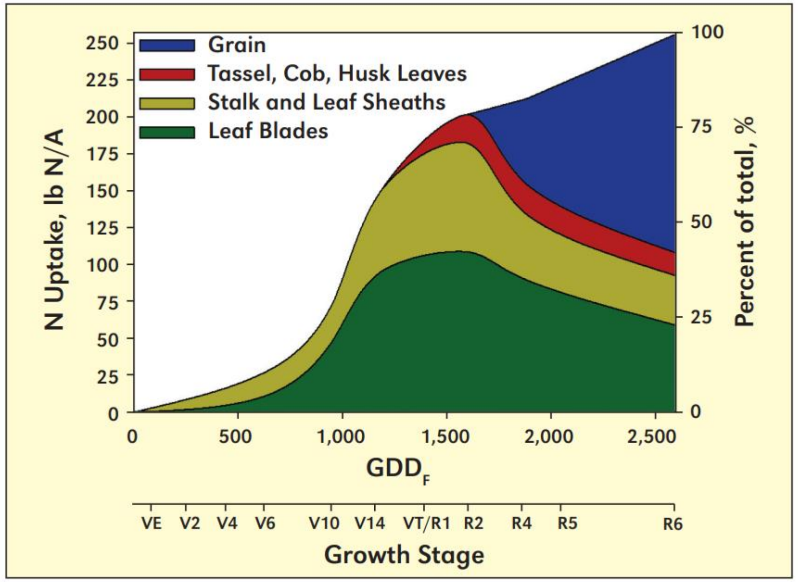
Soil Fertility & Crop Nutrition

## Nutrient Uptake, Partitioning, and Remobilization in Modern, Transgenic Insect-Protected Maize Hybrids

Ross R. Bender, Jason W. Haegele, Matias L. Ruffo, and Fred E. Below*

ABSTRACT

Modern maize (*Zea mays* L.) hybrids coupled with improved agronomic practices may have influenced the accumulation and partitioning of nutrient uptake since the last comprehensive studies were published. The objective of this study was to investigate nutrient uptake and partitioning among elite commercial germplasm with transgenic insect protection grown under modern management practices. Plants were sampled at six growth stages and divided into four fractions for nutrient determination. Total nutrients required per hectare to produce 23.0 Mg ha$^{-1}$ of total biomass with 12.0 Mg ha$^{-1}$ of grain included 286 kg N, 114 kg $P_2O_5$, 202 kg $K_2O$, 59 kg Mg, 26 kg S, 1.4 kg Fe, 0.5 kg Mn, 0.5 kg Zn, 0.1 kg Cu, and 0.08 kg B. A 10-d period (V10–V14) denoted the maximum rates of accumulation on a per day basis for dry weight (439 kg), N (8.9 kg), $P_2O_5$ (2.4 kg), $K_2O$ (5.8 kg), Mg (2.2 kg), S (0.7 kg), Zn (14.2 g), Mn (18.0 g), B (3.3 g), Fe (95.3 g), and Cu (3.0 g). The majority of total uptake occurred post-flowering for P, S, Zn, and Cu. Harvest index values of P (79%), S (57%), Zn (62%), and N (58%) were identified in the grain. These results provide much needed data on the nutrient uptake and partitioning of current hybrids, and provide an opportunity to further refine fertilizer method and timing recommendations for maize biomass and grain production.

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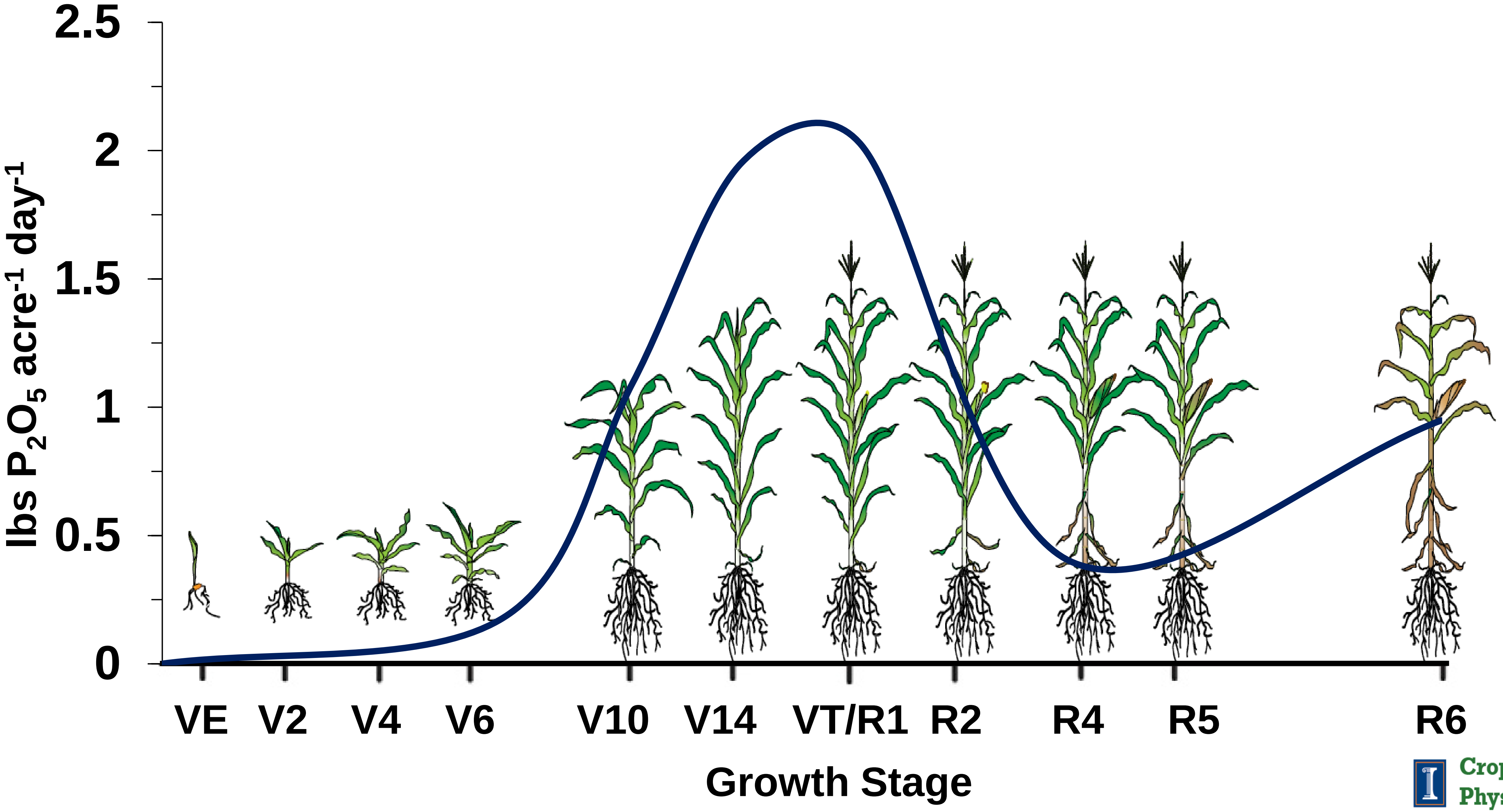
# Corn Seasonal Phosphorus Uptake Rate

Crop Physiology

# Phosphorus Uptake Rate by 230 bu/A Corn




Crop Physiology

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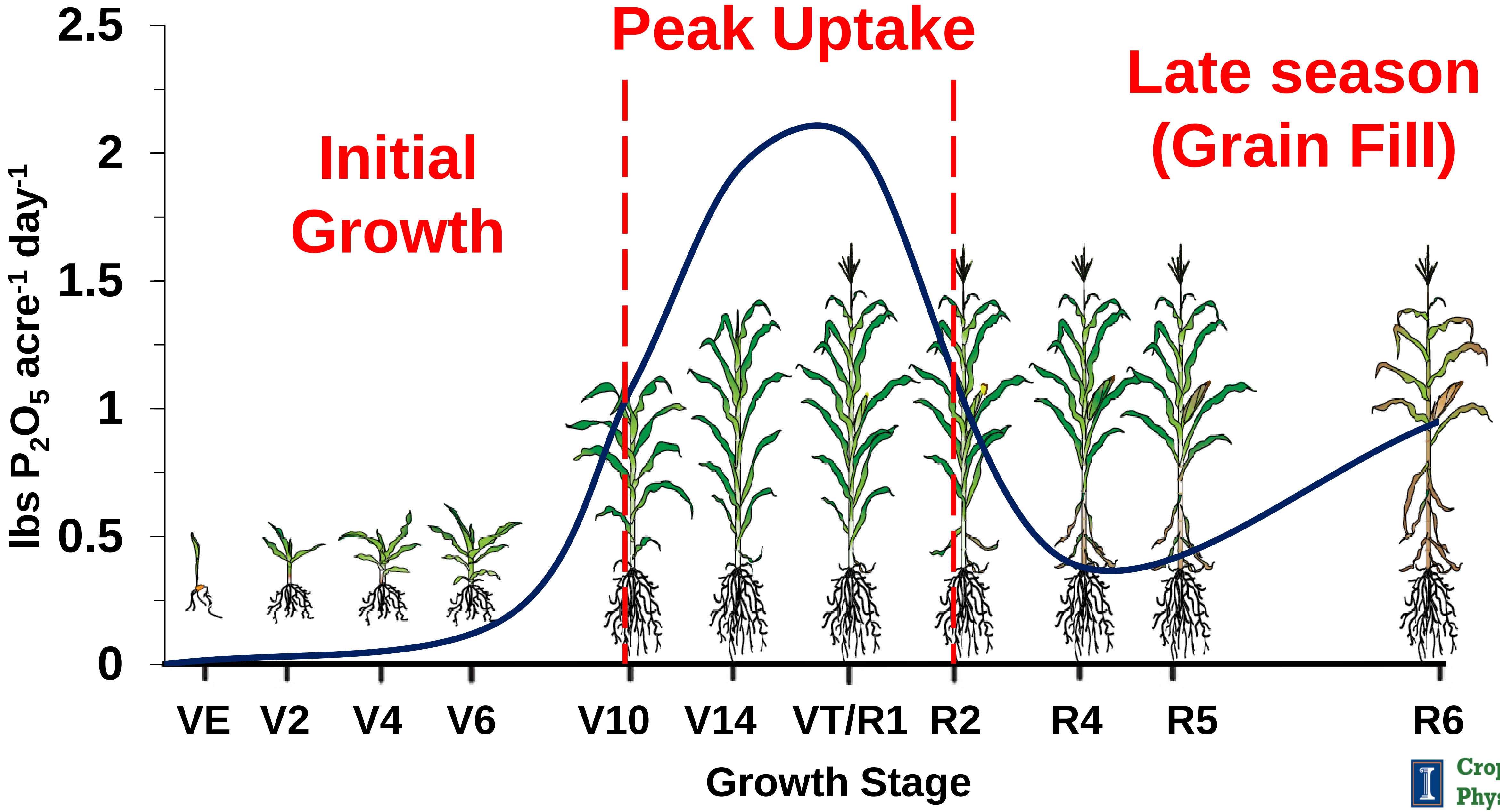


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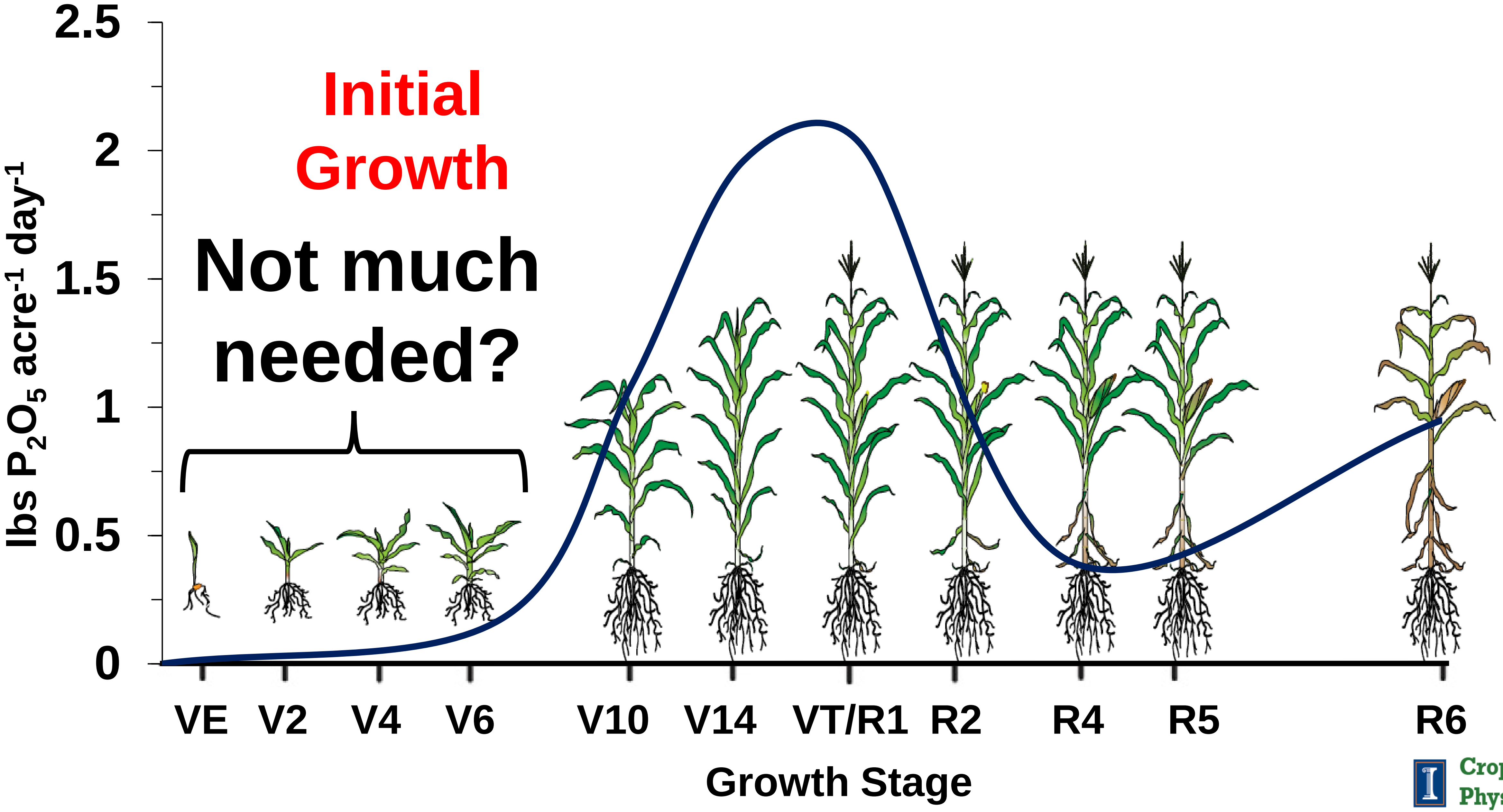


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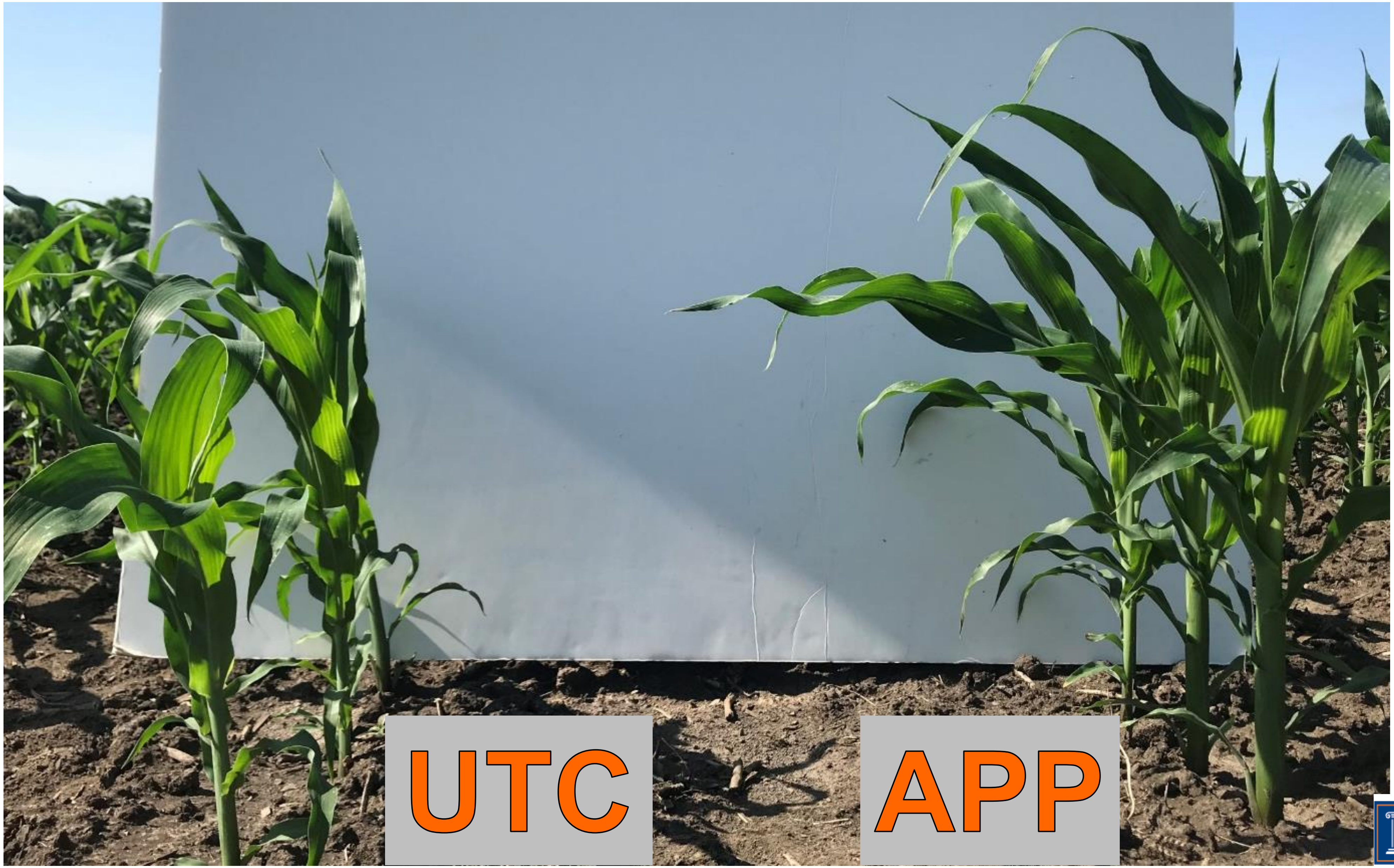
# Starter Effects on Early-Season Growth

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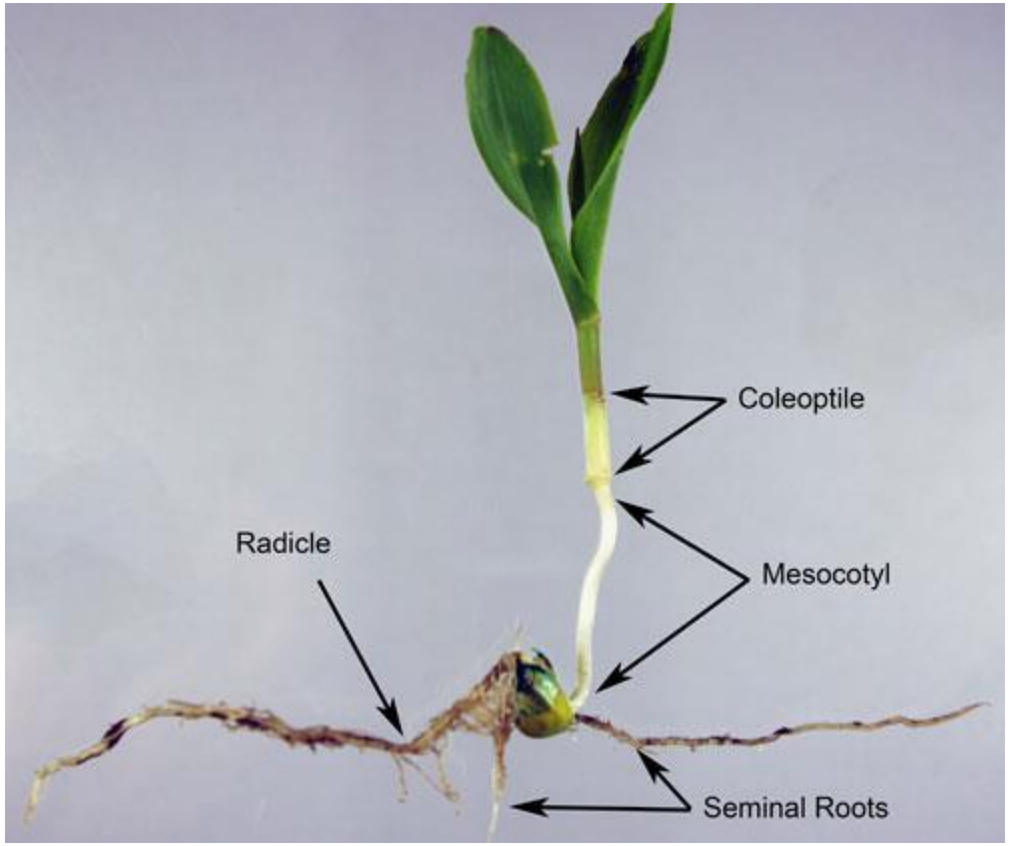
# Small Root System at Early Stages

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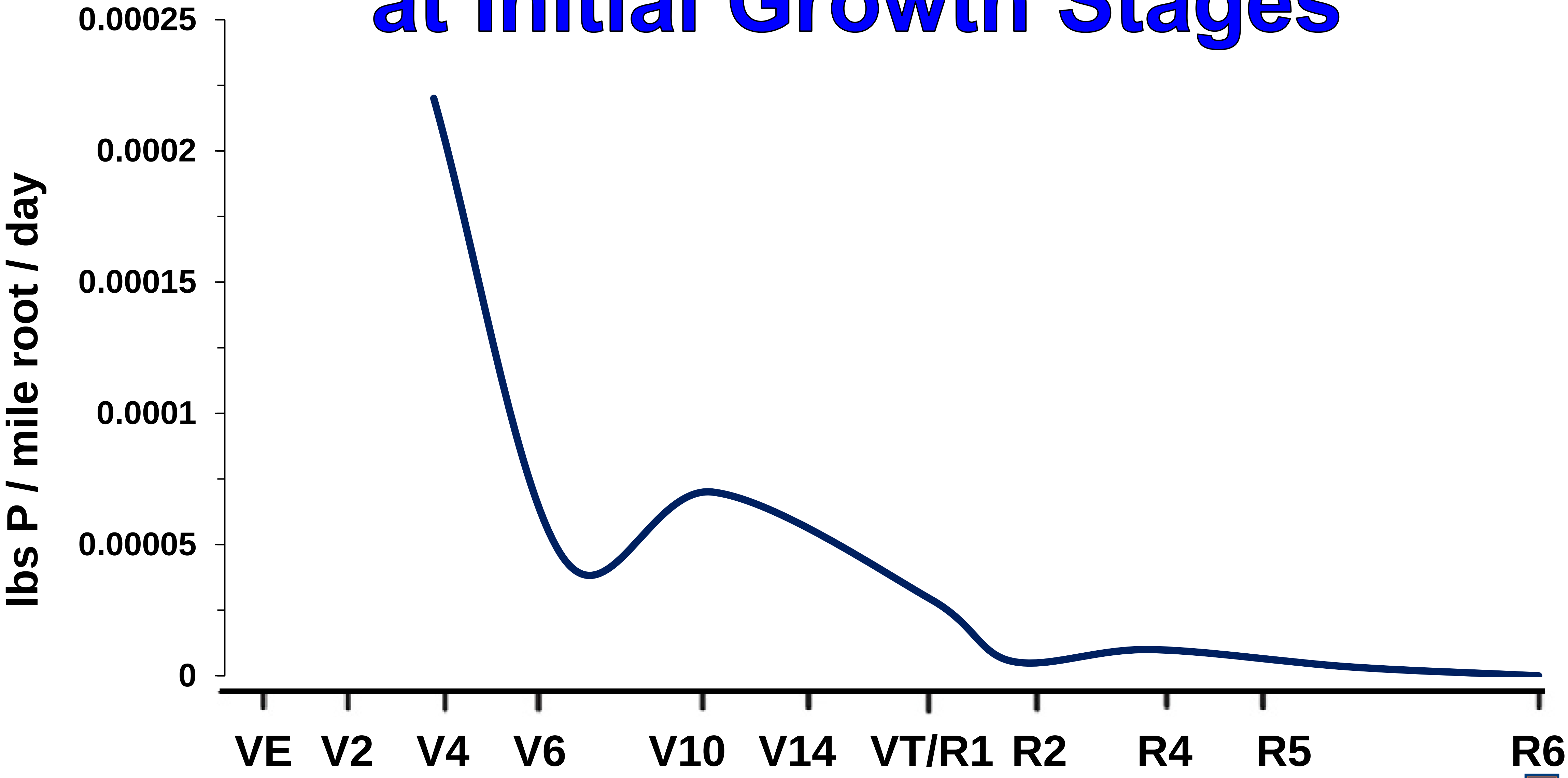
# High Uptake Rate per Unit of Root at Initial Growth Stages




Adapted from Mengel (1995)

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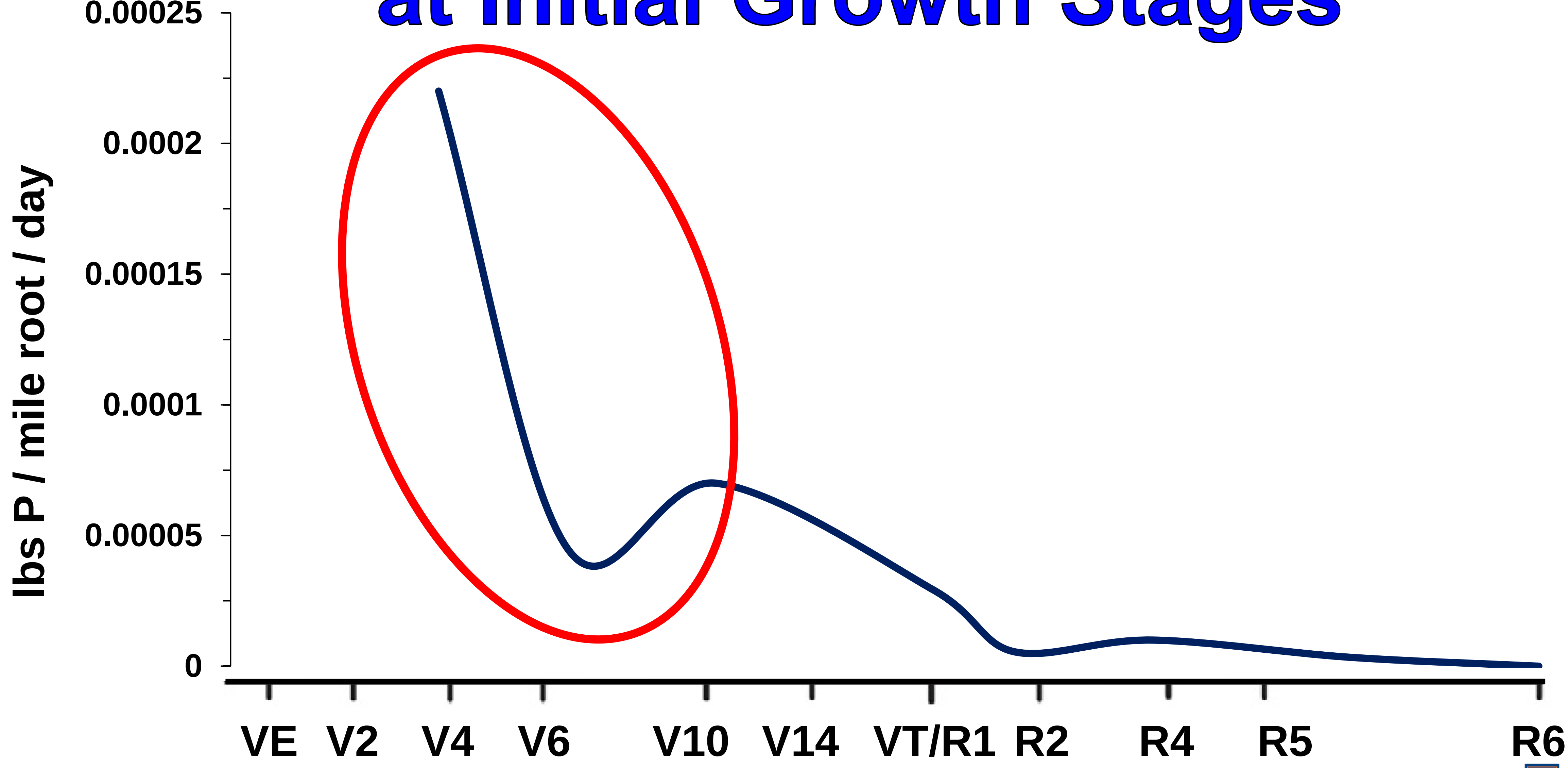


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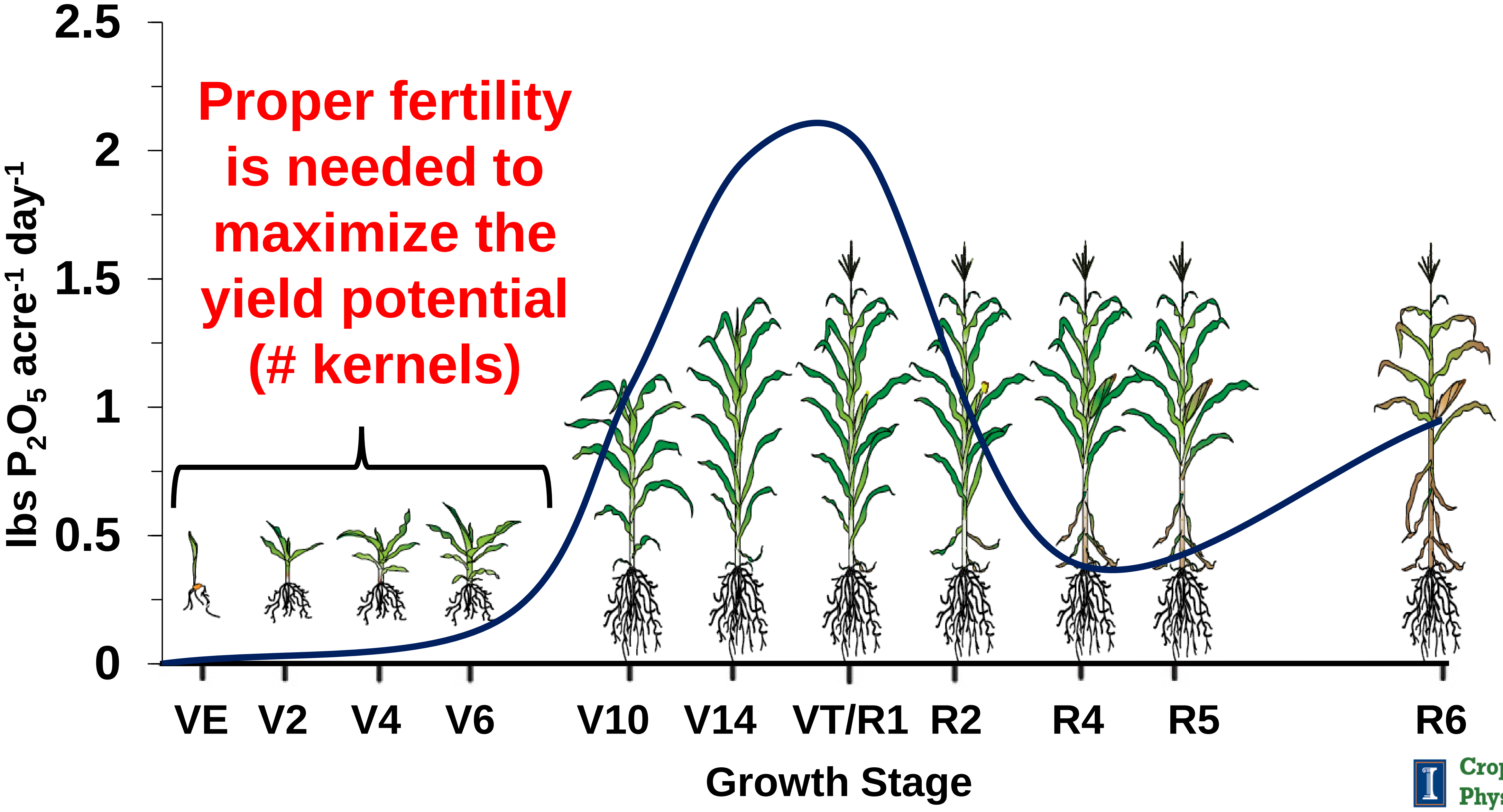


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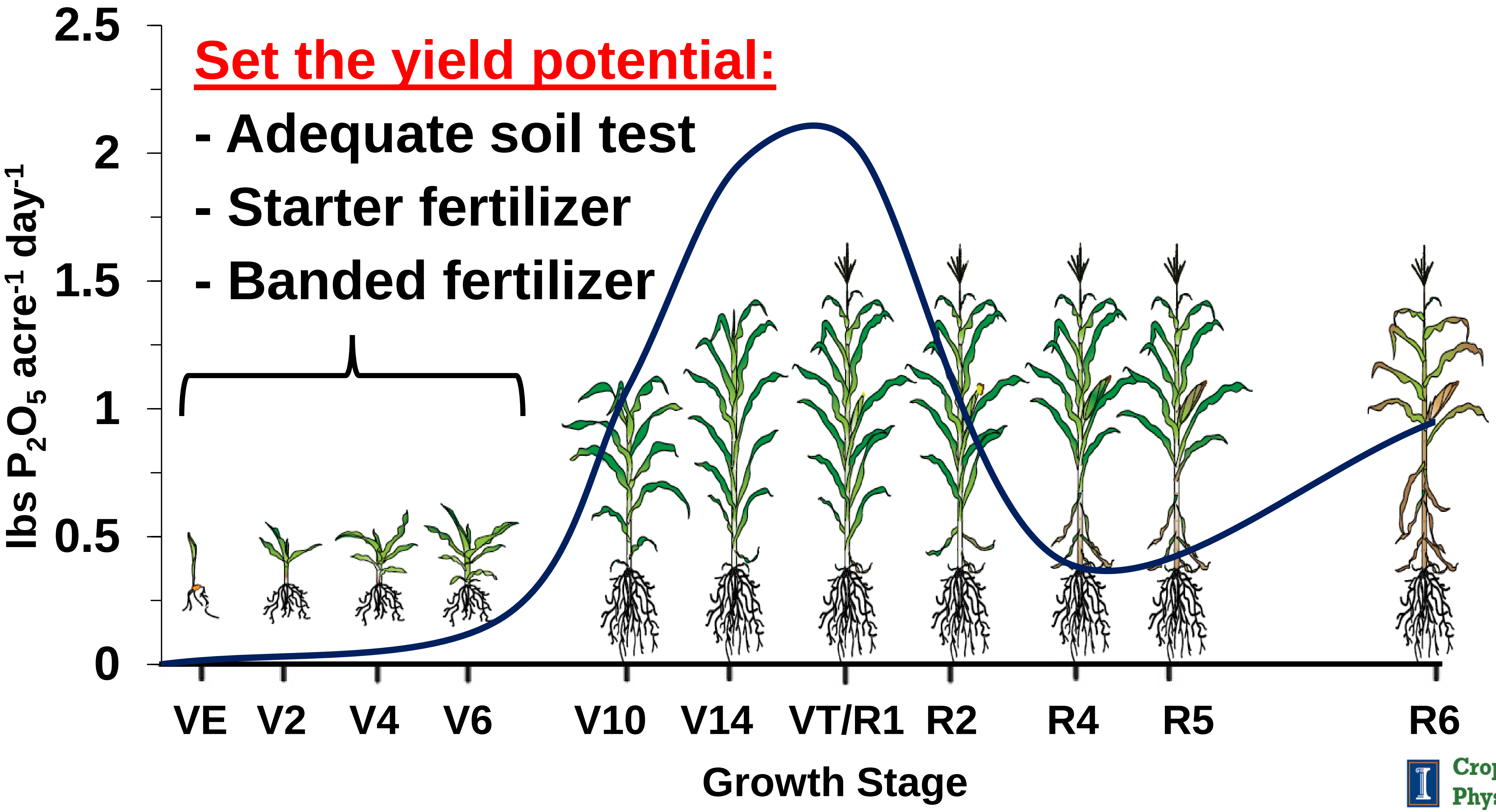


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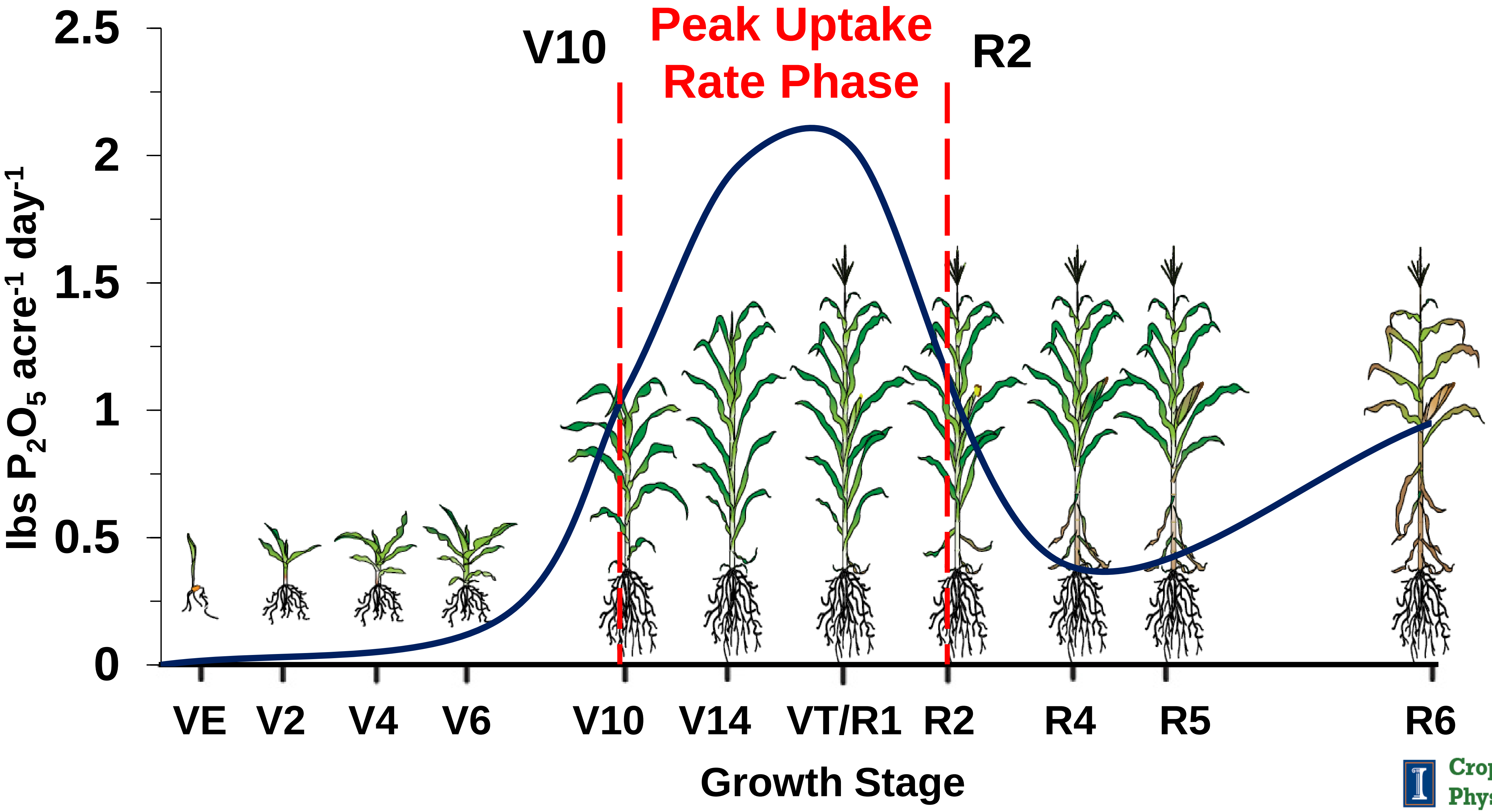


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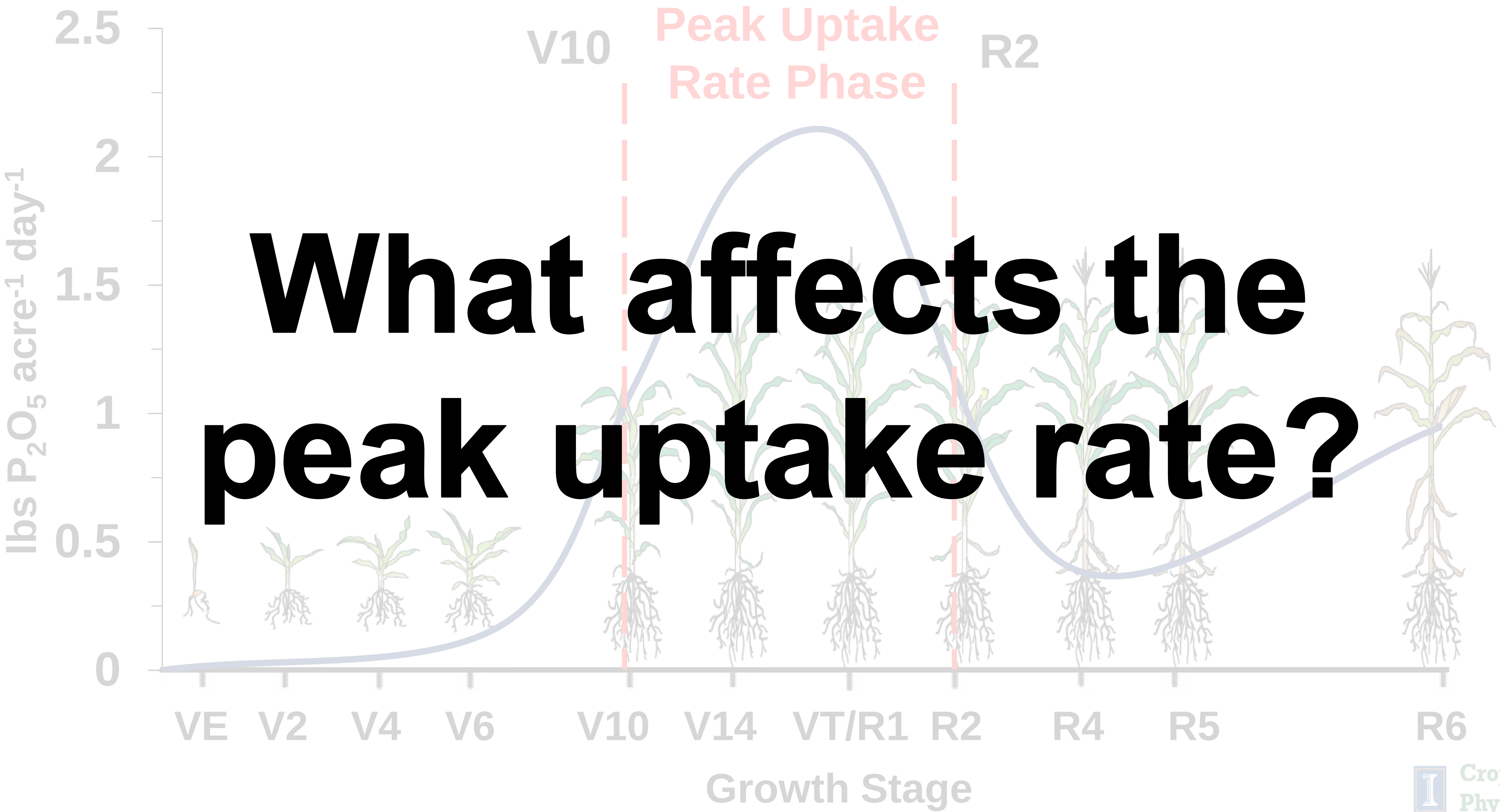


# What affects the peak uptake rate?

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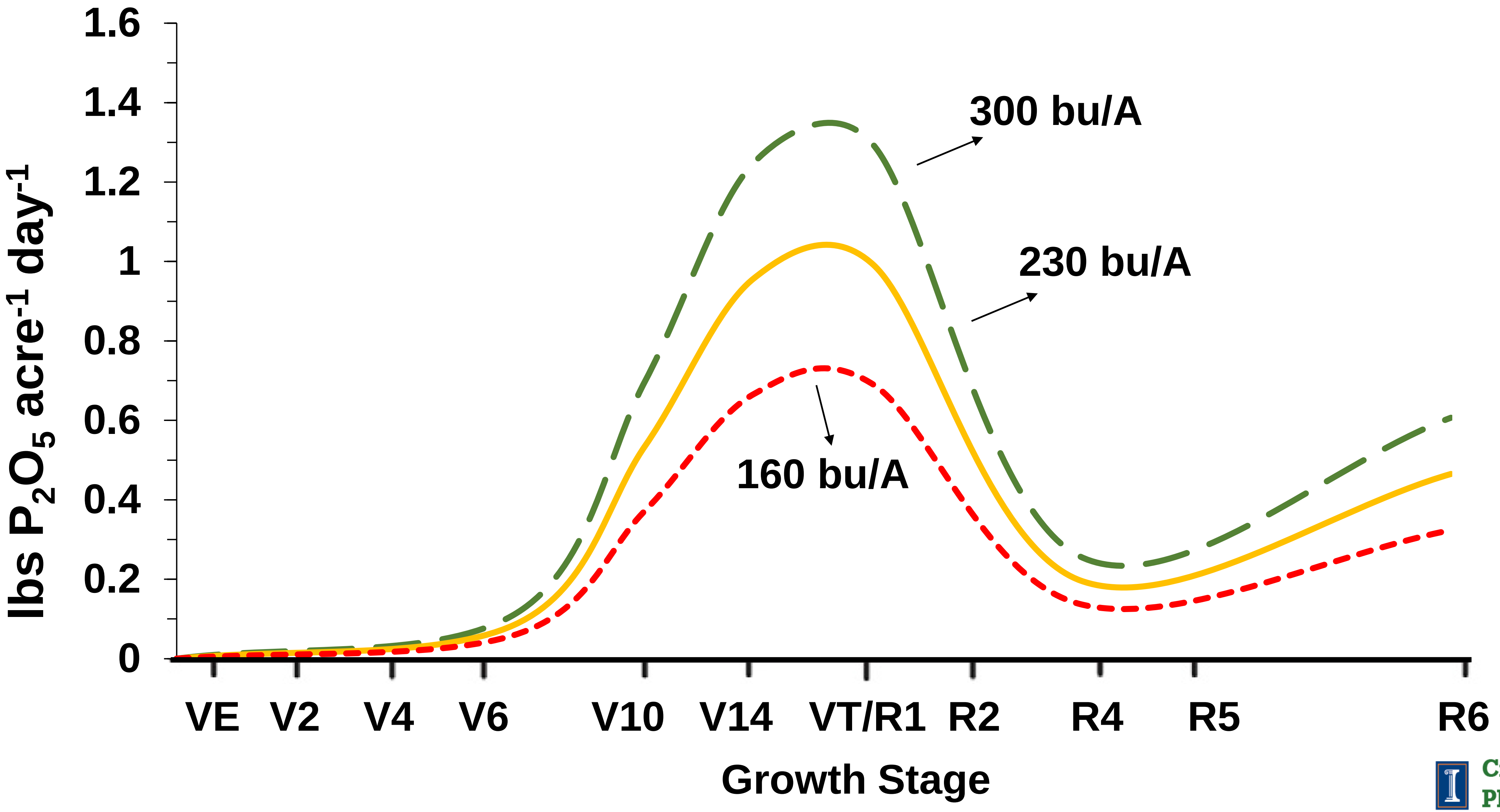
# Corn Phosphorus Uptake Rate x Yield

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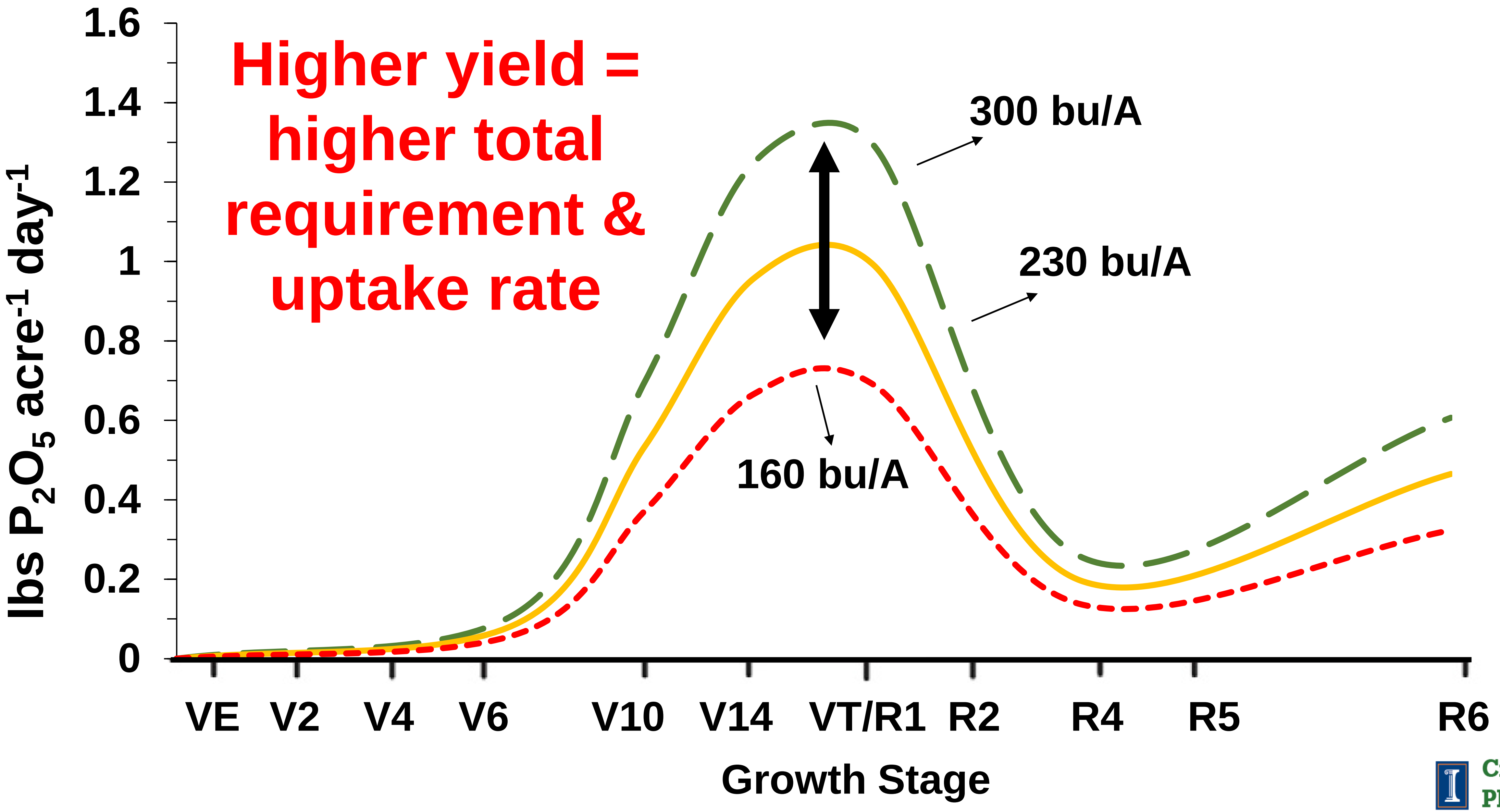


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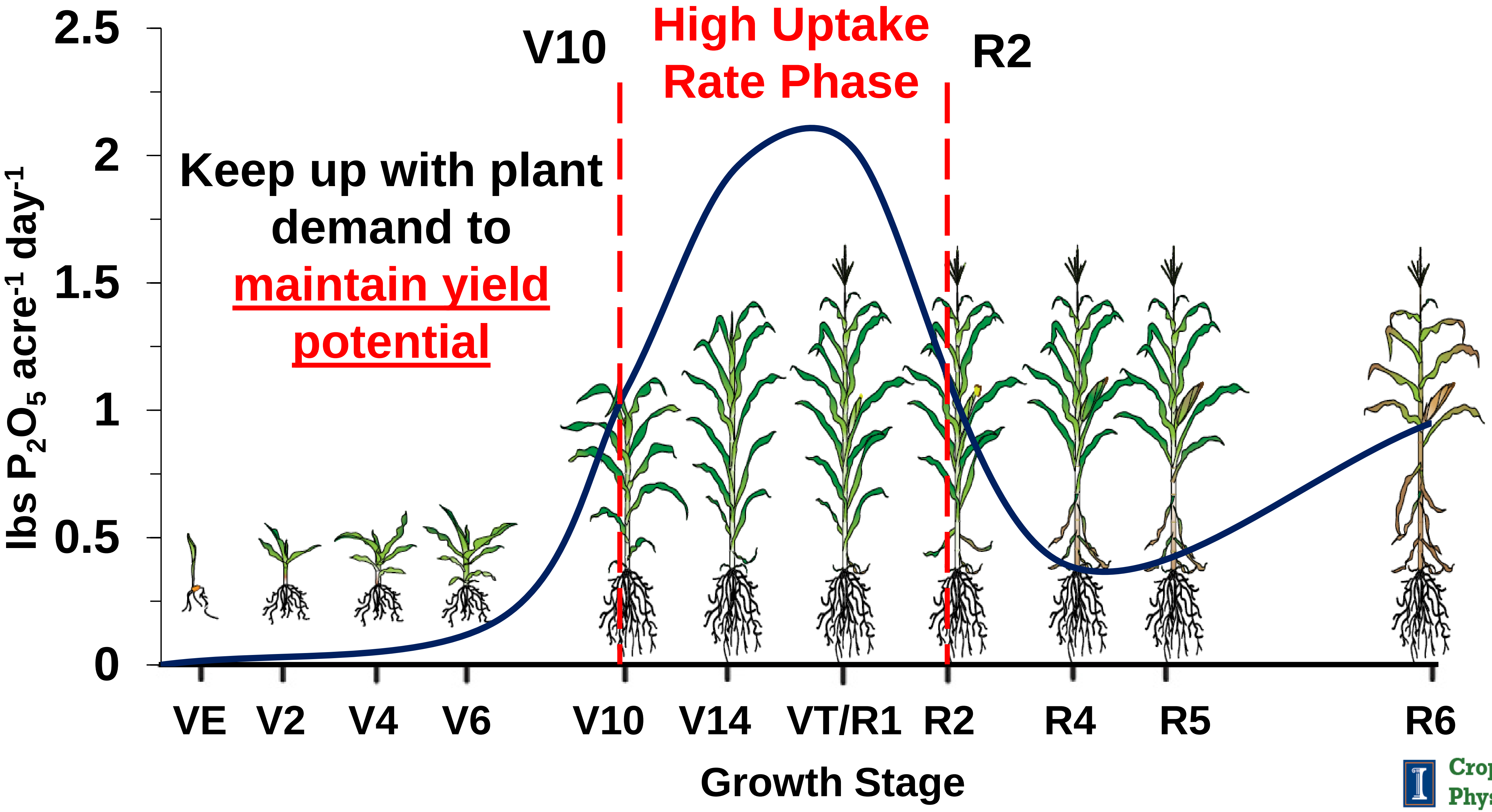
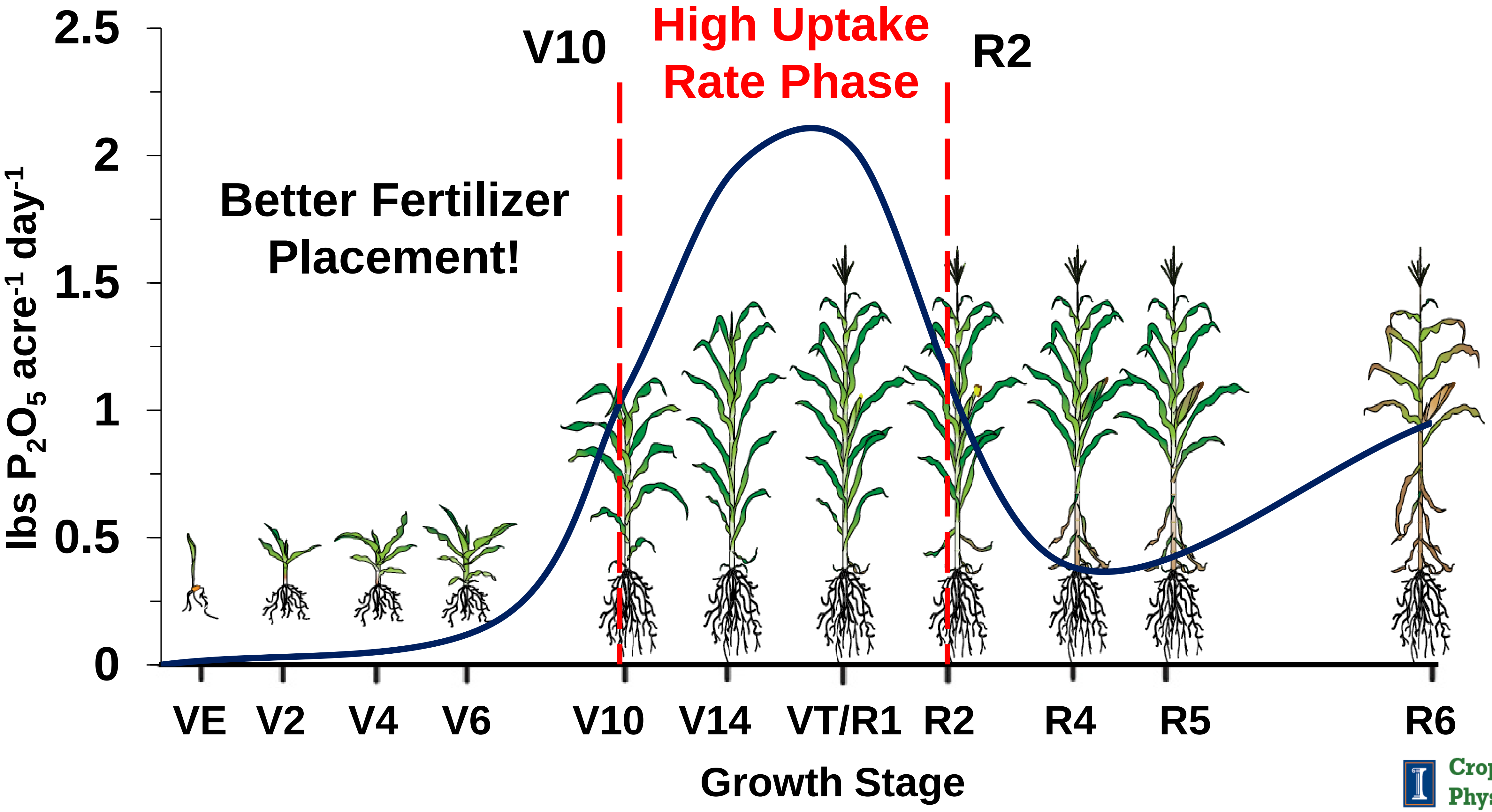


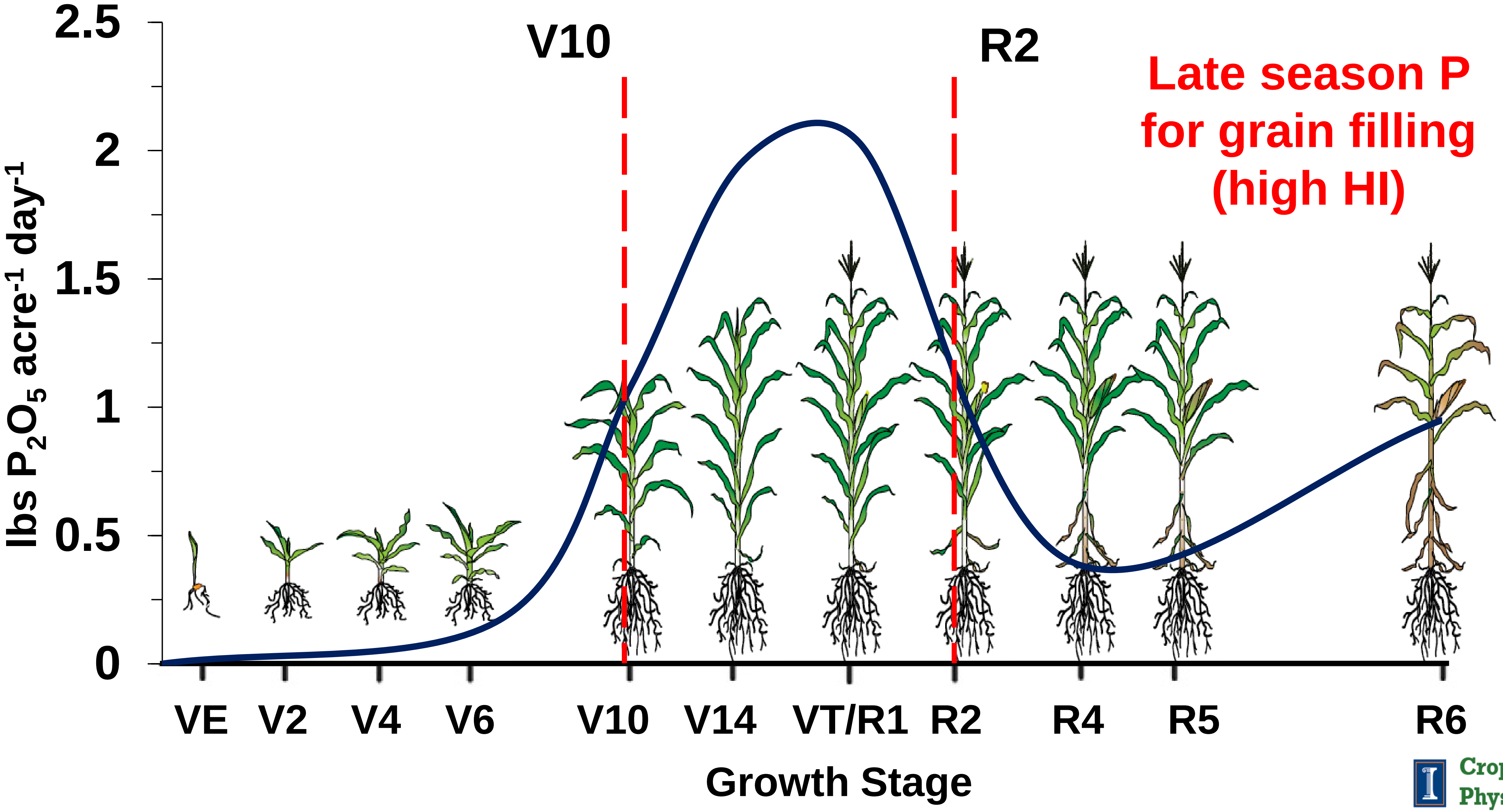

Crop Physiology

# Phosphorus Uptake Rate by 230 bu/A Corn




Crop Physiology

# Phosphorus Uptake Rate by 230 bu/A Corn

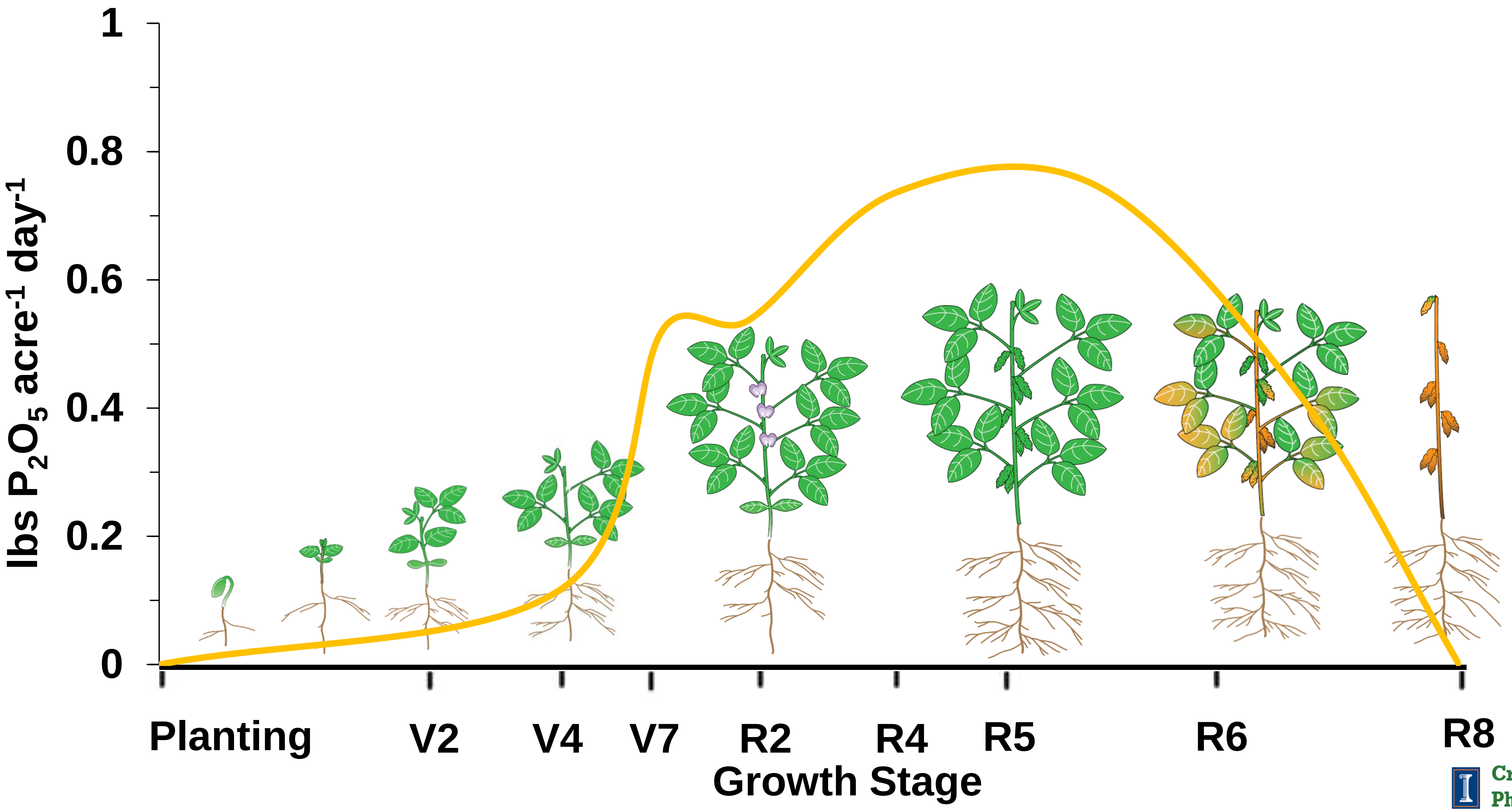



Crop Physiology

# Soybean Seasonal Phosphorus Uptake Rate

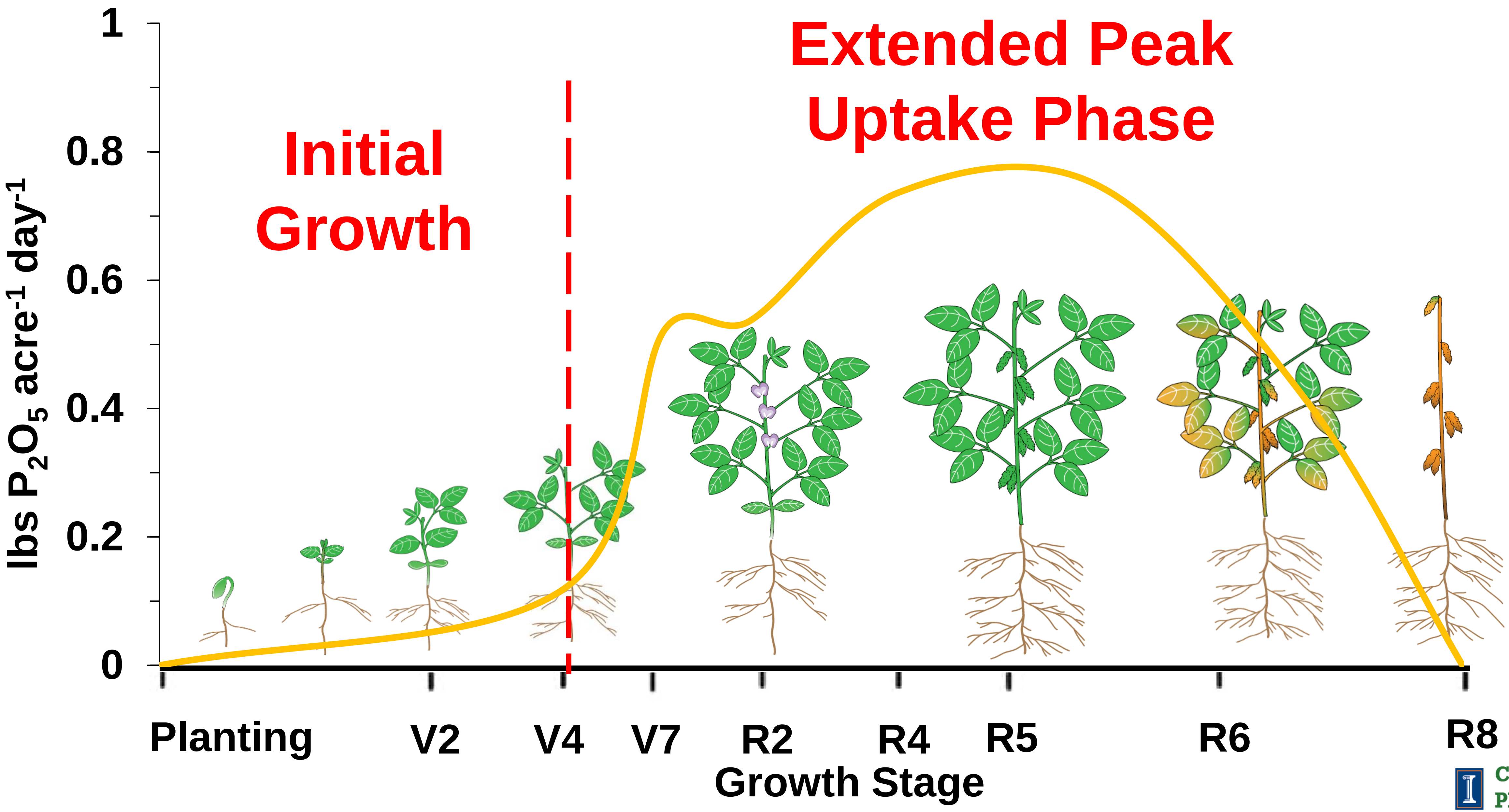
Crop Physiology

# Phosphorus Uptake Rate by 60 bu/A Soybean



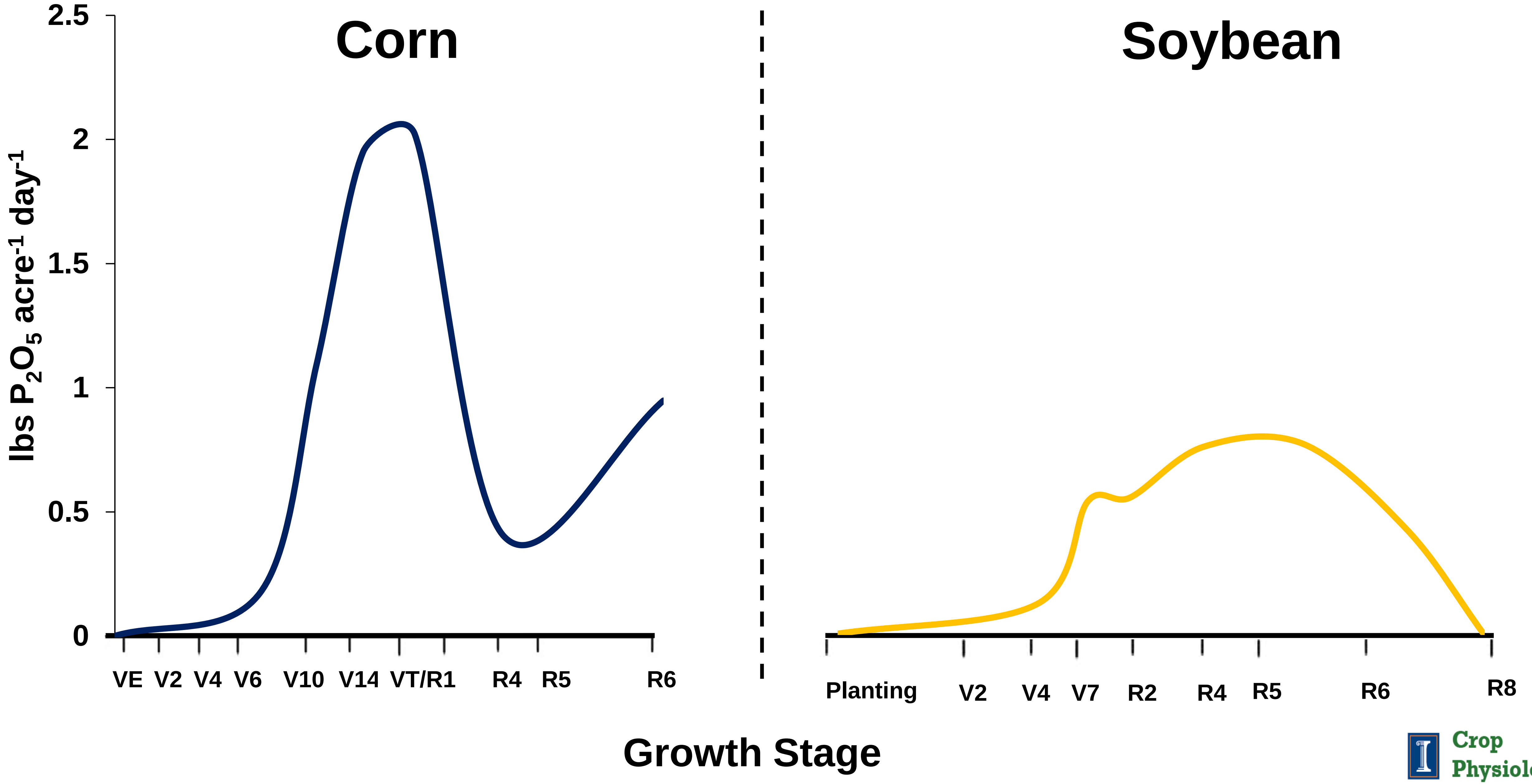

Crop Physiology

# Phosphorus Uptake Rate by 60 bu/A Soybean



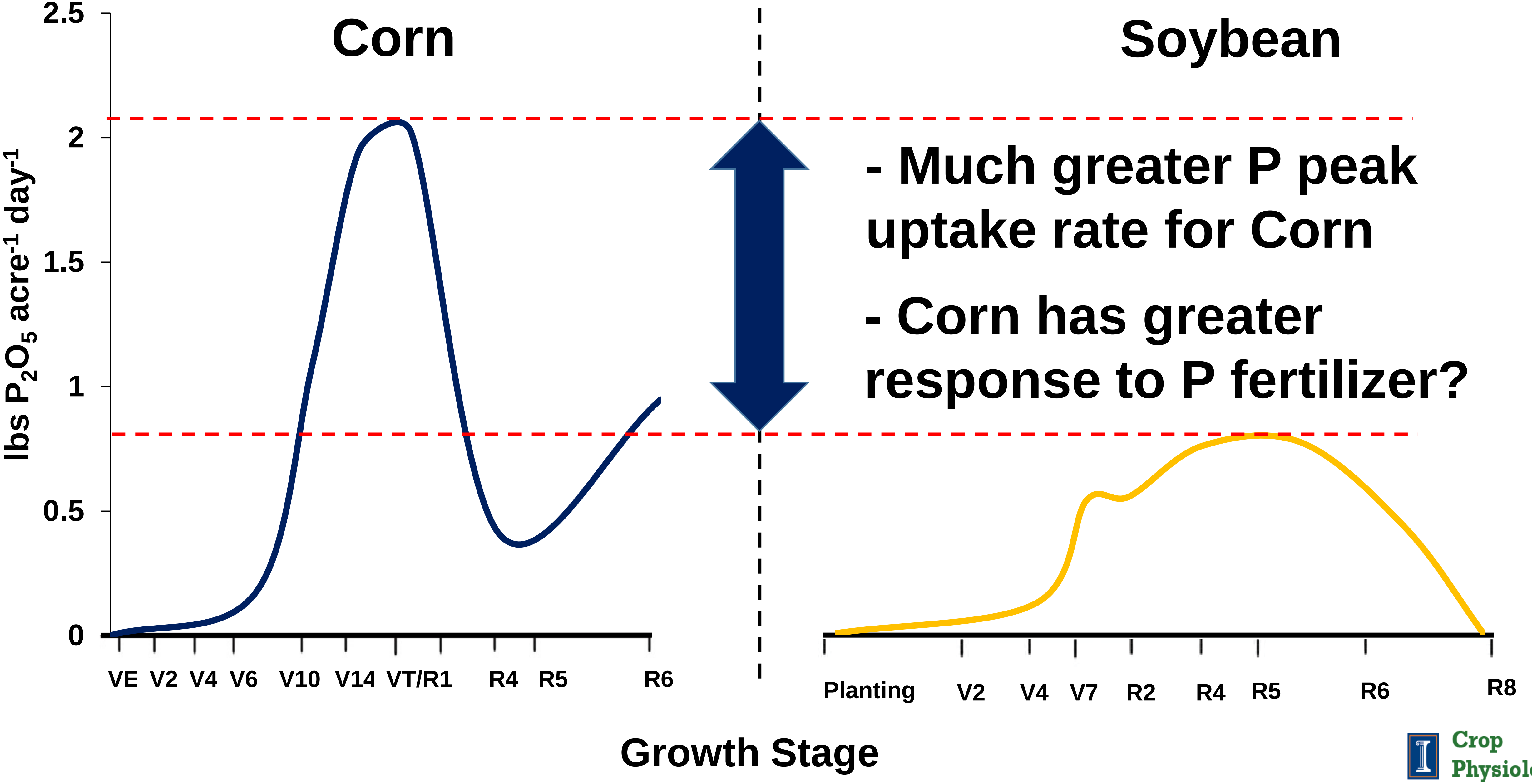

Crop Physiology

# Phosphorus Uptake Rate by Corn vs Soybean




Crop Physiology

# Phosphorus Uptake Rate by Corn vs Soybean




Crop Physiology

# Key Differences Between Corn and Soybean Nutrient Uptake Rates

- **Soybean has an extended peak uptake for most nutrients.**
- **Corn has greater peak uptake rate for all nutrient besides boron.**
- **Peak uptake for most nutrients on corn is during the rapid growth phase (V10-VT).**
- **For soybean, peak uptake for most nutrients is around R3-R4.**

| Nutrient | Corn 230bu/A | Soybean 60 bu/A | Δ Corn - Soybean |
|---|---|---|---|
| | — kg $ha^{-1}$ $day^{-1}$ — | | |
| N | 8.9 | 4.6 | 93% |
| P | 2.4 | 0.8 | 204% |
| K | 5.8 | 3.4 | 71% |
| Mg | 2.2 | 0.7 | 219% |
| S | 0.7 | 0.3 | 141% |
| Zn | 14.2 | 4.0 | 256% |
| Mn | 18.0 | 5.3 | 241% |
| B | 3.3 | 5.2 | -36% |
| Fe | 95.3 | 9.7 | 882% |
| Cu | 3.0 | 0.9 | 245% |

# Key Takeaways

- **Set the yield potential with proper early season nutrient availability (adequate soil test or planter applied fertility).**

- **The future has to be better placement of fertilizer to meet the high demand for nutrients during the phase of peak uptake.**

Crop Physiology

# Air as the Third Source of Nitrogen for Corn

Logan Woodward
Crop Physiology Field Day
University of Illinois at Urbana-Champaign

PIVOT BIO

Crop Physiology

# Limited N "Pools" for Crop Production

PIVOT BIO




Crop Physiology

# The Nitrogen Puzzle

PIVOT BIO

## Crop Uptake

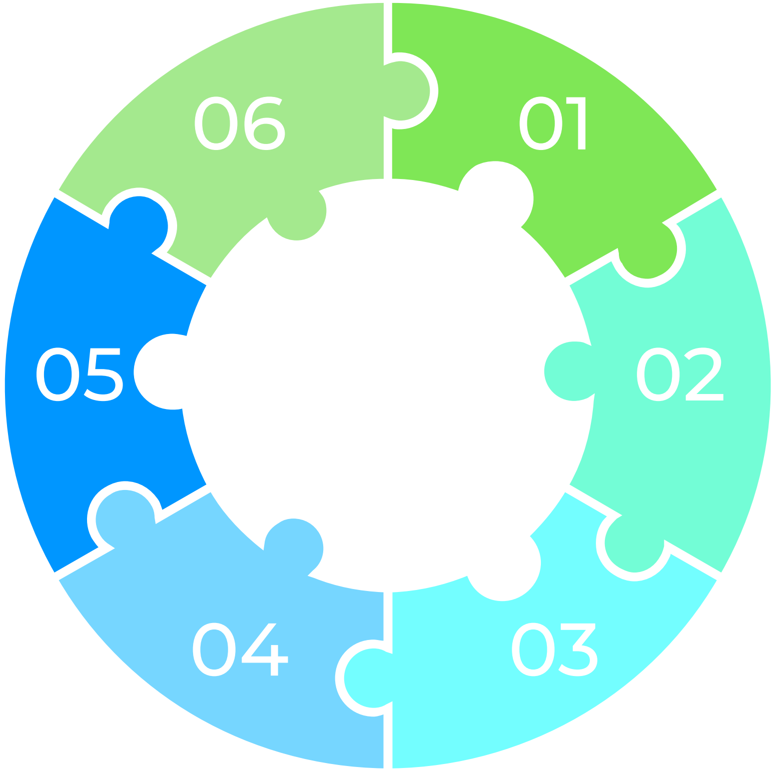
Plant available nitrogen taken up by the crop

## Erosion and Runoff

Nitrogen lost with movement of water and soil

## Immobilization

Plant available nitrogen converted to unavailable forms




## Leaching

Nitrate Nitrogen ($NO_3^-$) lost with water

## Denitrification

Nitrate Nitrogen ($NO_3^-$) lost to the air

## Volatilization

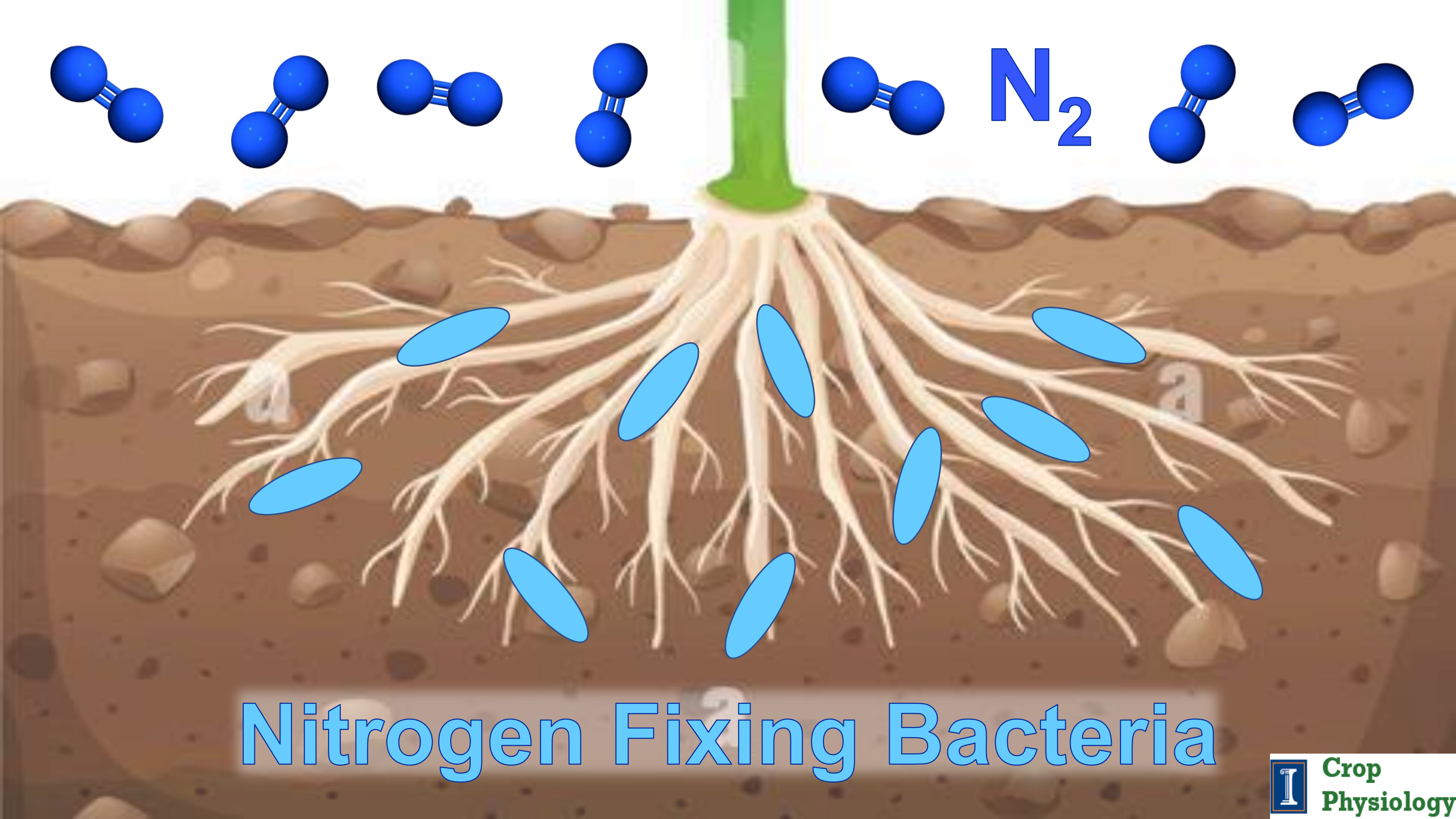
Nitrogen ($NH_4$) lost to the air

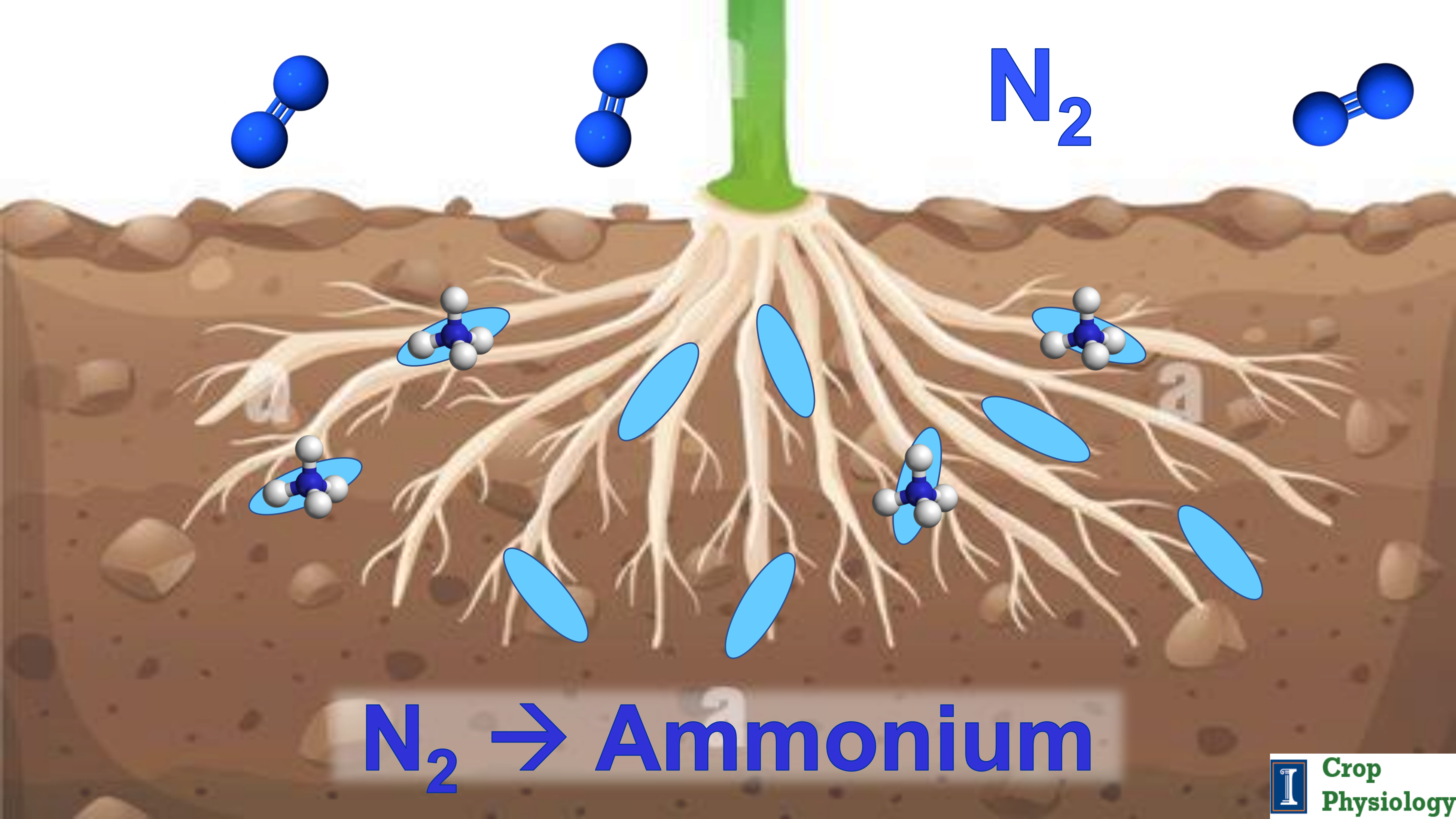
Crop Physiology

# Spatial Variability of Plant-Available N

PIVOT BIO

Crop Physiology


$N_2$
Nitrogen Fixing Bacteria
Crop Physiology



N2
N2 → Ammonium
Crop Physiology

# Benefits of N-Fixing Bacterial Inoculants | PIVOT BIO

- **Provide a source of N in rooting zone with a lower likelihood of loss.**
- **$NH_4^+$ may be a plant-preferred source.**
- **$NH_4^+$ plant uptake can enhance anion nutrient uptake (P & S).**

# What is PIVOT BIO PROVEN 40?



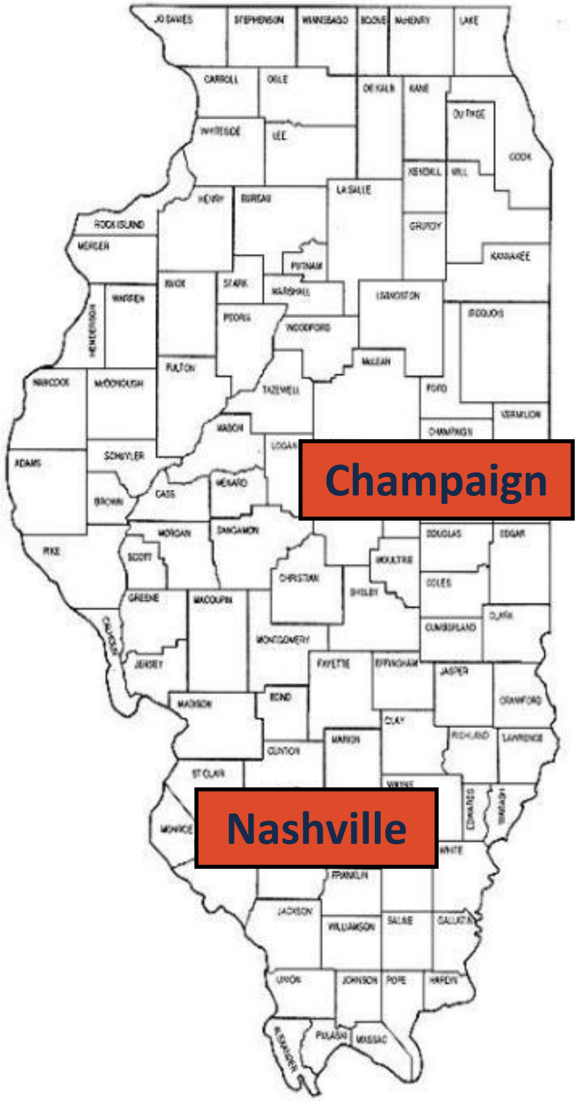
- Nitrogen-fixer with two bacteria species.
  - *Klebsiella variicola & Kosakonia sacchari*
- Bacterial species have been deregulated to “turnoff” natural feedback mechanism.

# Field Trial Treatments – 2019-2021

PIVOT BIO

| Nitrogen Rate | In-Furrow |
|---|---|
| lbs N/acre | |
| 0 | |
| 40 | None |
| 80 | |
| 120 | PROVEN® 40 |
| 200 | |

Nitrogen fertilizer applied as urea preplant broadcast incorporated.
Corn seeded at a target population of 36,000 or 34,000 plants/acre at Champaign or Nashville, respectively.




Crop Physiology

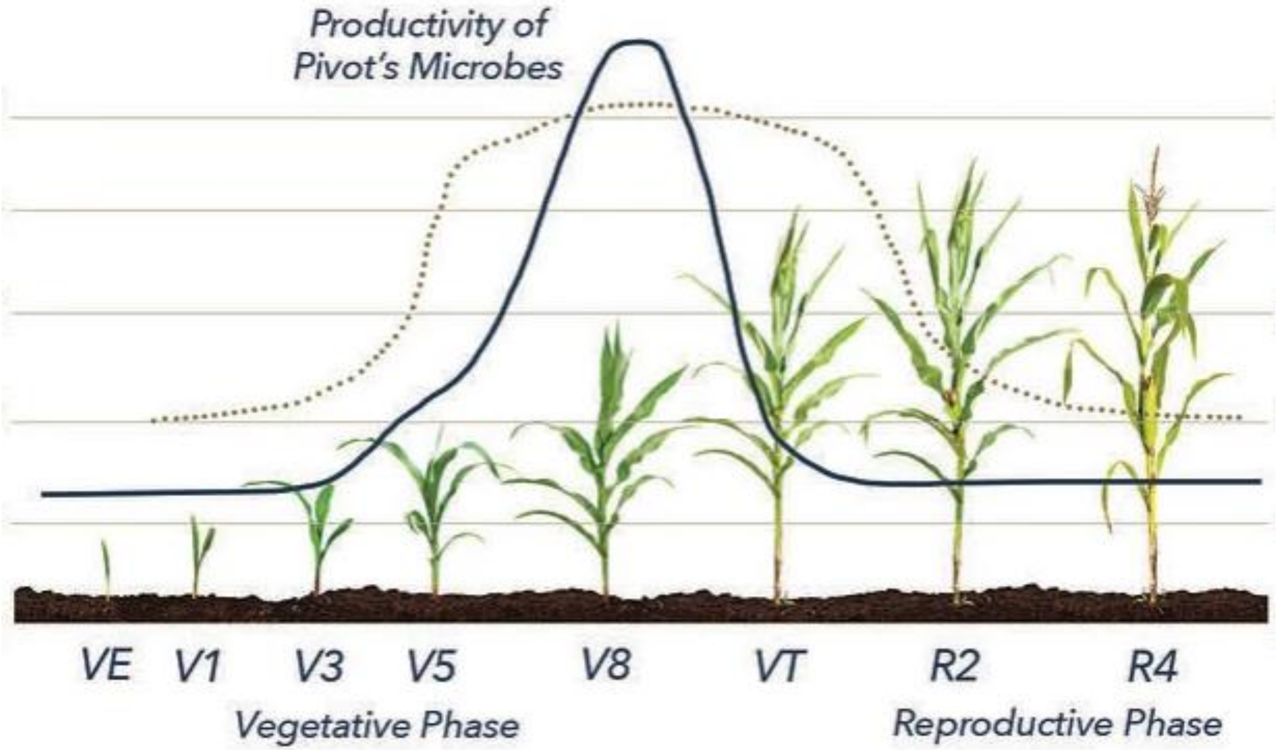
# V8 Total N Uptake – 4 Site-Years 2019-2021 | PIVOT BIO

| Nitrogen Rate | In-Furrow Treatment | | |
|---|---|---|---|
| | None | PROVEN® 40 | |
| lbs N/acre | lbs N/acre | | |
| 0 | 28.2 | 29.4 | +1.2 |
| 40 | 33.9 | 37.1 | +3.3 |
| 80 | 40.4 | 43.1 | +2.7 |
| 120 | 45.5 | 46.1 | +0.6 |
| 200 | 45.7 | 47.0 | +1.2 |
| Average | | | |

Champaign, IL 2019-2021 & Nashville, IL 2021
* Denotes a significant difference compared to the untreated control
LSD (0.10) PROVEN® 40 Treatment = 1.1; N Rate x PROVEN® 40 Treatment = NS

Crop Physiology

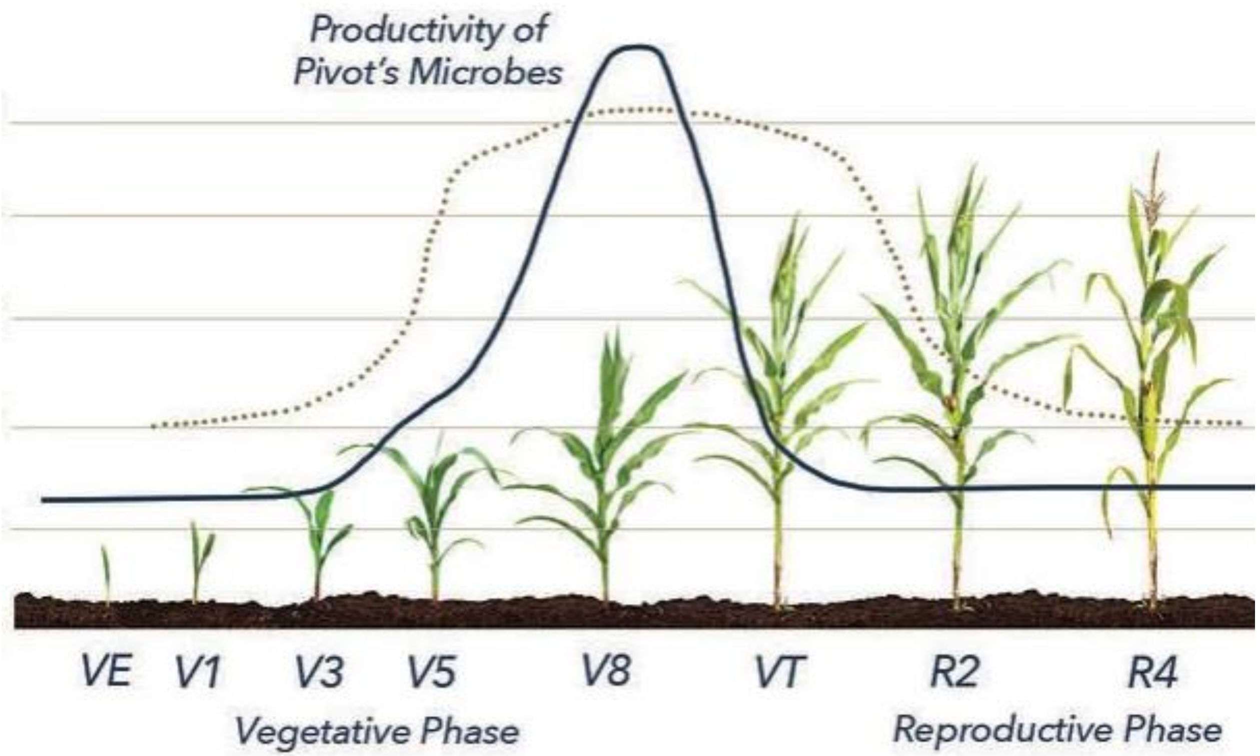
# PROVEN® 40 Activity Across the Season | PIVOT BIO

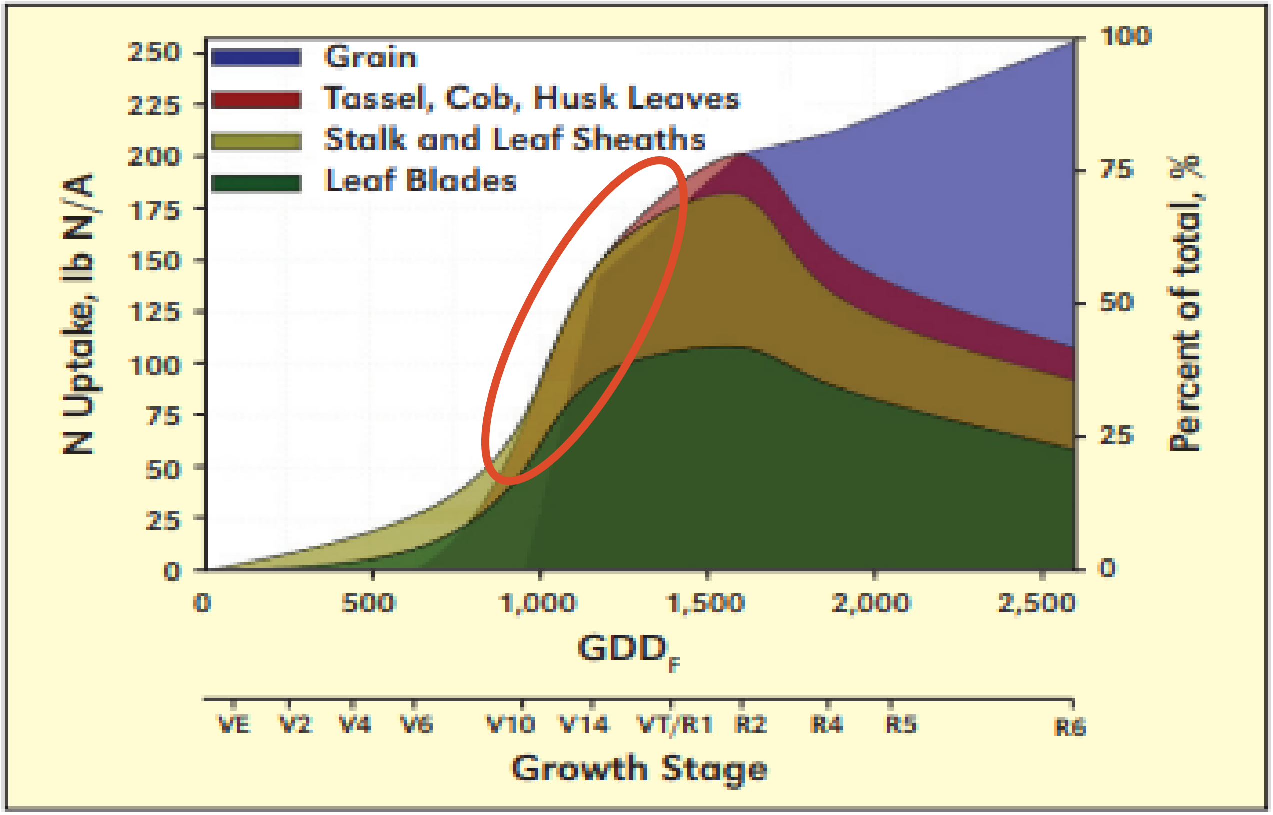



**Obtained from Pivot Bio**

# Corn N Demand Throughout the Season

PIVOT BIO



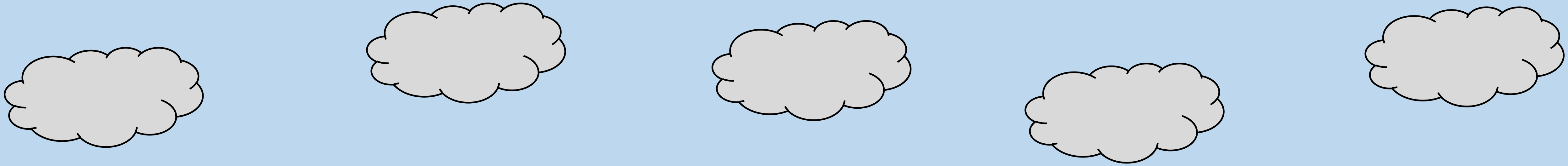




**Obtained from Pivot Bio**

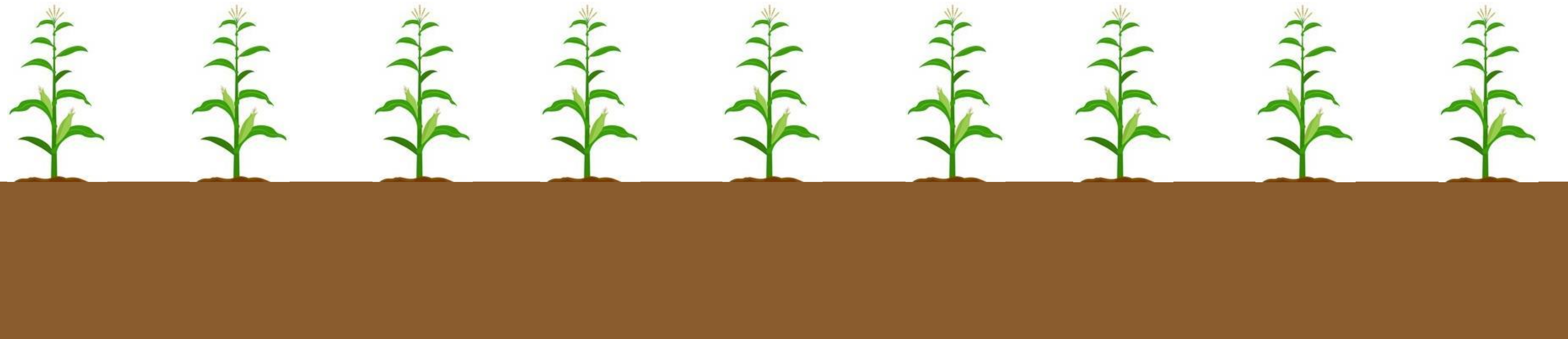
**Bender et al., 2013**

Crop Physiology

# What is ∂15N Abundance?



**Earth's atmosphere mainly consists of $^{14}N$**
**~99.6337%**



# What is ∂15N Abundance?

PIVOT BIO

**Earth's atmosphere mainly consists of $^{14}$N ~99.6337%**

**Naturally $^{15}$N Enriched Soils**

Reduction in $\partial^{15}$N is a result of greater $^{14}$N fixed from the atmosphere by N-fixing bacteria

# V8 Maize ∂15N – 3 Site-Years 2020-2021 | PIVOT BIO

| | Leaf ∂$^{15}$N | | Stalk ∂$^{15}$N | |
|---|---|---|---|---|
| | In-Furrow Treatment | | | |
| Nitrogen Rate | None | PROVEN® 40 | None | PROVEN® 40 |
| lbs N/acre | ∂15N (‰) | | | |
| 0 | 4.88 | 4.83 -0.05 | 2.33 | 2.18 -0.15 |
| 40 | 4.65 | 4.37 -0.28 | 2.98 | 2.74 -0.24 |
| 80 | 4.28 | 3.80 -0.48 | 1.95 | 2.03 +0.08 |
| 120 | 3.70 | 3.74 +0.04 | 2.17 | 1.85 -0.32 |
| 200 | 3.69 | 3.49 -0.20 | 2.41 | 1.81 -0.60 |
| Average | 4.24 | 4.05* | 2.37 | 2.12* |

Champaign, IL 2020-2021 & Nashville, IL 2021
* Denotes a significant difference compared to the untreated control
LSD (0.10) PROVEN® 40 Leaf ∂15N = 0.15, PROVEN® 40 Stalk ∂15N = 0.25
LSD (0.10) N Rate x PROVEN® 40 Leaf ∂15N = NS, N Rate x PROVEN® 40 Stalk ∂15N = NS

Crop Physiology

# Grain Yield – 4 Site-Years 2019-2021 | PIVOT BIO

| Nitrogen Rate | In-Furrow Treatment: None | In-Furrow Treatment: PROVEN® 40 | |
|---|---|---|---|
| lbs N/acre | bu/acre | bu/acre | |
| 0 | 126 | 126 | -- |
| 40 | 153 | 156 | +3 |
| 80 | 176 | 180 | +4 |
| 120 | 201 | 204 | +3 |
| 200 | 220 | 220 | -- |
| **Average** | 175 | 177* | |

Champaign, IL 2019-2021 & Nashville, IL 2021
* Denotes a significant difference compared to the untreated control
LSD (0.10) PROVEN® 40 Treatment = 2; N Rate x PROVEN® 40 Treatment = NS

Crop Physiology

# Grain Yield and Kernel Number – 4 Site-Years 2019-2021

PIVOT BIO

| | Grain Yield | | | Kernel Number | | |
|---|---|---|---|---|---|---|
| | In-Furrow Treatment | | | | | |
| Nitrogen Rate | None | PROVEN® 40 | | None | PROVEN® 40 | |
| lbs N/acre | bu/acre | | | kernel/m² | | |
| 0 | 126 | 126 | -- | 3172 | 3163 | -9 |
| 40 | 153 | 156 | +3 | 3641 | 3779 | +138 |
| 80 | 176 | 180 | +4 | 4007 | 4134 | +127 |
| 120 | 201 | 204 | +3 | 4429 | 4480 | +51 |
| 200 | 220 | 220 | -- | 4711 | 4707 | -4 |
| Average | 175 | 177* | | 3992 | 4053* | |

Champaign, IL 2019-2021 & Nashville, IL 2021

* Denotes a significant difference compared to the untreated control

LSD (0.10) PROVEN® 40 Grain Yield = 2, PROVEN® 40 Kernel Number = 47

LSD (0.10) N Rate x PROVEN® 40 Grain Yield = NS, N Rate x PROVEN® 40 Kernel Number = NS

Crop Physiology

# Application and Colonization of Pivot Bio Nitrogen Fixing Bacteria

# Grain Yield – 4 Locations in 2022

PIVOT BIO

| Treatment | Grain Yield† | |
|---|---|---|
| | bu/acre | |
| UTC | 240 | |
| PROVEN® 40 | 245* | +5* |
| + Growth Supplement 1 | 250* | +5* |
| + Growth Supplement 2 | 243 | -2 |
| + Growth Supplement 3 | 252* | +7* |
| + Growth Supplement 4 | 247 | +2 |
| + HFCS | 242 | -2 |
| + Humic Acid | 246* | +7* |
| LSD (0.05) | 5 | |

† Grain yields presented at 15.5% moisture

* Denotes significant response compared to the UTC

Crop Physiology

# Grain Yield – 4 Locations in 2022

PIVOT BIO

| Treatment | Grain Yield† | |
|---|---|---|
| | bu/acre | |
| UTC | 240 | |
| PROVEN® 40 | 245* | |
| + Growth Supplement 1 | 250* | +5* |
| + Growth Supplement 2 | 243 | -2 |
| + Growth Supplement 3 | 252* | +7* |
| + Growth Supplement 4 | 247 | +2 |
| + HFCS | 242 | -2 |
| + Humic Acid | 246* | +6* |
| LSD (0.05) | 5 | |

† Grain yields presented at 15.5% moisture

* Denotes significant response compared to the UTC

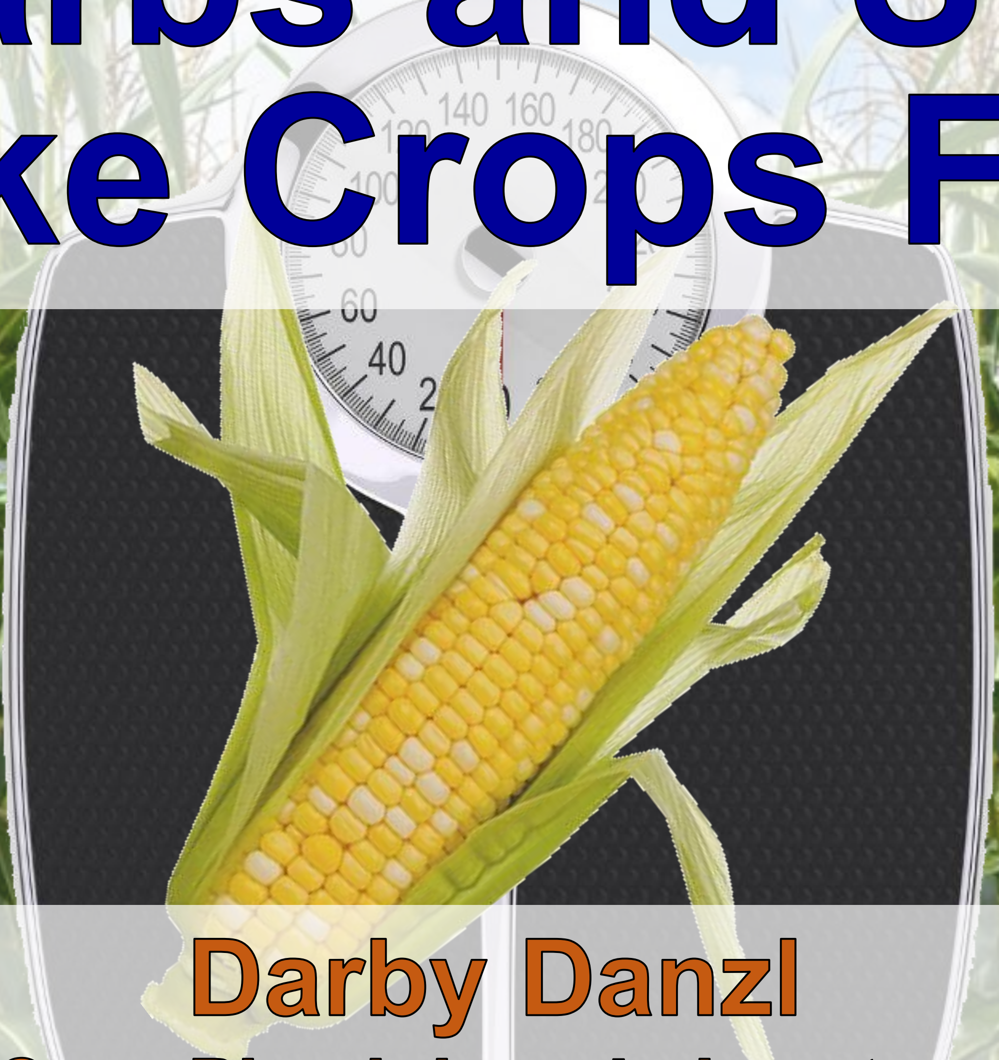
Crop Physiology

# Key Takeaways

PIVOT BIO

- PROVEN® 40 is providing additional N to plants, which is derived from the atmosphere.
- Greater early-season N uptake due to PROVEN® 40 treatment led to increased yield potential.
- Grain yield responses have occurred from PROVEN® 40 alone.
- With the right growth supplement, PROVEN® 40 yield responses are even greater.

# Do Carbs and Sugars Make Crops Fat?




**Darby Danzl**

Crop Physiology Laboratory

Department of Crop Sciences

University of Illinois, Urbana-Champaign

Crop Physiology

# What are Carbs and Sugars?

**Nutrition Facts**

7.56 servings per container

| **Serving size** | **(30g)** |
|---|---|
| **Amount per serving** | |
| **Calories** | **130** |
| | **% Daily Value*** |
| **Total Fat** 5g | **6%** |
| Saturated Fat 3g | **15%** |
| Trans Fat 0g | |
| **Cholesterol** 20mg | **7%** |
| **Sodium** 80mg | **3%** |
| **Total Carbohydrate** 19g | **7%** |
| Dietary Fiber 0g | **0%** |
| Total Sugars 11g | |
| Includes 11g Added Sugars | **22%** |
| **Protein** 2g | |
| Vitamin D 0mcg | 0% |
| Calcium 19mg | 2% |

Crop Physiology

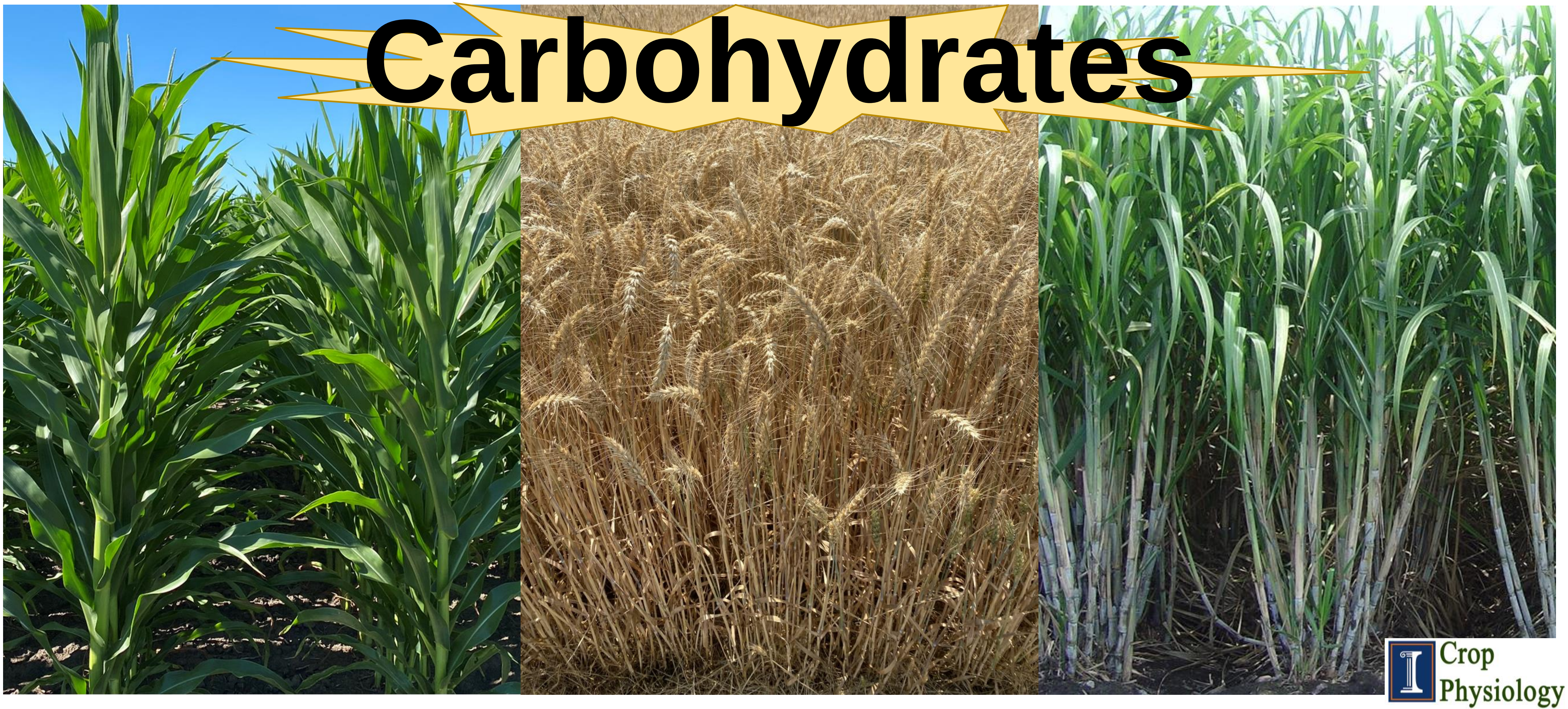
# What are Carbs and Sugars?

## Carbohydrates

Play a crucial role in the growth and development of plants, serving as their primary source of energy

Crop Physiology

# What are Carbs and Sugars?



# What are Carbs and Sugars?

**Carbohydrates**

- **Simple Carbs**
- **Complex Carbs**

Crop Physiology

# What are Carbs and Sugars?

## Carbohydrates

**Espresso Shot for Microbes**

**Long-term Food Source**

Crop Physiology

# What are Carbs and Sugars?

**Carbohydrates**

- **Readily Available**
- **Slow Release**

Crop Physiology

# What are Carbs and Sugars?

## Carbohydrates

- **Simple Carbs**
- **Complex Carbs**

Crop Physiology

# Simple Carbohydrates for Humans


Crop Physiology

# Simple Carbohydrates for Ag Production

- High fructose corn syrup
- Molasses
- Clintose
- Cane sugar


Crop Physiology

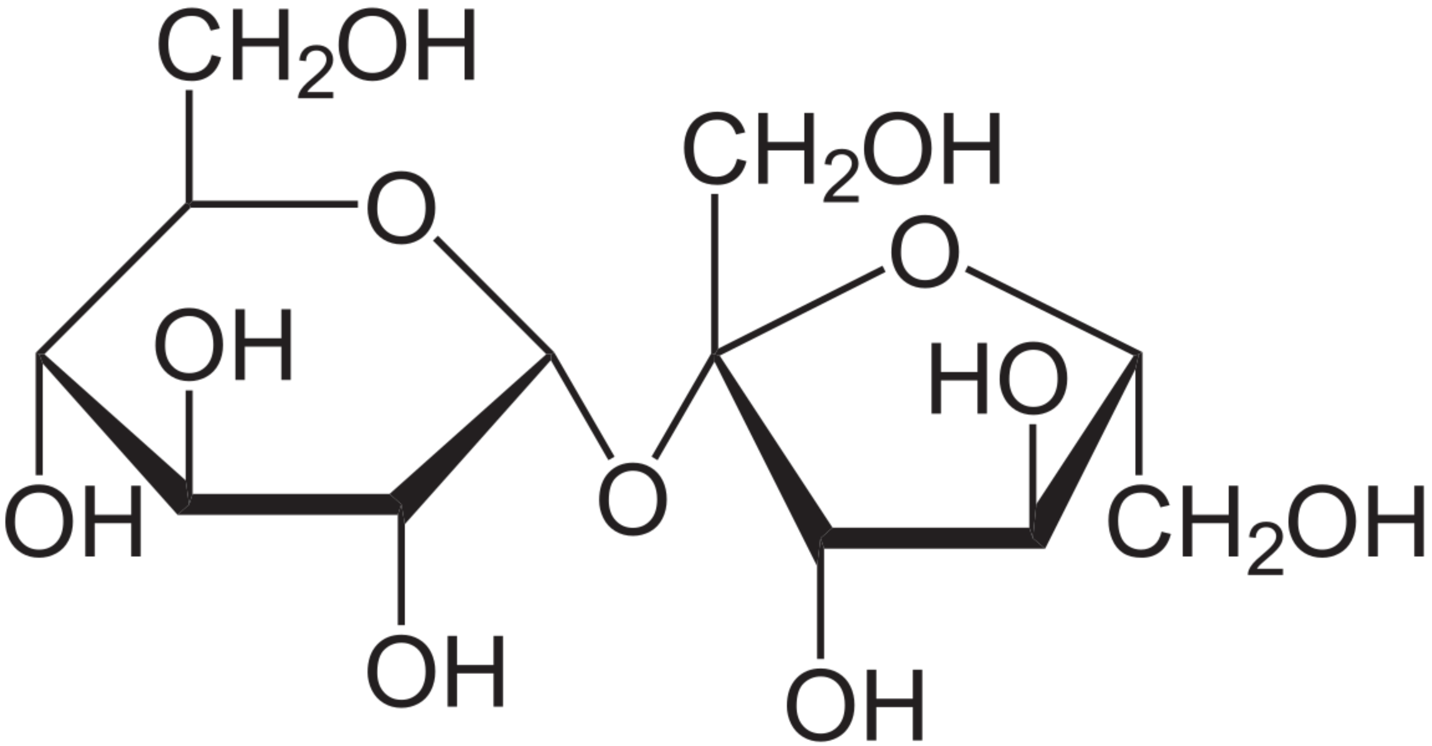
# Simple Carbohydrates for Plants

- High fructose corn syrup
- Mo
- Cli
- Ca

**Sucrose!**

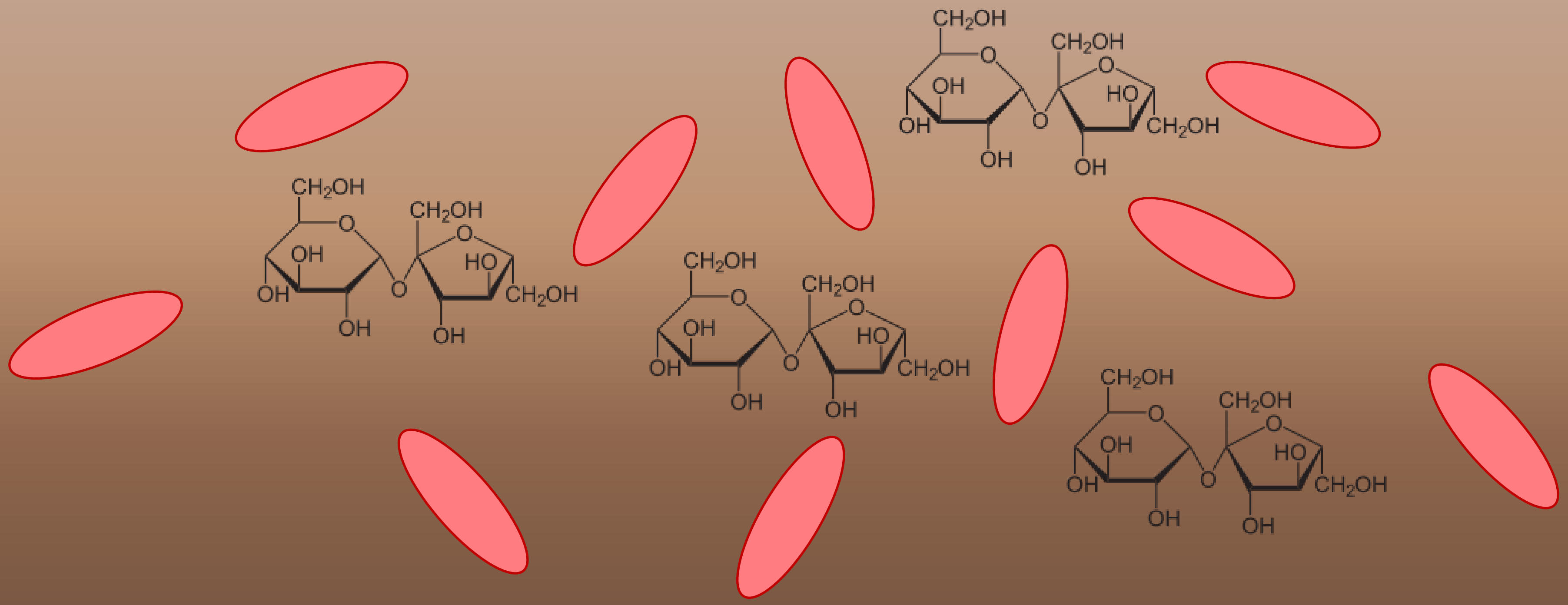

Crop Physiology

# Molecular Structure of Sucrose



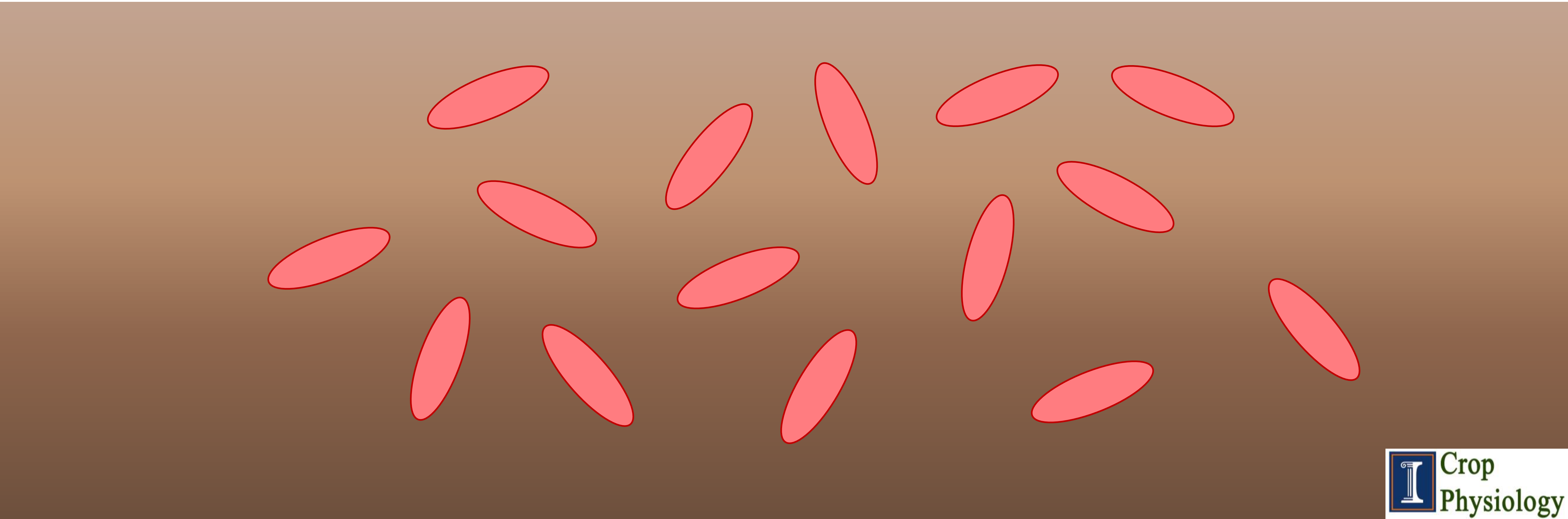

Crop Physiology

# Sugars Stimulates Microbes!




Crop Physiology

# Sugars Stimulates Microbes!



Crop Physiology

# Soil Microbes May Prefer One Sugar Source Over Another!

<

Crop Physiology

# What are Carbs and Sugars?

## Carbohydrates

Simple Carbs

Complex Carbs

Crop Physiology

# Complex Carbohydrates for Humans

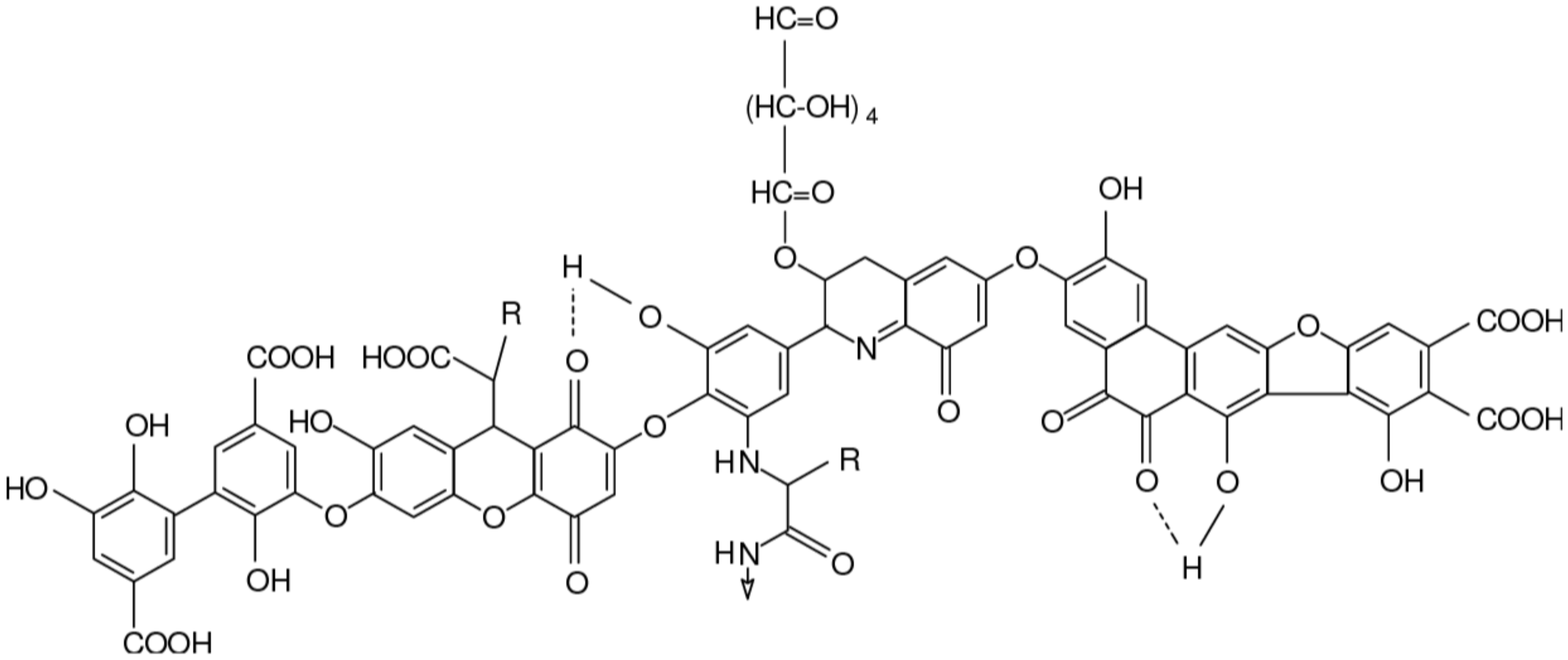
Crop Physiology

# Complex Carbohydrates for Ag Production

- Plant residues
- Humic/fulvic acids
- Soil organic matter
- Biochar

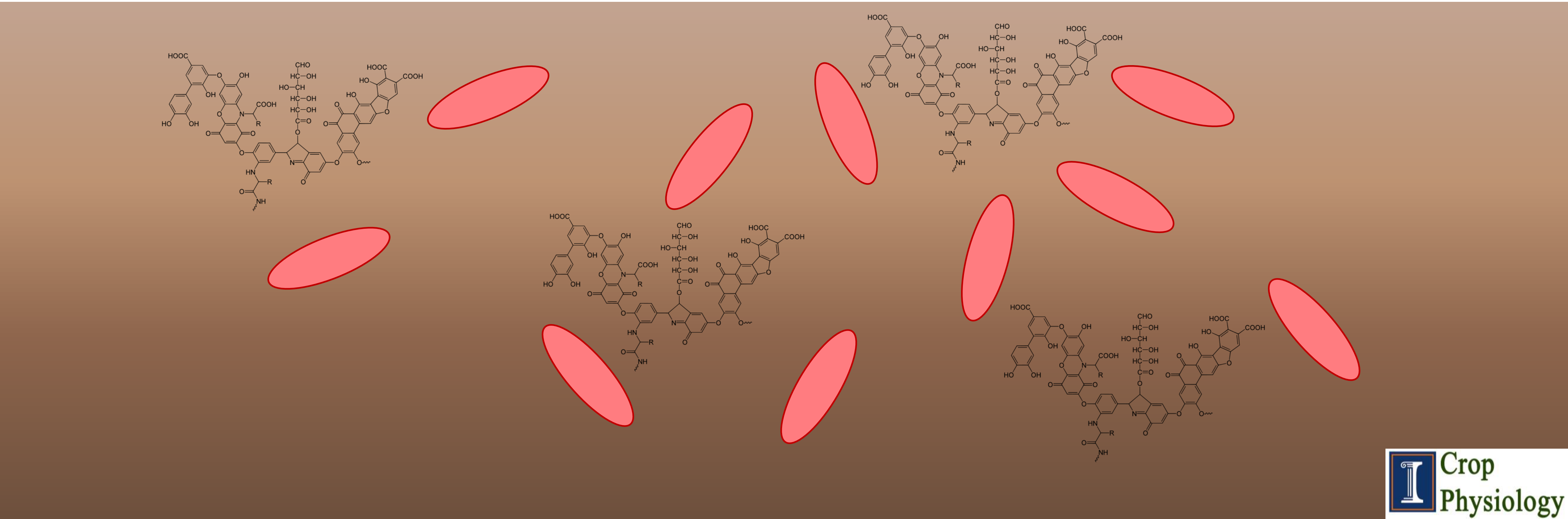
Crop Physiology

# Generic Molecular Structure of Humic Acid




(de Melo et al., 2016)

# Humic Acid is Integrated into the Soil!



Crop Physiology

# Key Takeaways

- **Sugar products are utilized as a readily available food source (espresso shot) for soil microorganisms**
- **Complex Carb (carbon, humic acid) products are utilized as a slow release (long term) soil amendment**

Crop Physiology

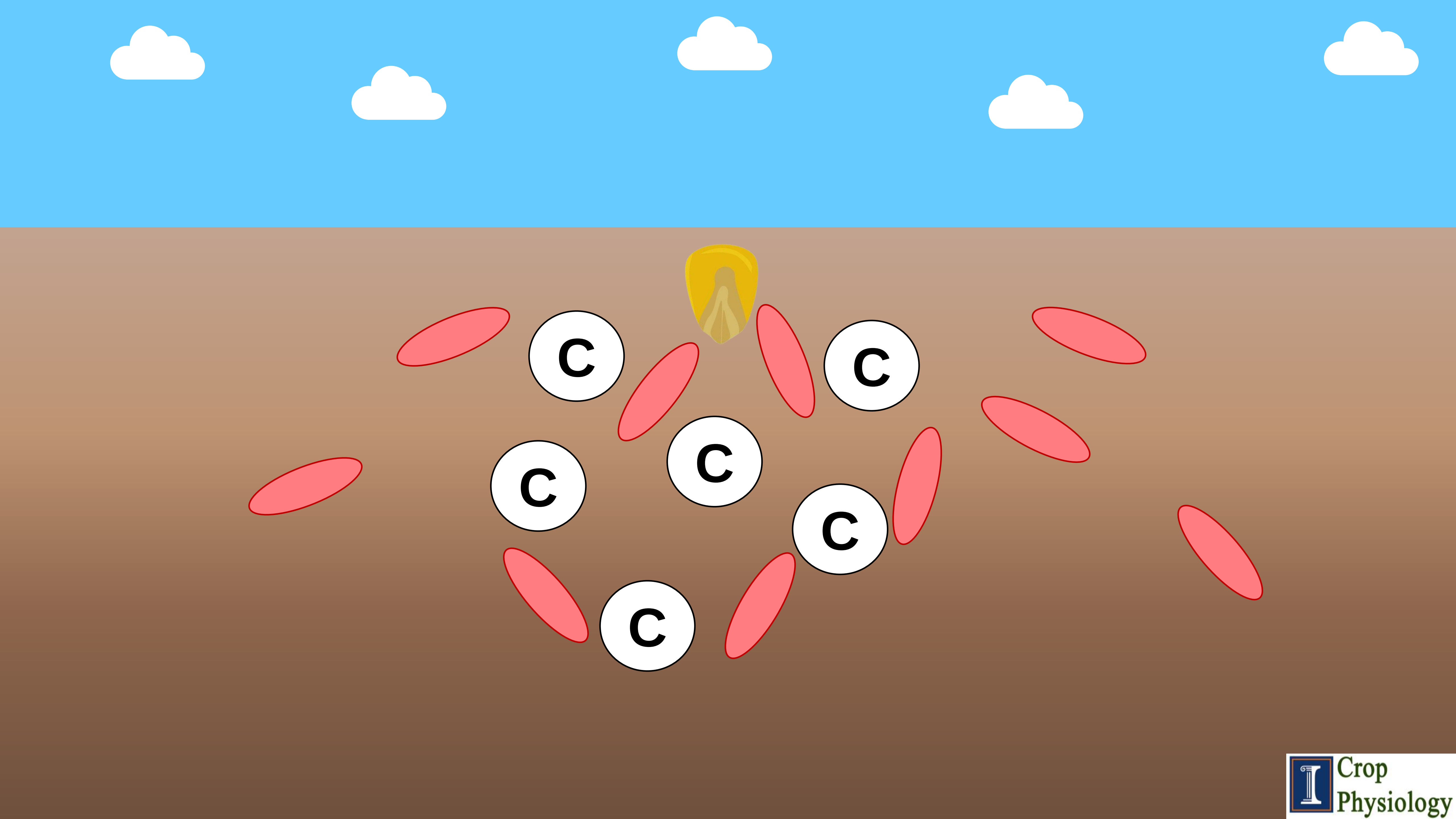
# How can we utilize sugars in crop production?


Crop Physiology

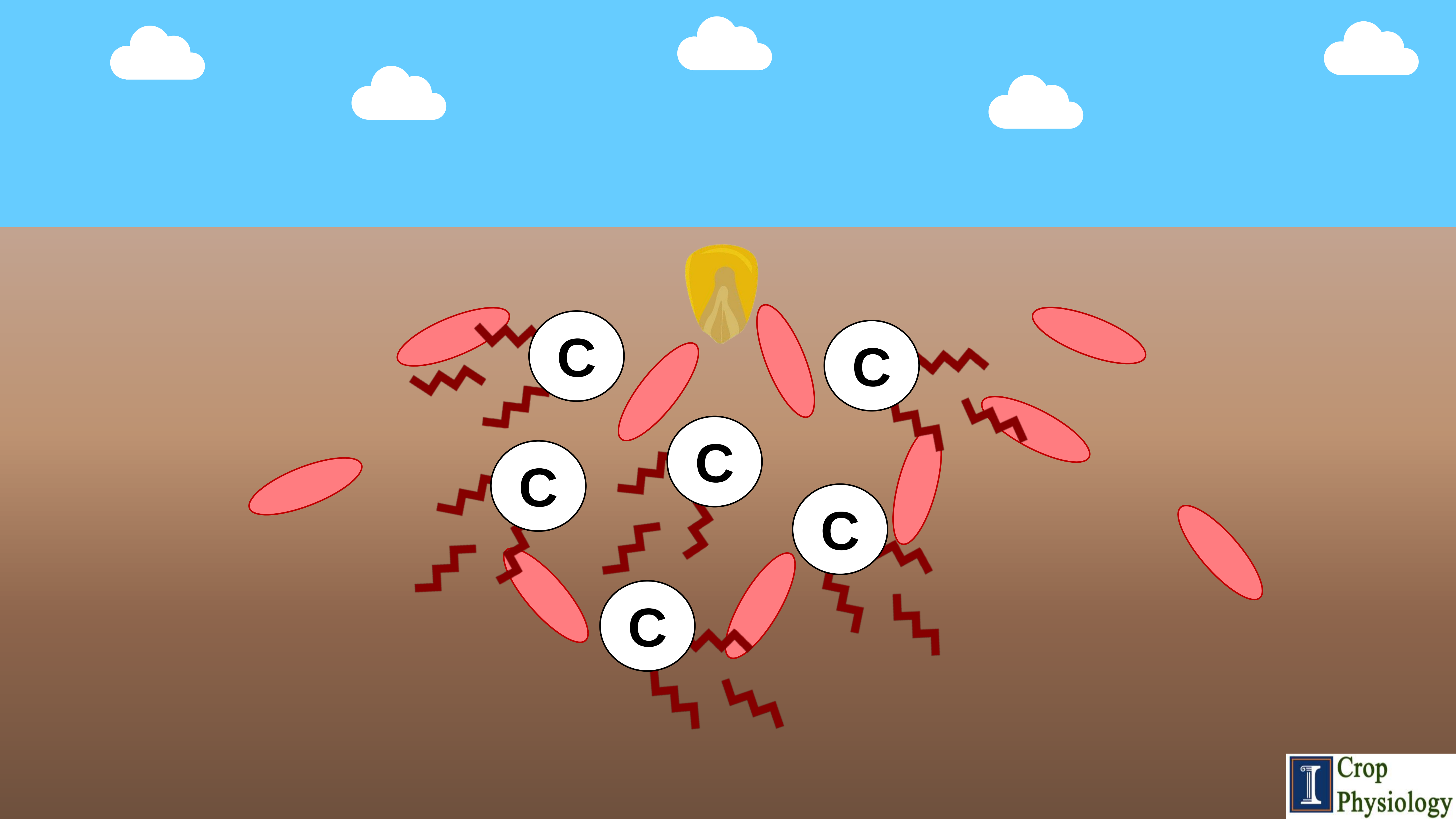
# Utilizing Sugars In-Furrow

Crop Physiology

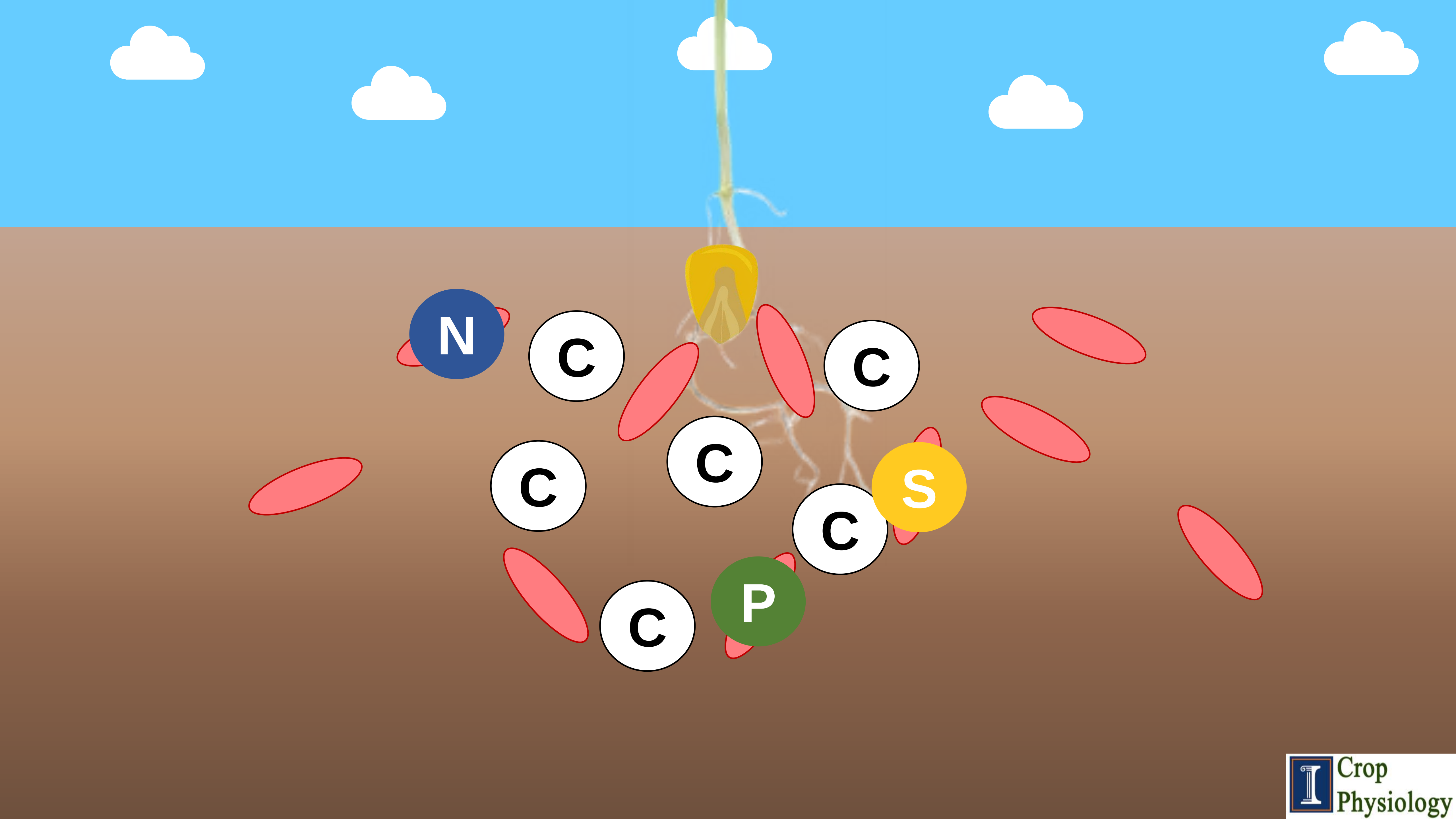

Root Exudates!
Crop
Physiology



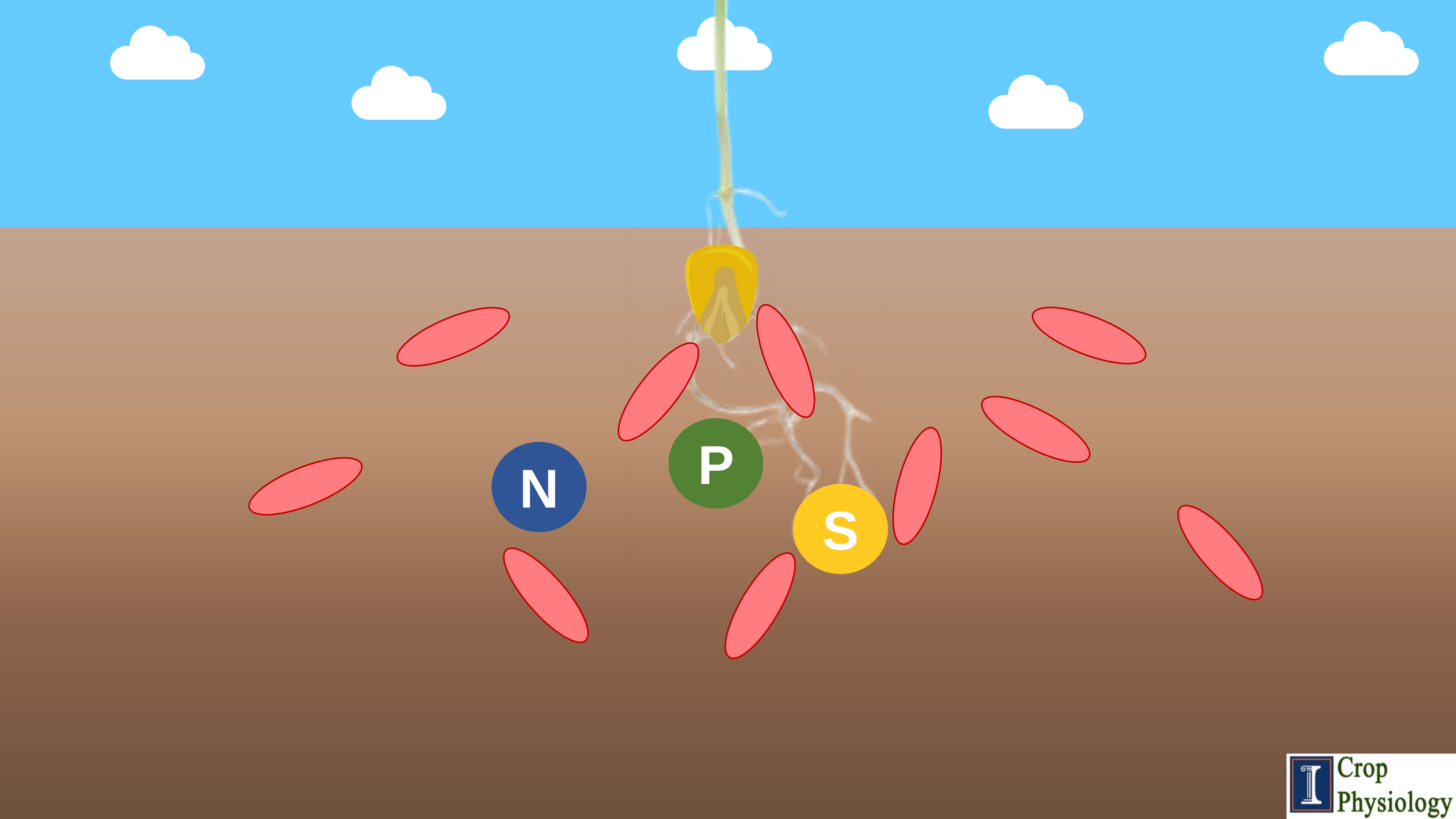

Crop Physiology




Crop Physiology




Crop Physiology




Crop Physiology

# Utilizing Sugars In-Furrow

Crop Physiology

# Corn In-Furrow Yield – 2019 - 2022

| Treatment | 2019 CU | 2021 CU | 2022 CU | 2022 NV | 2022 YV | Avg. |
|---|---|---|---|---|---|---|
| | bushels / acre | | | | | |
| Untreated Control | 259 | 251 | 208 | 234 | 205 | 231 |
| Corn Syrup† | - 2 | - 1 | + 11 | + 7 | + 2 | + 3 |
| 10-34-0 | + 5 | + 5 | + 13 | + 9 | + 4 | + 7 |
| CS + 10-34-0 | + 7 | + 12 | + 9 | + 5 | + 6 | + 8 |
| LSD ($P \leq 0.05$) | NS | NS | 9 | NS | NS | |

† Corn syrup applied as *Neovita 43* in 2022
All planted with DKC62-52 at 36,000 plants per acre

Crop Physiology

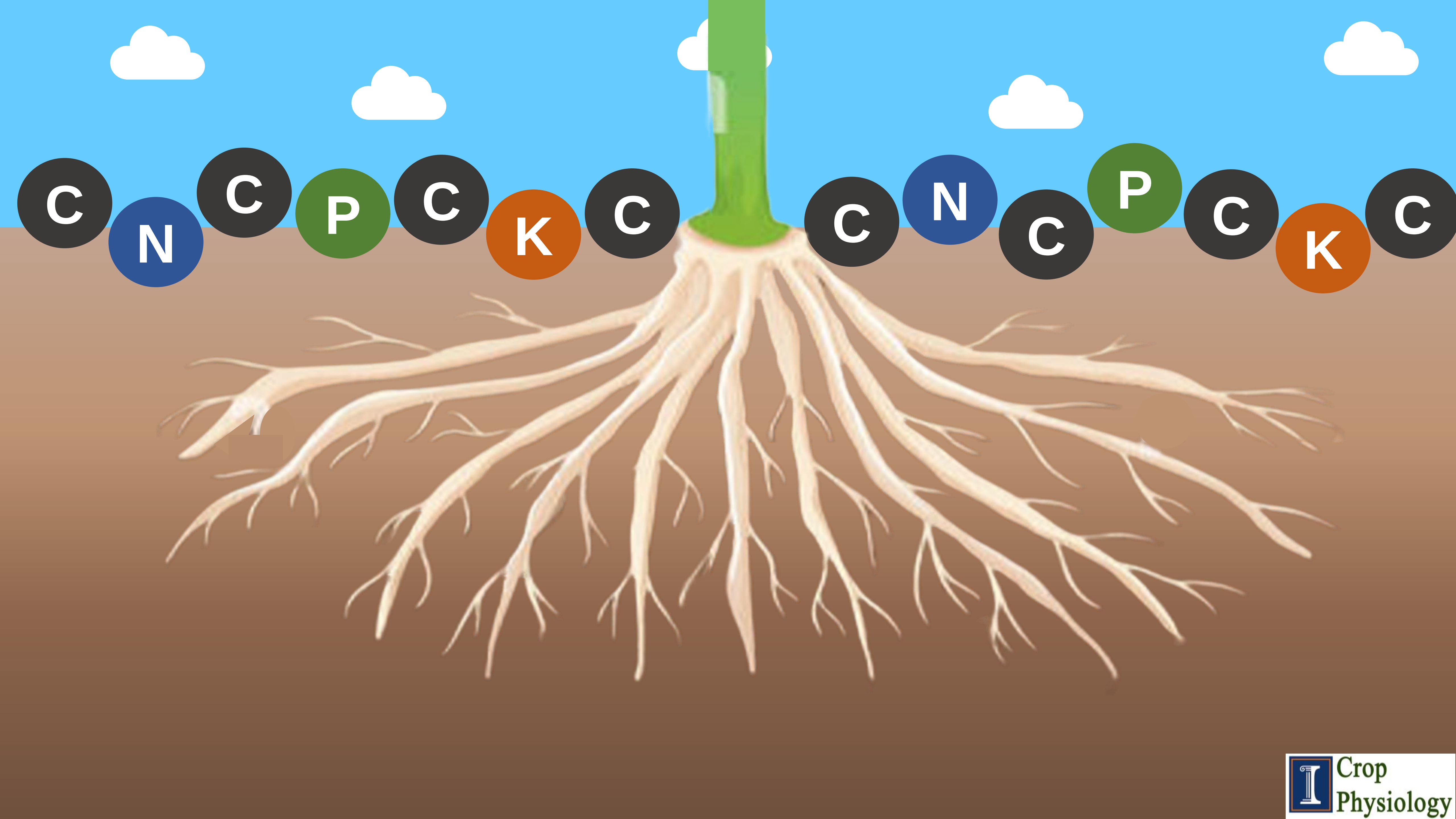
# How can we utilize complex carbs in crop production?

Crop Physiology

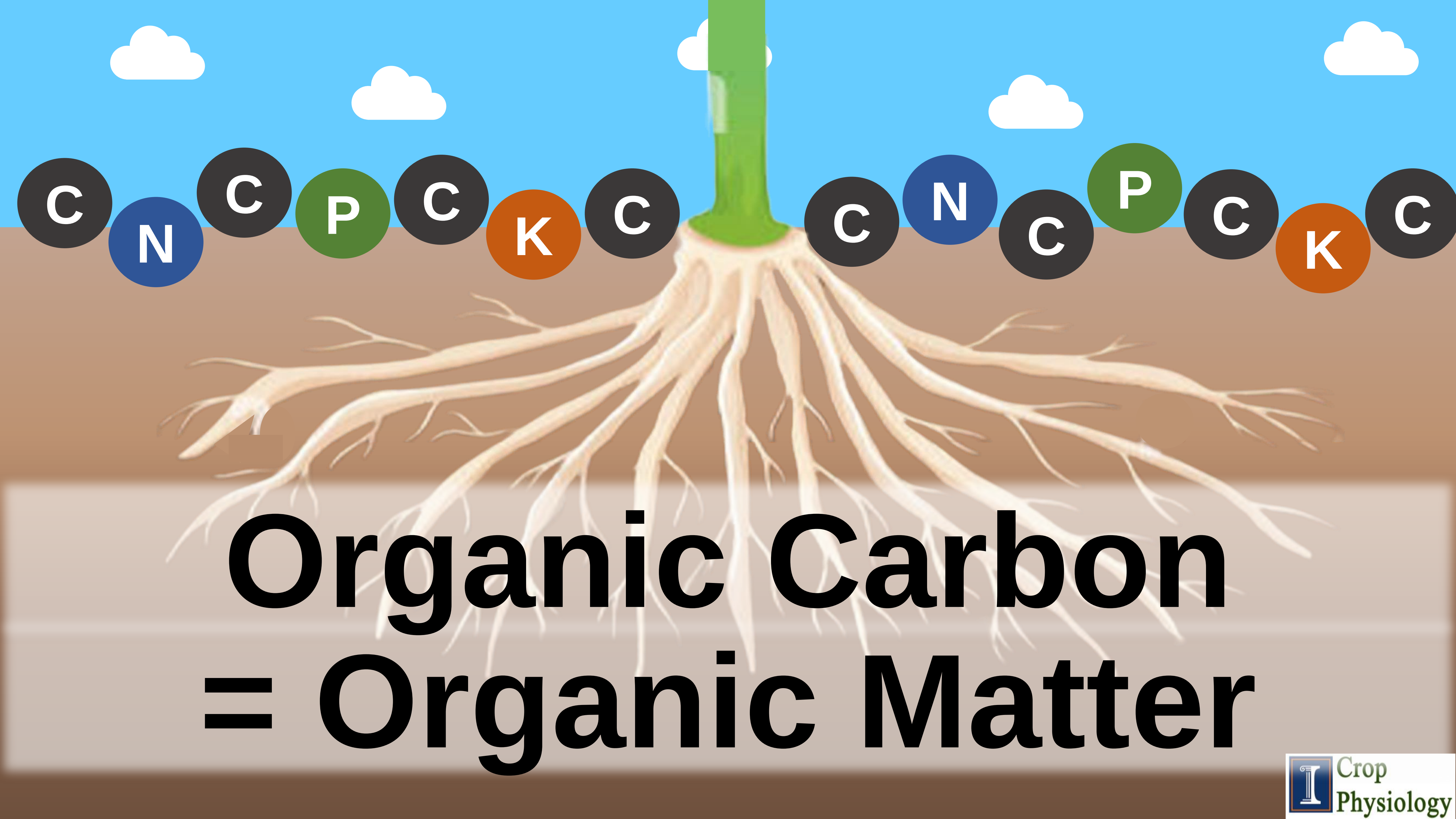
# Carbon Amendments

- **Carbon amendments contain high concentrations of carbon**
- **Do not require management change or the purchase of new equipment**
  - **- Broadcast with dry fertilization**
- **Increase soil quality and NUE**
  - **- Soil carbon increases**

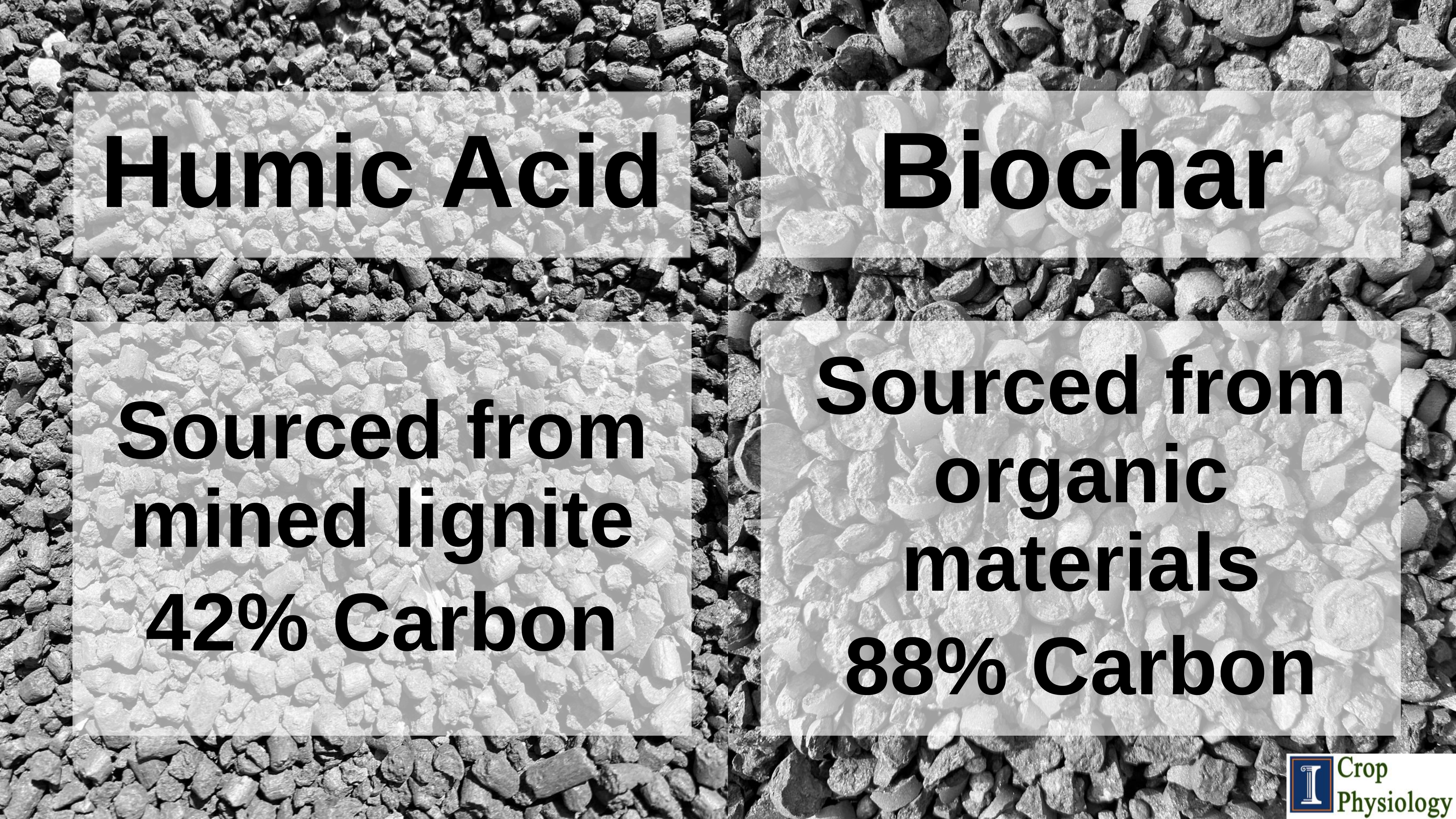
Crop Physiology




Crop Physiology


C
N
C
P
C
K
C
C
N
C
P
C
K
C
Organic Carbon
= Organic Matter
Crop
Physiology


SOC
SOIL STRUCTURE
AERATION
WATER RETENTION
PRODUCTIVITY
POLLUTANT FILTER
BIODIVERSITY
NUTRIENT CYCLING
SOIL STABILITY


Humic Acid
Sourced from mined lignite
42% Carbon
Biochar
Sourced from organic materials
88% Carbon
Crop Physiology

# 2022 Soil Supplements

| Carbon Source† | | Fertility‡ |
|---|---|---|
| None | | None |
| Biochar | X | |
| Humic Acid | | MAP & MOP |

† Average rate of carbon applied at 205 lbs C/Acre

‡ MAP applied at 60 lbs of $P_2O_5$/A; MOP applied at 60 lbs of $K_2O$/A; all plots received N at 180 lbs/A as UAN

Crop Physiology

# Yield

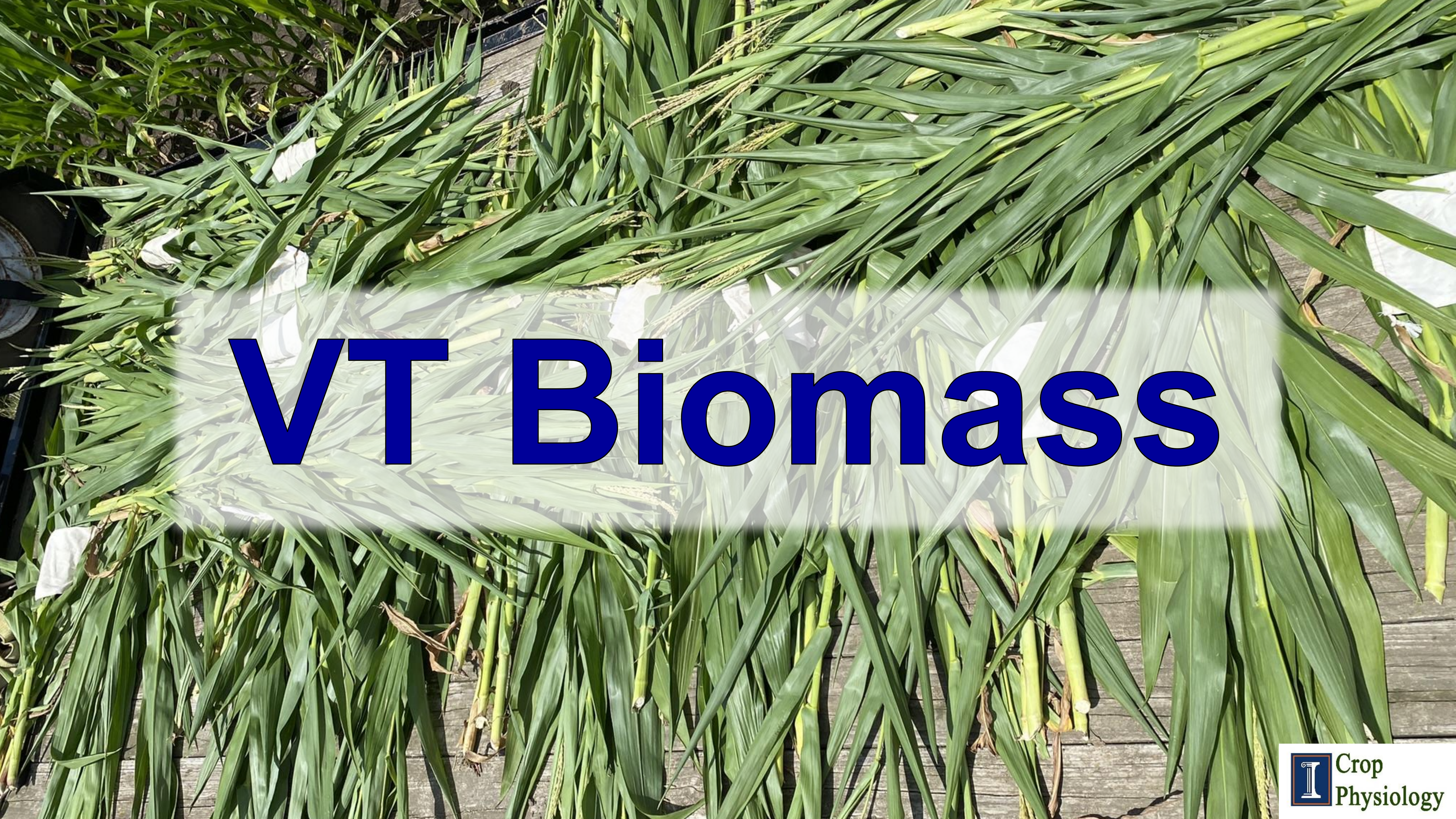
Crop Physiology

# Effect of Carbon Source and Fertility on Corn Grain Yield

| Carbon Amendment | Fertility: None | Fertility: P + K |
|---|---|---|
| | bushels / acre | |
| None | 234 | 245 +9 |
| Biochar | 241 +7 | 247 +2 |
| Humic Acid | 237 +3 | 247 +2 |

Champaign, IL (2022)

Crop Physiology


VT Biomass
Crop
Physiology

# Effects of Carbon Treatments on VT Corn Biomass Nutrient Concentration

| Treatment | N | P | K | Ca | Mg | S |
|---|---|---|---|---|---|---|
| | % | | | | | |
| UTC | 1.76 | 0.22 | 1.07 | 0.52 | 0.55 | 0.12 |
| Biochar | 1.75 | 0.23 | 1.14 | 0.51 | 0.49 | 0.12 |
| Humic Acid (HA) | 1.67 | 0.22 | 1.14 | 0.47 | 0.46 | 0.11 |
| Fertility | 1.67 | 0.22 | 1.16 | 0.55 | 0.54 | 0.12 |
| Biochar + Fertility | 1.73 | 0.22 | 1.19 | 0.51 | 0.48 | 0.12 |
| HA + Fertility | 1.70 | 0.22 | 1.17 | 0.49 | 0.49 | 0.12 |

Champaign, IL (2022)

Crop Physiology

# Effects of Carbon Treatments on VT Corn Biomass Nutrient Concentration

| Treatment | N | P | K | Ca | Mg | S |
|---|---|---|---|---|---|---|
| | % | | | | | |
| UTC | 1.76 | 0.22 | 1.07 | 0.52 | 0.55 | 0.12 |
| Biochar | 1.75 | 0.23 | 1.14 | 0.51 | 0.49 | 0.12 |
| Humic Acid (HA) | 1.67 | 0.22 | 1.14 | 0.47 | 0.46 | 0.11 |
| Fertility | 1.67 | 0.22 | 1.16 | 0.55 | 0.54 | 0.12 |
| Biochar + Fertility | 1.73 | 0.22 | 1.19 | 0.51 | 0.48 | 0.12 |
| HA + Fertility | 1.70 | 0.22 | 1.17 | 0.49 | 0.49 | 0.12 |

Champaign, IL (2022)

Crop Physiology

# Effects of Carbon Treatments on VT Corn Biomass Nutrient Concentration

| Treatment | N | P | K | Ca | Mg | S |
|---|---|---|---|---|---|---|
| | % | | | | | |
| UTC | | | 1.07 | | | |
| Biochar | | | 1.14 | | | |
| Humic Acid (HA) | | | 1.14 | | | |

Champaign, IL (2022)

Crop Physiology

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| Treatment | N | P | K | Ca | Mg | S |
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| Biochar | | | 1.14 | | | |
| Humic Acid (HA) | | | 1.14 | | | |
| Fertility | | | 1.16 | | | |
| Biochar + Fertility | | | 1.19 | | | |
| HA + Fertility | | | 1.17 | | | |

Champaign, IL (2022)

Crop Physiology

# Effects of Carbon Treatments on VT Corn Biomass Nutrient Concentration

| Treatment | N | P | K | Ca | Mg | S |
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| | % | | | | | |
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Champaign, IL (2022)

Crop Physiology

# Effects of Carbon Treatments on VT Corn Biomass Nutrient Concentration

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| Humic Acid (HA) | | | | 0.47 | 0.46 | |
| Fertility | | | | 0.55 | 0.54 | |
| Biochar + Fertility | | | | 0.51 | 0.48 | |
| HA + Fertility | | | | 0.49 | 0.49 | |

Champaign, IL (2022)

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Crop
Physiology

# Applying a CEC source that does not fix K
# = more plant available K

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# Do Carbs and Sugars Make Crops Fat?

- Sugars immediately increase microbial activity and accelerate nutrient release
- Complex carbs breakdown slowly and enhance soil composition
- BOTH CONTRIBUTE TO FATTER YIELDS!

Crop Physiology

# Reduce, Reuse, Recycle…Your Residue!


## Connor Sible

**Crop Physiology Laboratory**
**Department of Crop Sciences**
**University of Illinois at Urbana-Champaign**


**2023 Crop Physiology Field Day**
**August 2nd, 2023**

Crop Physiology

# Where does residue come from?

Cover Crops (cereal rye)

Double Crops

Higher Yields

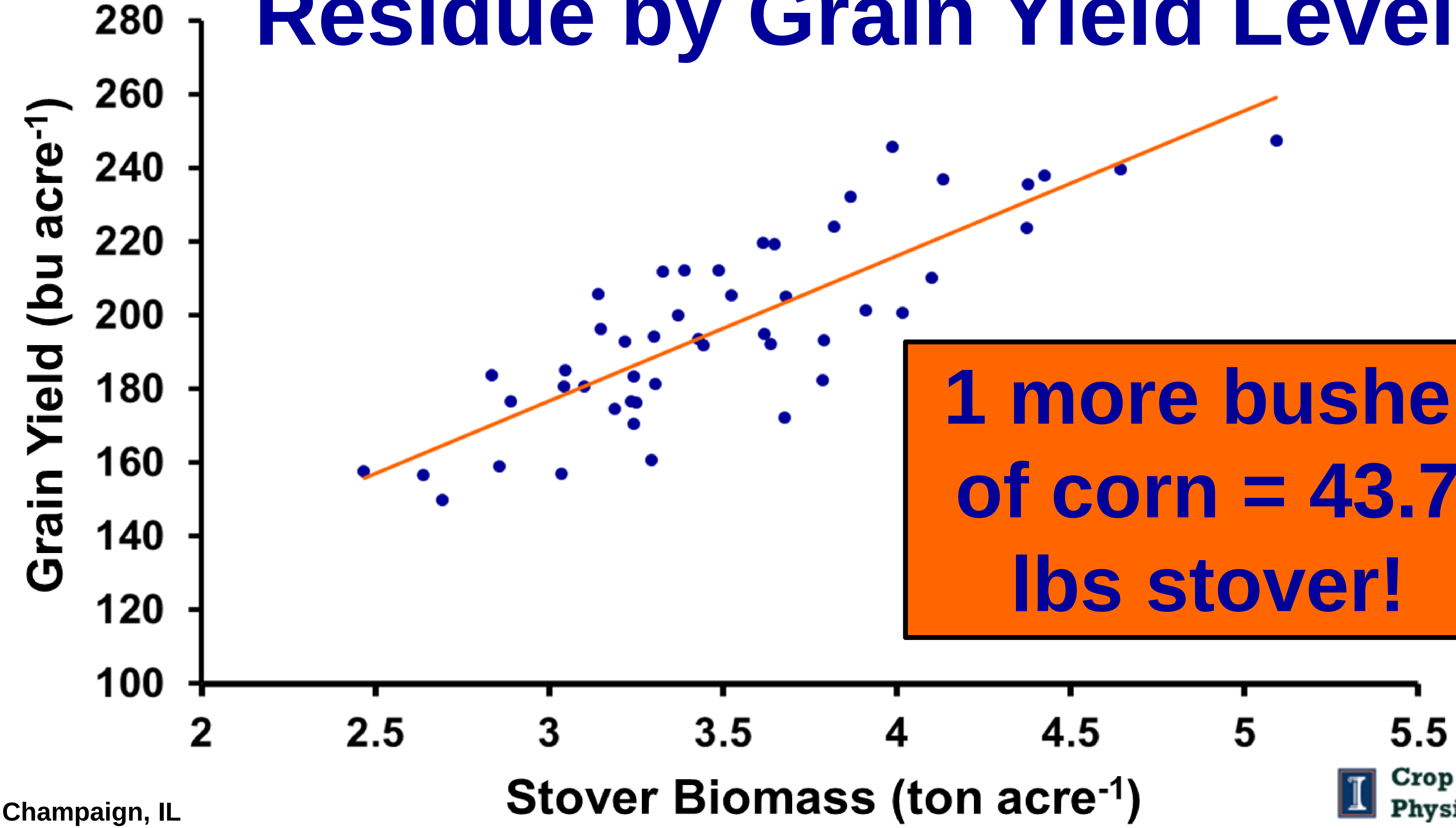
# Where does residue come from?

Cover Crops (cereal rye)

Double Crops

Higher Yields

# Residue by Grain Yield Level




**1 more bushel of corn = 43.7 lbs stover!**

Champaign, IL

Crop Physiology

# Corn Residue by Yield Level

| Grain Yield | Stover Accumulation |
|---|---|
| bu $acre^{-1}$ | ton $acre^{-1}$ |
| 180 | 3.9 |
| 250 | 5.5 |
| 300 | 6.6 |
| 616 | 13.5 |

Assuming a harvest index of 52%

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# Is residue trash or treasure?

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# Too Much Residue Can be a Problem


**"Trash"**

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# Residue and the Continuous Corn Yield Penalty

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# The Idea of the Soybean N Credit

- It has been well established that corn-soybean rotation results in greater corn yields than continuous corn

- Traditional thinking was in relation to the soybean nitrogen credit due to association with rhizobium bacteria where a legume in rotation adds N to the soil for the next season's crop

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# The Idea of the Soybean N Credit

- **While some residual N can be associated with nodulated soybean, the N removed in the grain is greater than the N supplied by the nodules**

- **The "N Credit" is largely the result of a decrease in net N mineralization under continuous corn…rather, a "carbon penalty"**

Gentry et al., 2001

Crop Physiology

# Continuous Corn vs. Corn-Soybean Rotation

# The Nutritional Value of Corn Residue

| Nutrient | Remaining in Residue | |
|---|---|---|
| | lbs $ton^{-1}$ | lbs $acre^{-1}$ |
| N | 20 | 108 |
| $P_2O_5$ | 4 | 21 |
| $K_2O$ | 23 | 122 |

"Treasure"

Assuming grain yield of 230 bu $acre^{-1}$ and 5.4 tons residue $acre^{-1}$.
Agron. J. 105:161-170 (2013).

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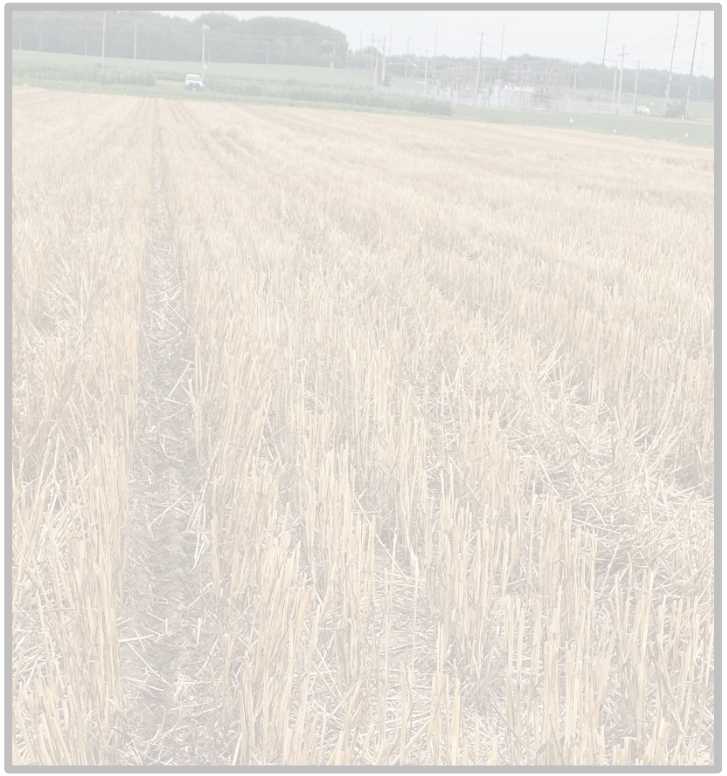
# Where does residue come from?



Cover Crops (cereal rye)

Double Crops

Higher Yields

# The Nutritional Value of Cereal Rye

| Nutrient | Remaining in Residue | |
|---|---|---|
| | lbs $ton^{-1}$ | lbs $acre^{-1}$ |
| N | 37 | 92 |
| $P_2O_5$ | 14 | 35 |
| $K_2O$ | 64 | 159 |

Assuming biomass yield of 2.5 tons per acre (recommended termination)

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# What can one do to ‘unlock’ the value of their residue?

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# Reduce, Reuse, Recycle…

- Reduce
  - Minimize Waste
- Reuse
  - Use 2x or More
- Recycle
  - Find a New Use

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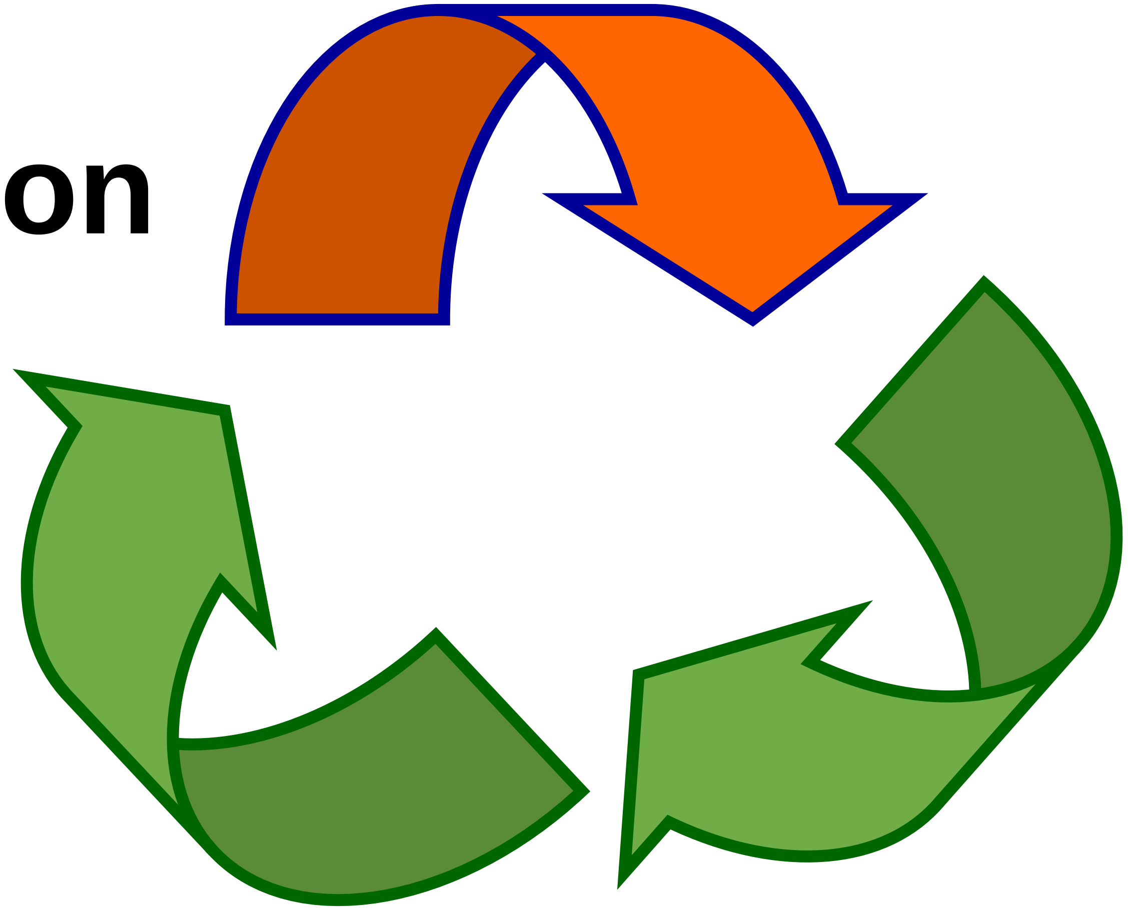
# Reduce, Reuse, Recycle…

- Reduce
  - Residue Degradation



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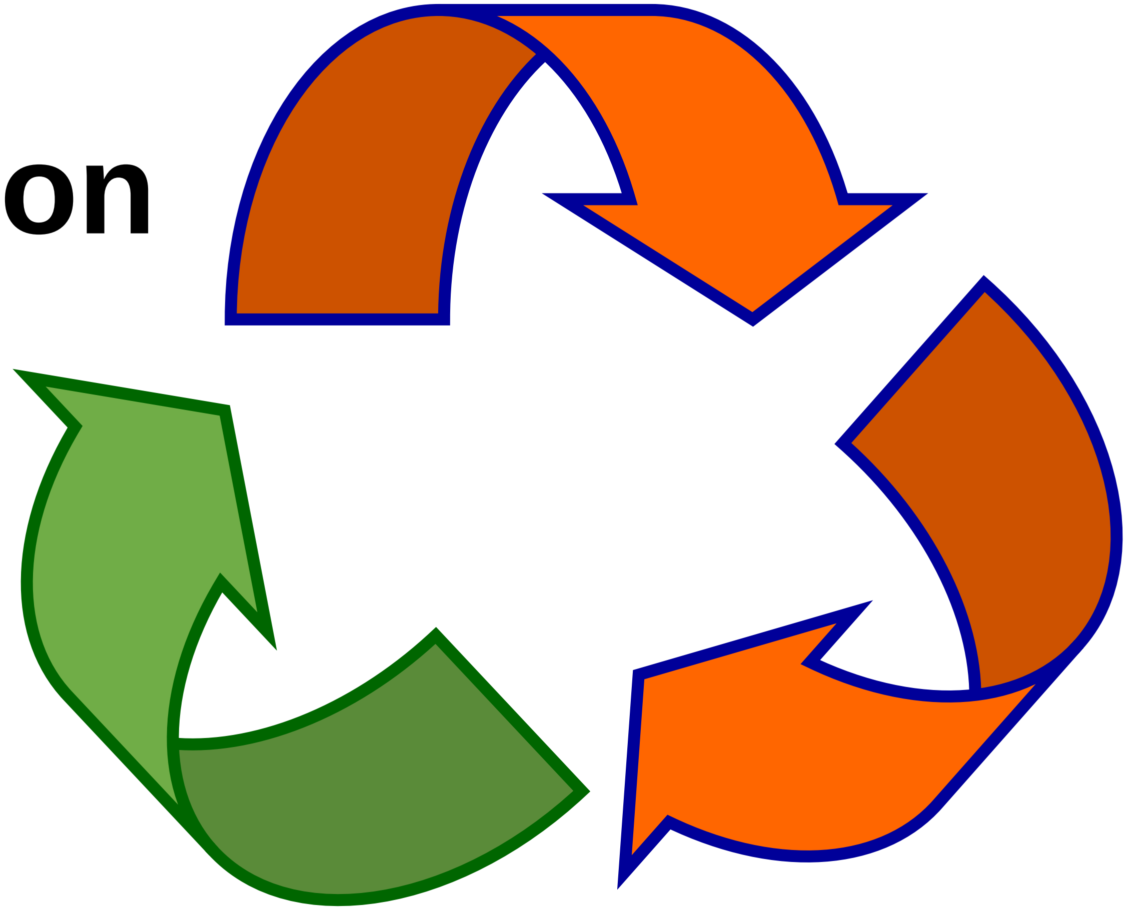
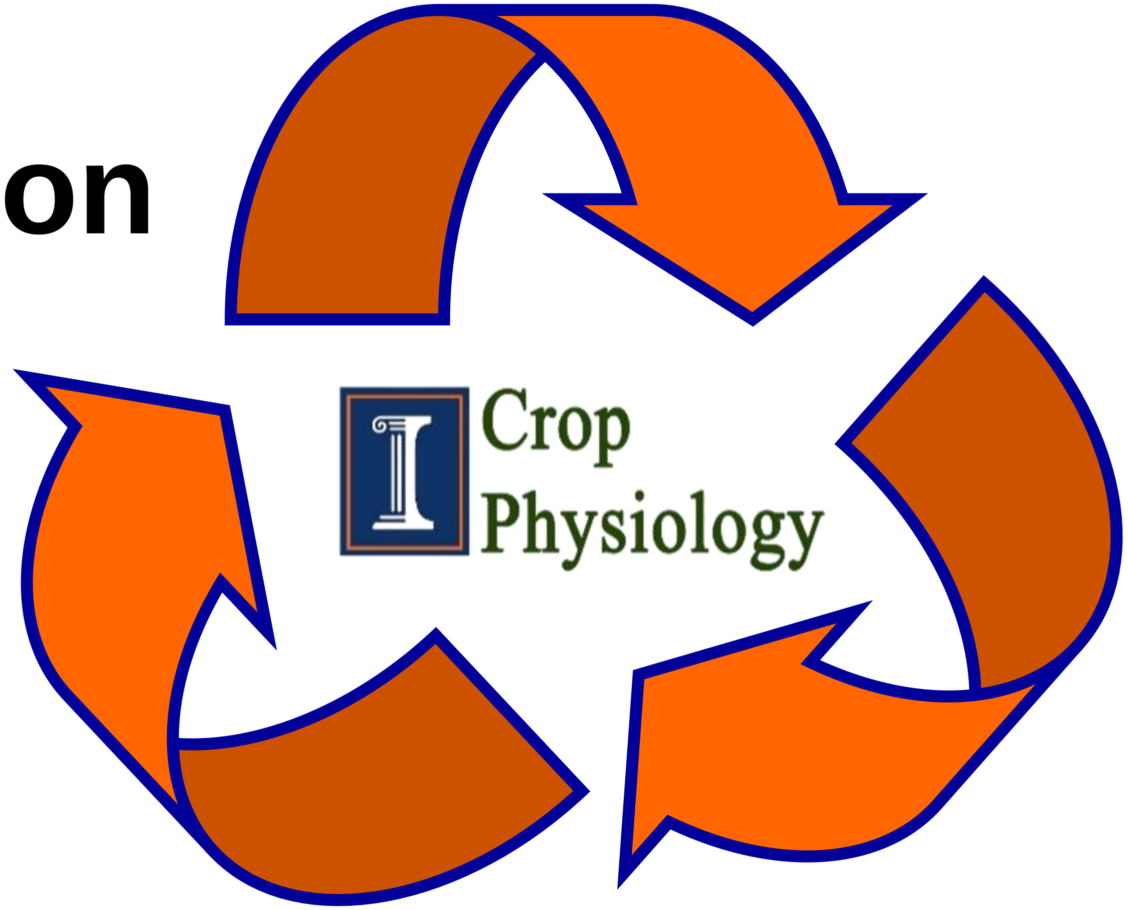
# Reduce, Reuse, Recycle…

- Reduce
  - Residue Degradation
- Reuse
  - Nutrient Value



# Reduce, Reuse, Recycle…

- Reduce
  - Residue Degradation
- Reuse
  - Nutrient Value
- Recycle
  - Increase Yield



# Let’s start with the combine – mechanical management

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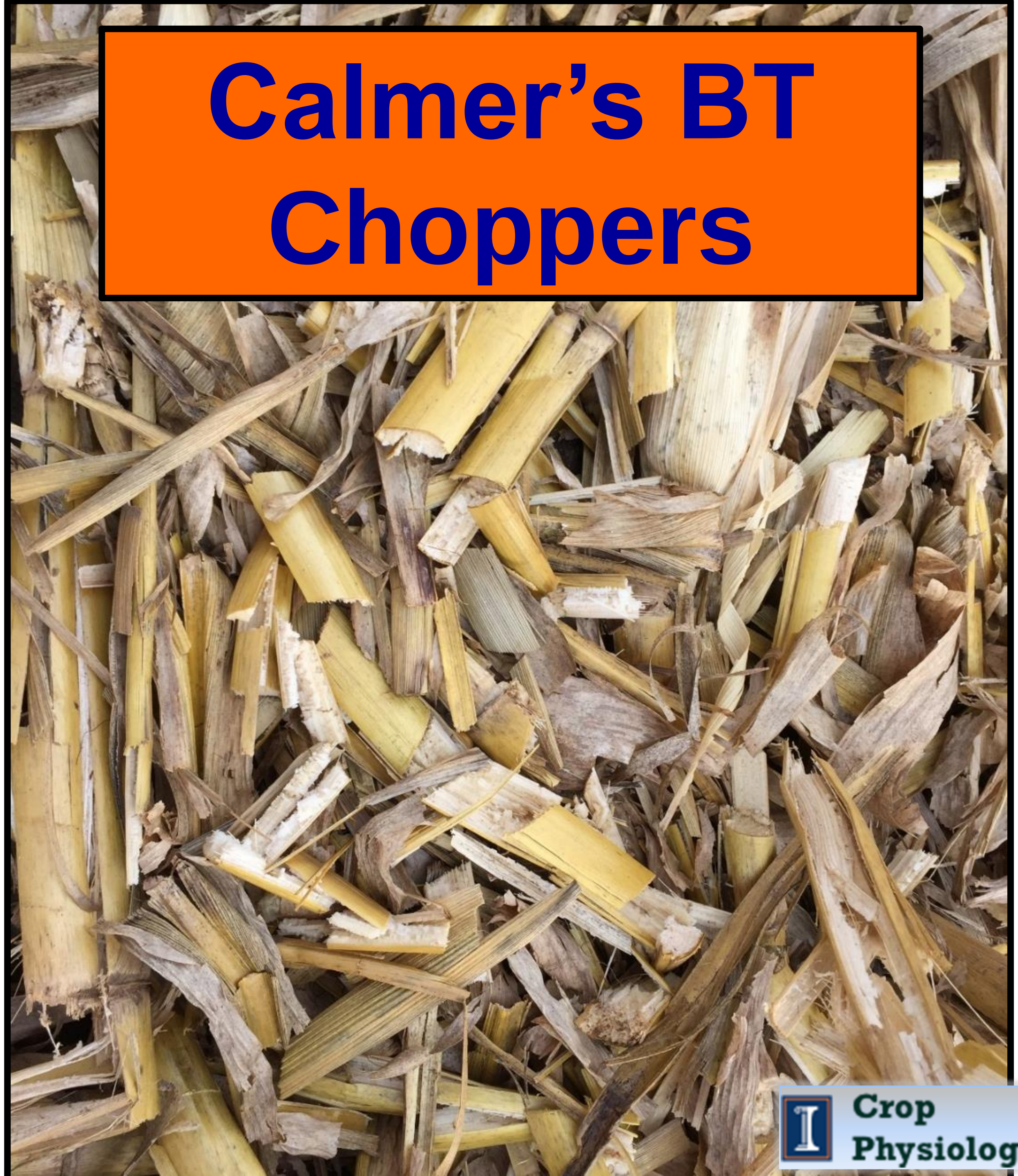
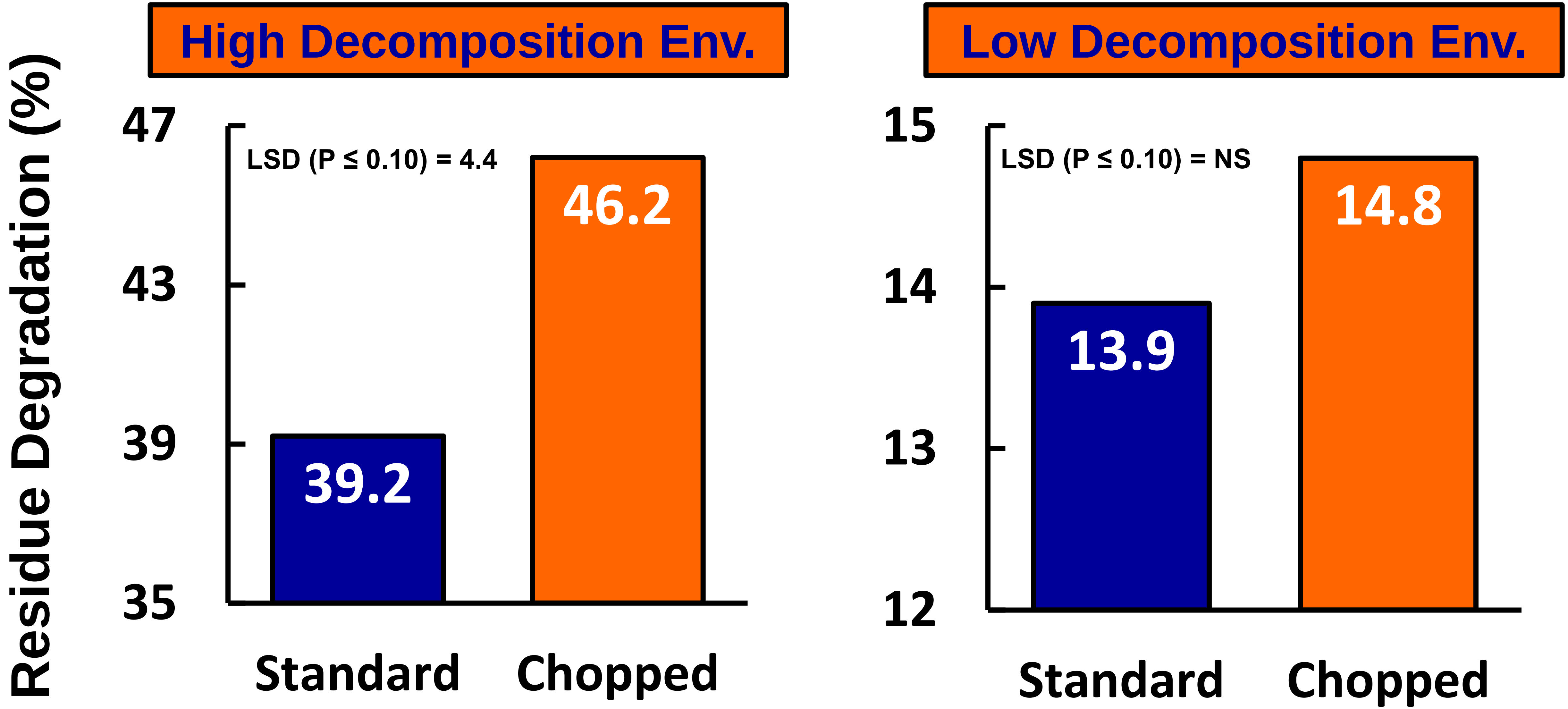
Standard Stalk Rollers


Calmer’s BT Choppers
Crop Physiology

# Overwinter Residue Degradation

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# Overwinter Residue Degradation

**High Decomposition Env.**

**Low Decomposition Env.**

**On average, residue decay was 6-18% greater with sized residue compared to standard stalk rollers.**

**Corn-Corn Standard**

**Corn-Corn Chopped**

Champaign, IL

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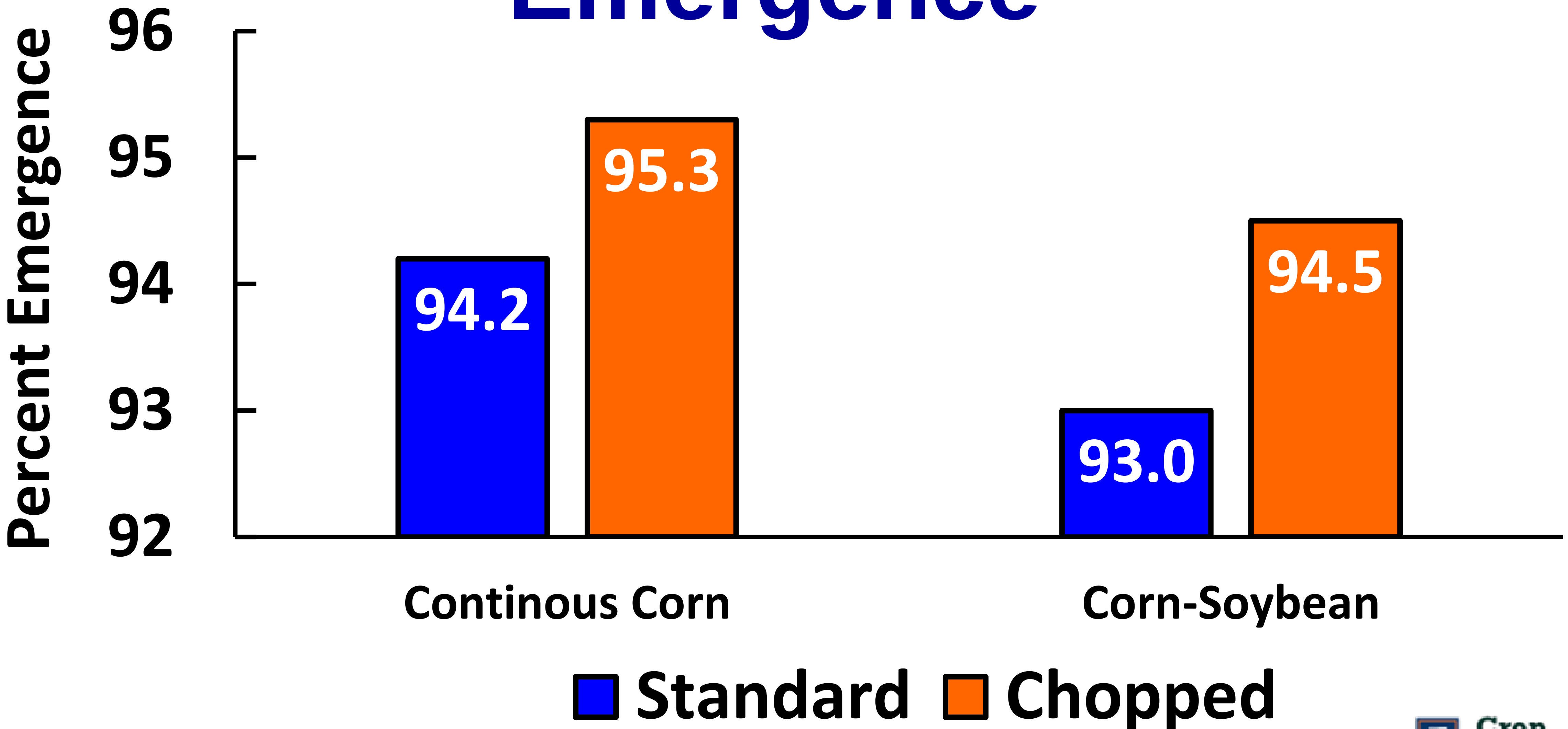
# Mechanical Management Effect on Emergence




Averaged across year, hybrid, input, and population.

# Residue has been mechanically sized, crop has better emergence, is that enough?

# Residue and the C:N Ratio

- C:N is source dependent
- Soil microbes like a C:N Ratio of 24:1
  - Microbes have a C:N ratio of 8:1
  - 16 C for energy, 8 for maintenance
- C:N ratio > 24:1 induces N immobilization
- C:N ratio < 24:1 induces N mineralization

# Common C:N Ratios

| Residue | C:N Ratio | |
|---|---|---|
| Rye Straw | 82:1 | Immobilization |
| Wheat Straw | 80:1 | Immobilization |
| Corn Stover | 57:1 | Immobilization |
| Rye Cover Crop (vegetative) | 26:1 | |
| Alfalfa | 25:1 | |
| Clover | 20:1 | Mineralization |
| Hairy Vetch | 11:1 | Mineralization |
| Soil Microorganisms | 8:1 | |

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| Hairy Vetch | 11:1 |
| Soil Microorganisms | 8:1 |

250 bu/acre = 5.5 tons!!

Immobilization (Rye Straw, Wheat Straw, Corn Stover)

Mineralization (Clover, Hairy Vetch)

# Fall Fertility Applications

**Ammonium Sulfate (21-0-0-24S)**

**200 lb/acre = 42 lb N, 48 lb S**

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# Harvest Method x AMS Grain Yields

| Harvest Method | Fertility | Conventional Till 2017 | Conventional Till 2018 | No-Till 2020 | No-Till 2021 | Avg. |
|---|---|---|---|---|---|---|
| | | bu acre$^{-1}$ | | | | |
| Standard | None | **175** | **215** | **180** | **176** | **187** |
| | Fall AMS | **181** | **218** | **185** | **184** | **192** |
| | Δ | **+ 6** | **+ 3** | **+ 5** | **+ 8** | **+ 5** |
| Chopped | None | **181** | **224** | **183** | **178** | **192** |
| | Fall AMS | **185** | **223** | **187** | **183** | **195** |
| | Δ | **+ 4** | **- 1** | **+ 4** | **+ 5** | **+ 3** |

**Averaged across hybrid, input, and crop rotation of corn-corn and corn-soybean.**

# Key Takeaway

**Adding fertility to the residue improves decomposition and subsequent grain yields regardless of mechanical management.**

**Microbes need nutrients too!**

# Long-Term Continuous Corn, A Case Study

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# Trial Design and Site Characteristics

- **Two "Sister-Sites" Established in 2003 (Site B) and 2004 (Site A)**

- **17$^{th}$ year continuous corn for Site A in 2020**

- **19$^{th}$ year continuous corn for Site B in 2021**

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# 2019-2021 Treatments

**Standard Stalk Roller (Left)**

**Sizing Knife Roller (Right)**

**Ammonium Sulfate**
**48 lb S $acre^{-1}$**
**42 lb N $acre^{-1}$**


**Fall burndown application with a bacterial blend**

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# Managing the CCYP – 2 Year Results

| Management | Yield | CCYP |
| --- | --- | --- |
| | —bushels per acre — | |
| Corn-Soybean Rotation | 201 | - |
| Long-Term Continuous Corn | 153 | 48 |

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# Managing the CCYP – 2 Year Results

| Management | Yield | CCYP |
|---|---|---|
| | —bushels per acre — | |
| Corn-Soybean Rotation | 201 | - |
| Long-Term Continuous Corn | 153 | 48 |
| + Calmer Super Choppers | 166 | 35 + 13 |

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| + Calmer Super Choppers | 166 | 35 + 13 |
| + Ammonium Sulfate (AMS) | 167 | 34 + 1 |

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# Managing the CCYP – 2 Year Results

| Management | Yield | CCYP |
|---|---|---|
| | —bushels per acre — | |
| Corn-Soybean Rotation | 201 | - |
| Long-Term Continuous Corn | 153 | 48 |
| + Calmer Super Choppers | 166 | 35 + 13 |
| + Ammonium Sulfate (AMS) | 167 | 34 + 1 |
| + Microbial Blend | 178 | 23 + 11 |

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# Managing the CCYP – 2 Year Results

| Management | Yield | CCYP |
|---|---|---|
| | —bushels per acre — | |
| Corn-Soybean Rotation | 201 | - |
| Long-Term Continuous Corn | 153 | 48 |
| + Calmer Super Choppers | 166 | 35 |
| + Ammonium Sulfate (AMS) | 167 | 34 |
| + Microbial Blend | 178 | 23 |

+25

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# Managing the CCYP – 2 Year Results

| Management | Yield | CCYP |
| --- | --- | --- |

**A 52% Reduction in the CCYP**

**Any combination of practices was better than any individual practice by itself.**

# Residue management of corn stover is synergistic.

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# Where does residue come from?

**Cover Crops (cereal rye)**

**Double Crops**

**Higher Yields**

# 5 Days Post Termination


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# Double Crop Management?

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# Research Conclusion

- **Residue management can be achieved with mechanical, chemical, or biological approaches.**

- **Combining these practices together can result in optimal residue management.**

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**For More Information:**

## Crop Physiology Laboratory

**University of Illinois**

**http://cropphysiology.cropsci.illinois.edu**

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