

# Understanding Biologicals for Improved Soybean Management

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Illinois Soybean Association Webinar  
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# Is Soybean Currently Managed Adequately?

**Are we achieving  
full yield potential?**

# **Test Your Knowledge of High Yield Soybean**

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

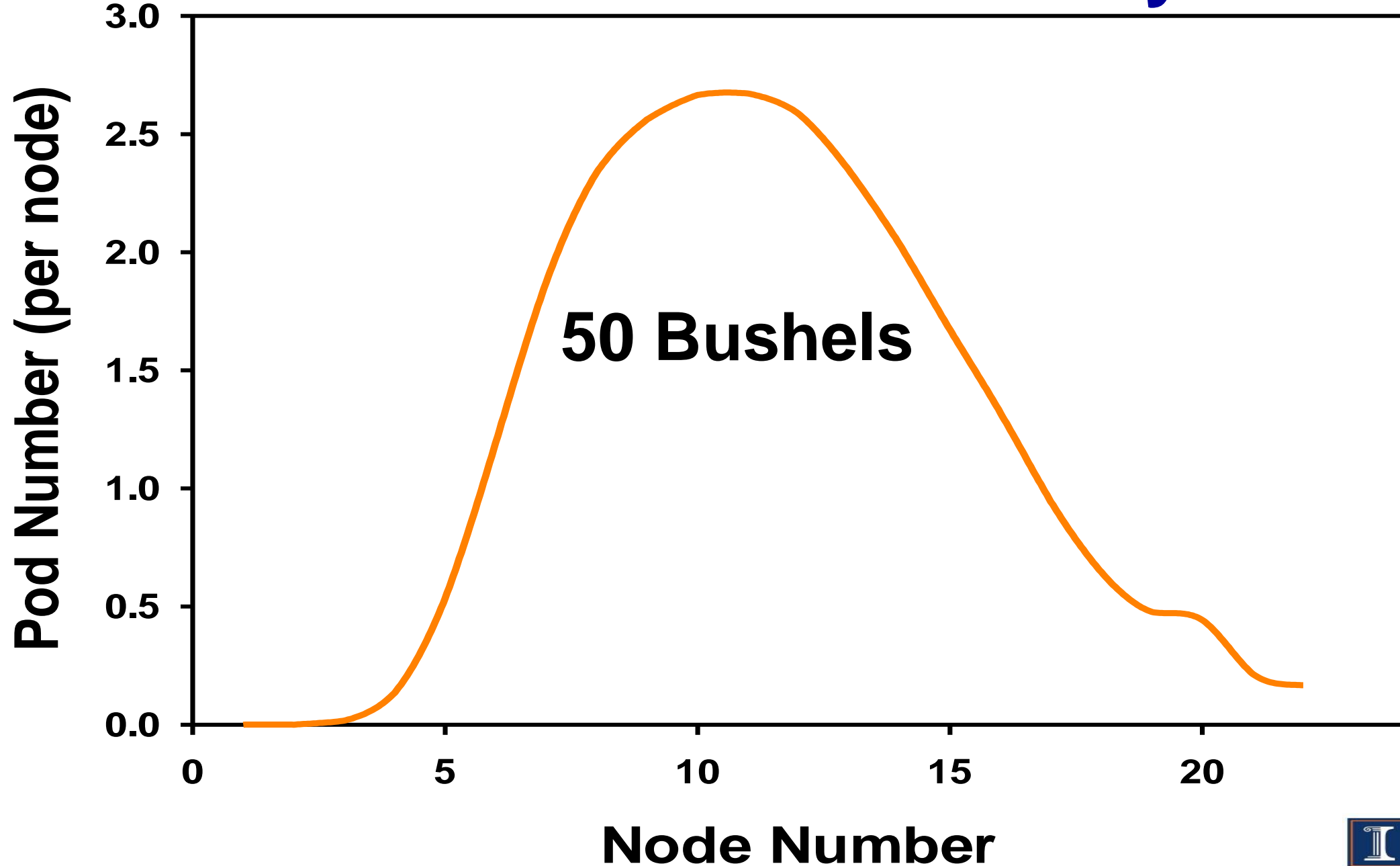
# The Soybean Yield Gap

- **World Record yield of 190.2 bushels per acre in 2019**
- **US average record yield of 52 bushels per acre in 2016**  
(Illinois record is 64 in 2018)
- **Yield Gap = Record Yield – Average Yield = 138 bushels**

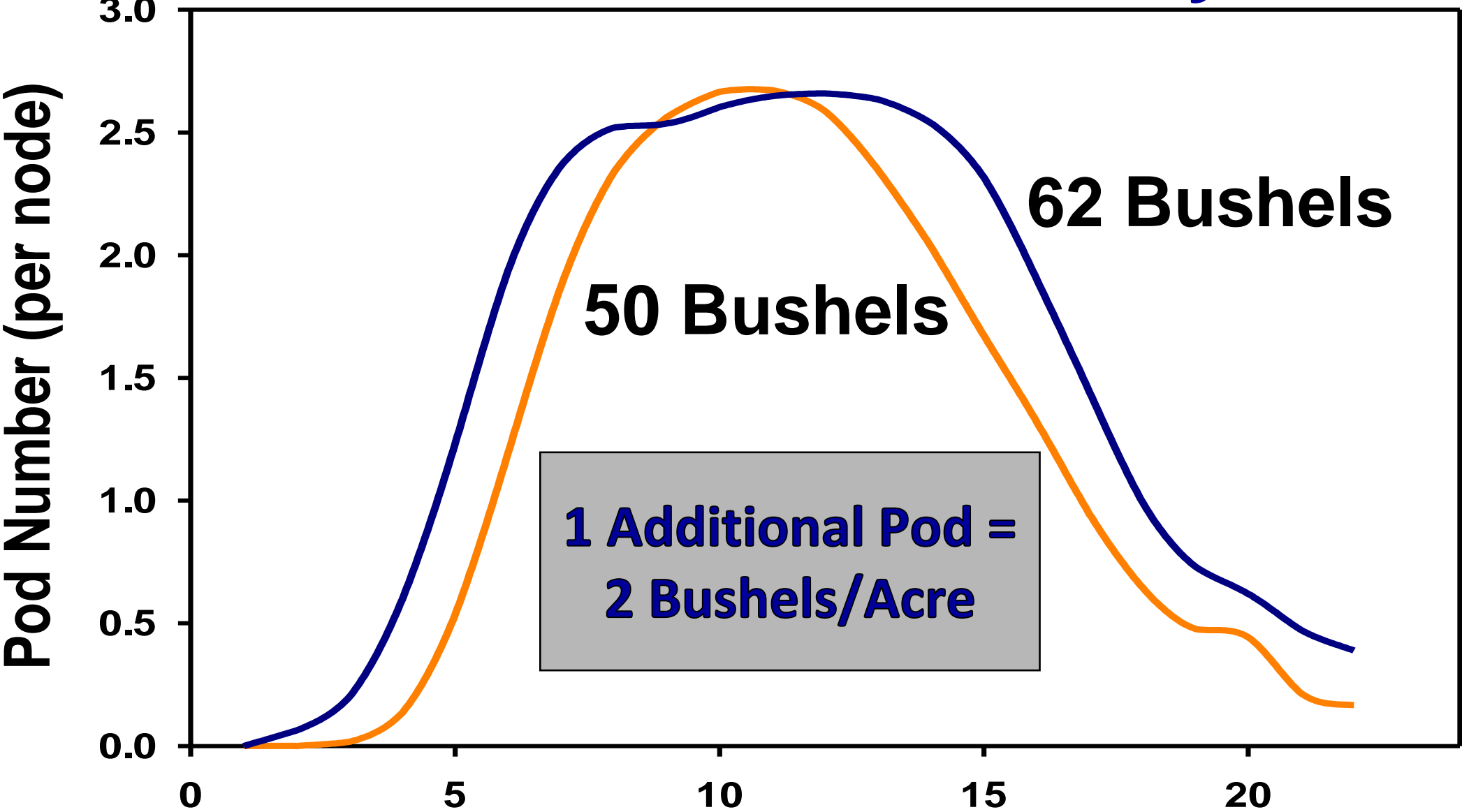
# Soybean Yield Components

**Yield = Pod number/acre x  
Seeds per pod x  
Weight per seed**

# How Does Pod Number Effect Soybean Yield



# How Does Pod Number Effect Soybean Yield



**1 Additional Pod =  
2 Bushels/Acre**

# Traditional Approaches to Soybean Management



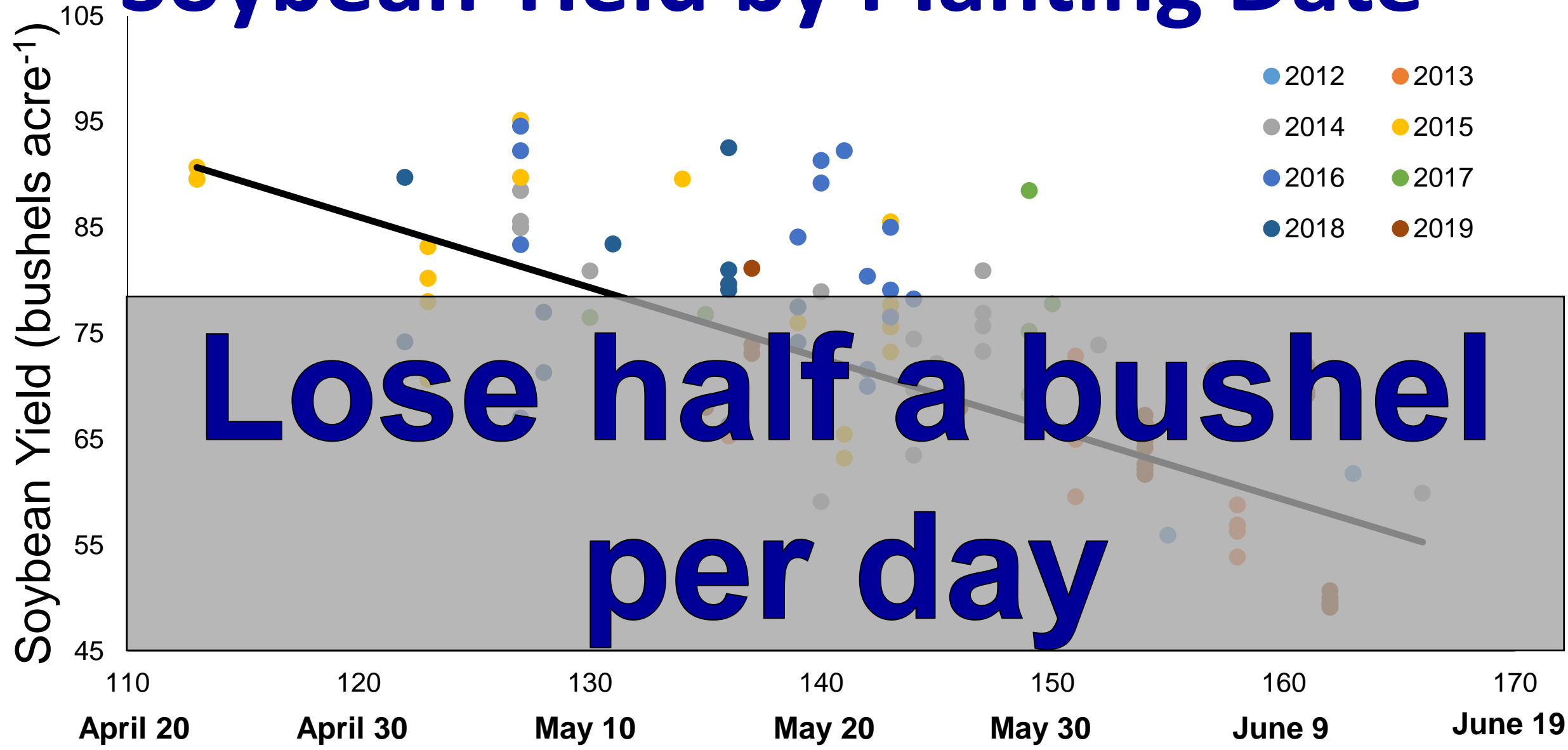


# Standard Management Practices

- **Variety Selection for Region (Illinois Ranges II-IV)**
- **Plant Populations 80k-160k**
- **Earlier Planting Dates**



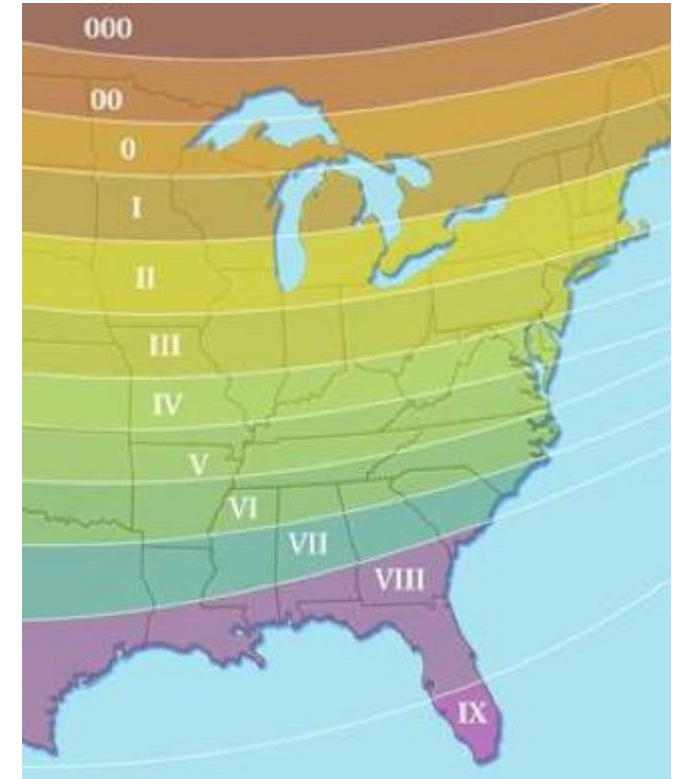
# Soybean Yield by Planting Date



Lose half a bushel per day

# Standard Management Practices

- **Variety Selection for Region (Illinois Ranges II-IV)**
- **Plant Populations 80k-160k**
- **Earlier Planting Dates**
- **Fertility – Leftovers from Previous Corn Crop**
- **Fungicide/Insecticide @ R3**



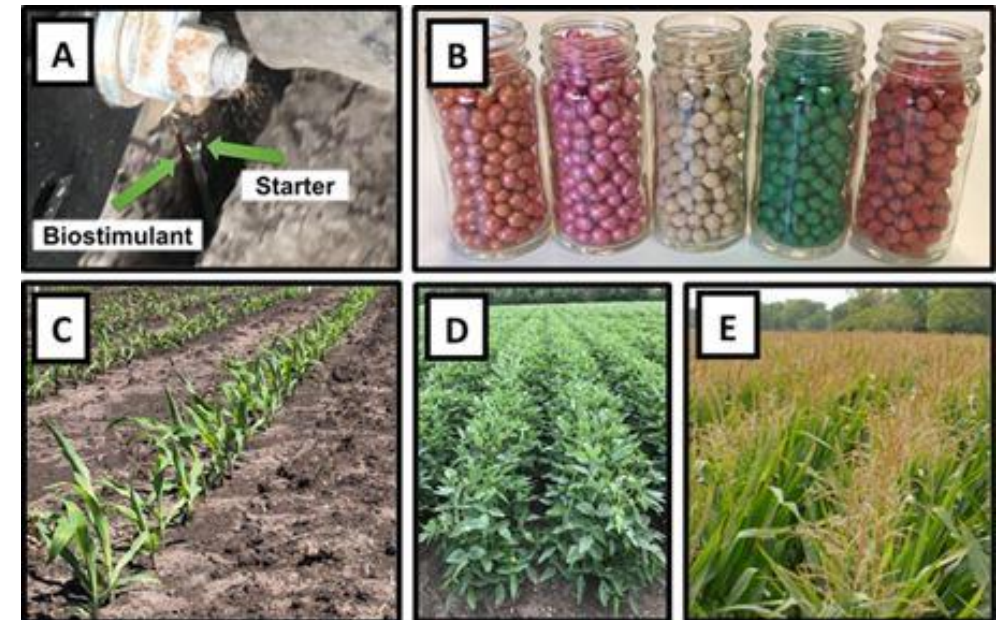
**How else can we  
manage soybean?**

**Biologicals!**



# How Can Biologicals Be Used?

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



# What are Biologicals?

- **Plant Growth Regulators (PGRs)**
- **Beneficial Microbes**
- **Biostimulants**

# What are Biologicals?

- **Beneficial Microbes**

**“The Living”**

- **Biostimulants**

**“The Dead”**

# Current Leading Biostimulant Description in the US

2018 US Farm Bill –

*“A “plant biostimulant” is considered a substance or micro-organism that, when applied to seeds, plants, or the rhizosphere, stimulates processes to enhance or benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, or crop quality and yield.”*



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# What are Biologicals?



# What are Biologicals? Stressful Question!



**2017**

***(Before Biostimulant Research)***



**2020**

***(After Biostimulant Research)***

# Biological Sub-Categories

- Nitrogen-Fixing Bacteria

- P-Solubilizing Bacteria

- Mycorrhizal Fungi

- Enzymes (Phosphatases)

- Humic/Fulvic Acids

- Marine Extracts

- Sugars

**Beneficial Microbes**

**Biostimulants**

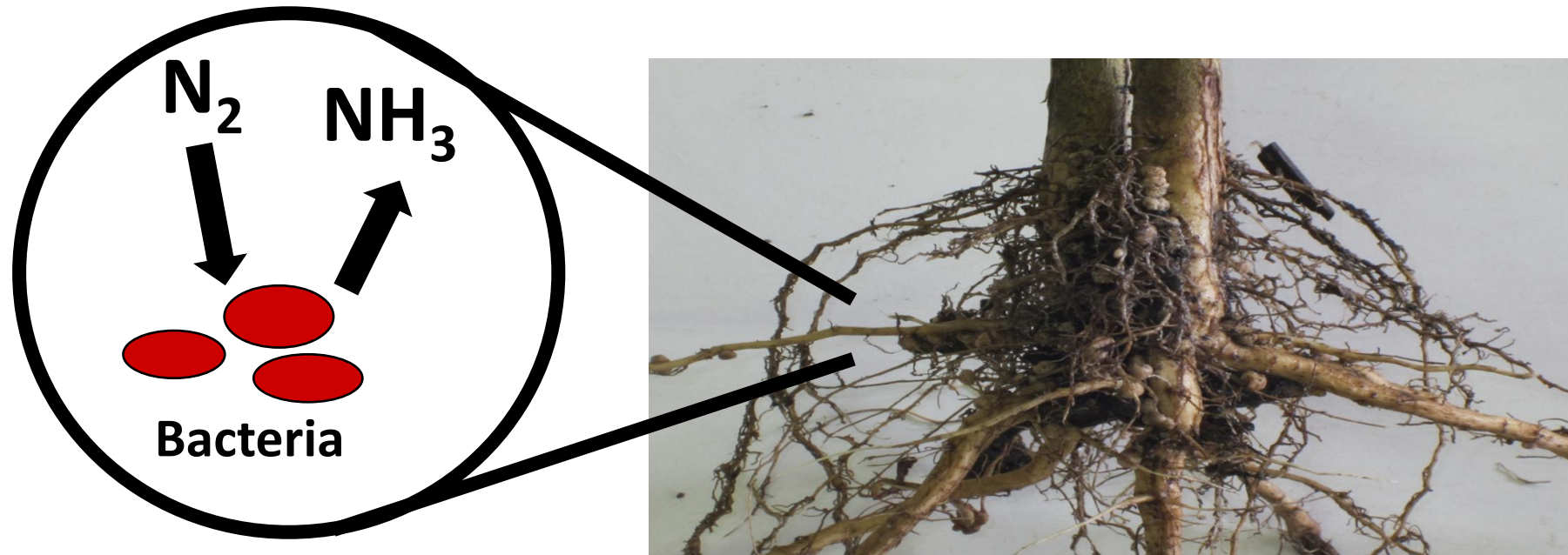
# Test Your Knowledge of High Yield Soybean

- How much N do soybean plants need to accumulate per each bushel of grain?

**4 to 5 lbs of N per Bushel**

# Biological Sub-Categories

- Nitrogen-Fixing Bacteria – Increase Plant Available N
- Legume – Rhizobium Relationship



# Test Your Knowledge of High Yield Soybean

- How much of soybean's N comes from the nodules?

**About half or 50%**



# Alternate N Sources for Soybean

**Are there other  
opportunities to enhance  
nitrogen fixation?**

# Biological Sub-Categories

- **Nitrogen-Fixing Bacteria – Increase Plant Available N**
- **Non-Rhizobia microbes – Root and/or leaf colonization to provide supplemental nitrogen**



**Continually fixes N in  
root zone**



**Colonizes inside the  
plant roots and leaves**

# Effect of N-Fixers on Soybean Grain Yield

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Treatment	Yield	$\Delta$
	———— bushels per acre ————	
Untreated Control	45.8	
In-Furrow Applied Proven	48.6	+2.8
In-Furrow Applied Envita	47.5	+1.7
V4 Foliar Applied Envita	47.6	+1.8

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Research of Vitor Favoretto

# Key Takeaways – N-Fixers

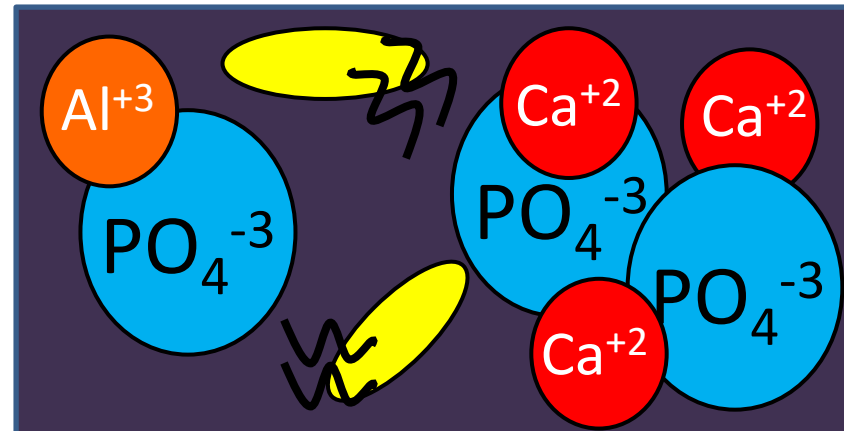
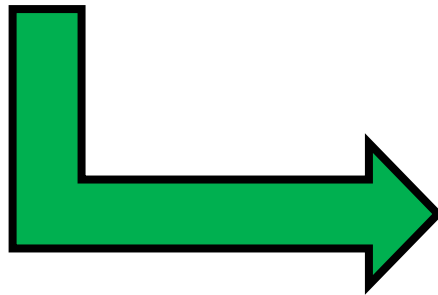
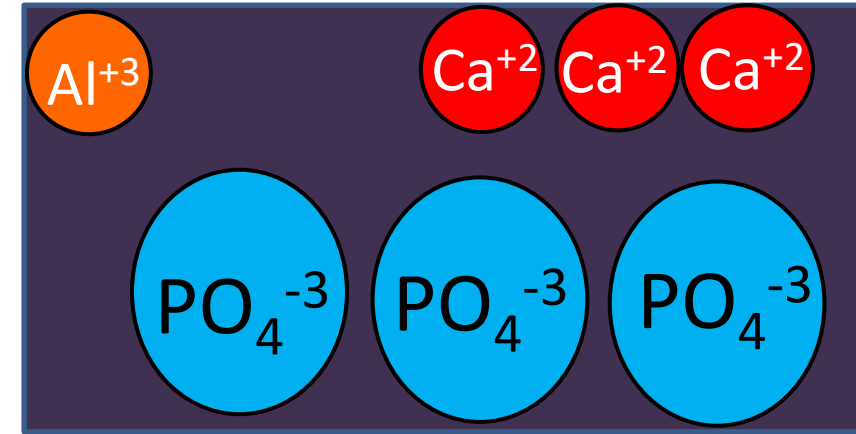
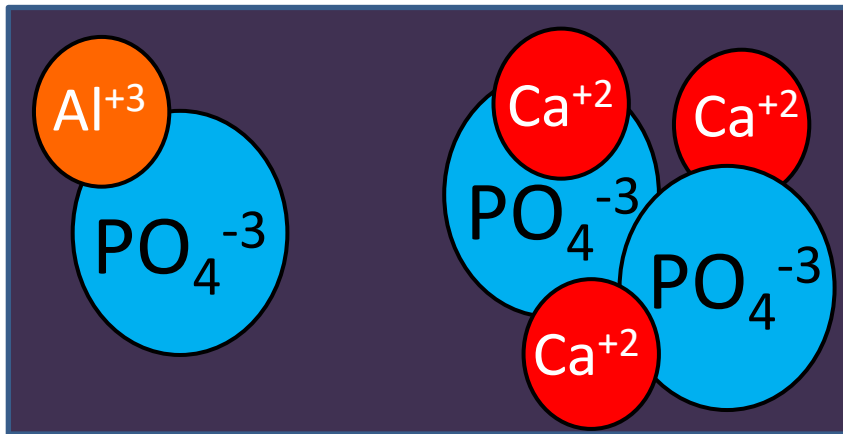
- **Biologically fixed nitrogen from an applied biological product can increase soybean grain yields**
- **New and innovative biologicals are able to provide alternative approaches to N-fixation in soybean, opening space for seed treatment**

# Biological Sub-Categories

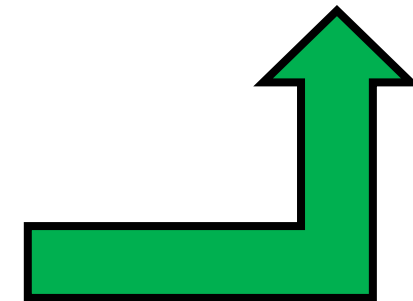
- Nitrogen-Fixing Bacteria – Increase Plant Available N
- P-Solubilizing Bacteria – Increase Availability of Mineral P
- Mycorrhizal Fungi
- Enzymes (Phosphatases)
- Humic/Fulvic Acids
- Marine Extracts
- Sugars

# Biological Sub-Categories

P-Solubilizing Bacteria – Increase Availability of Mineral P



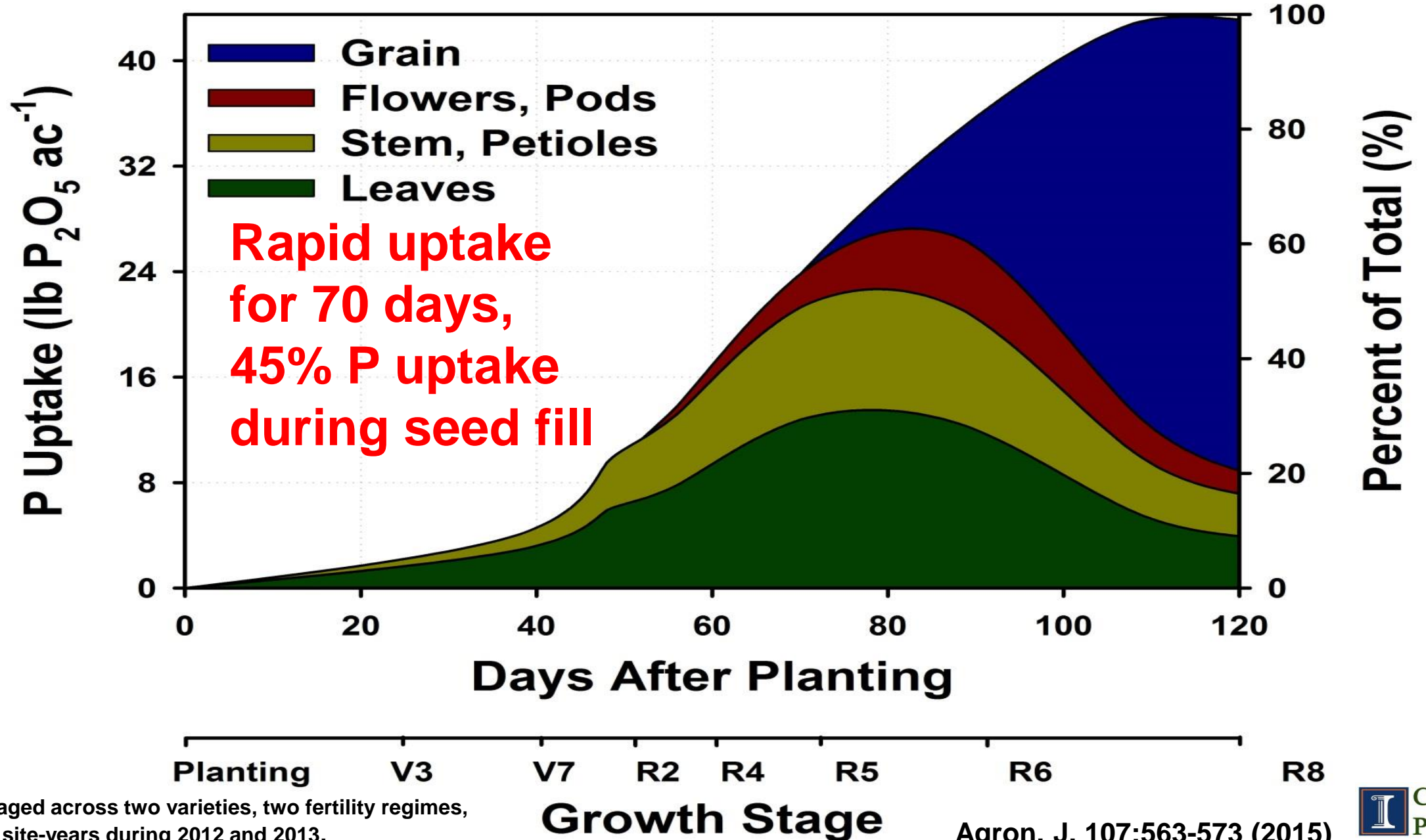
+ Bacteria



# Key Takeaways – PSB

- **Optimization of grain yield with PSB relies on adequate soil contact near the growing root to supply P for immediate uptake**
- **PSB can increase season-long phosphorus availability, essential to optimize grain fill**

# P Uptake & Partitioning for 60 Bushel Soybean



Data averaged across two varieties, two fertility regimes, and three site-years during 2012 and 2013.

Agron. J. 107:563-573 (2015)



# Key Takeaways – PSB

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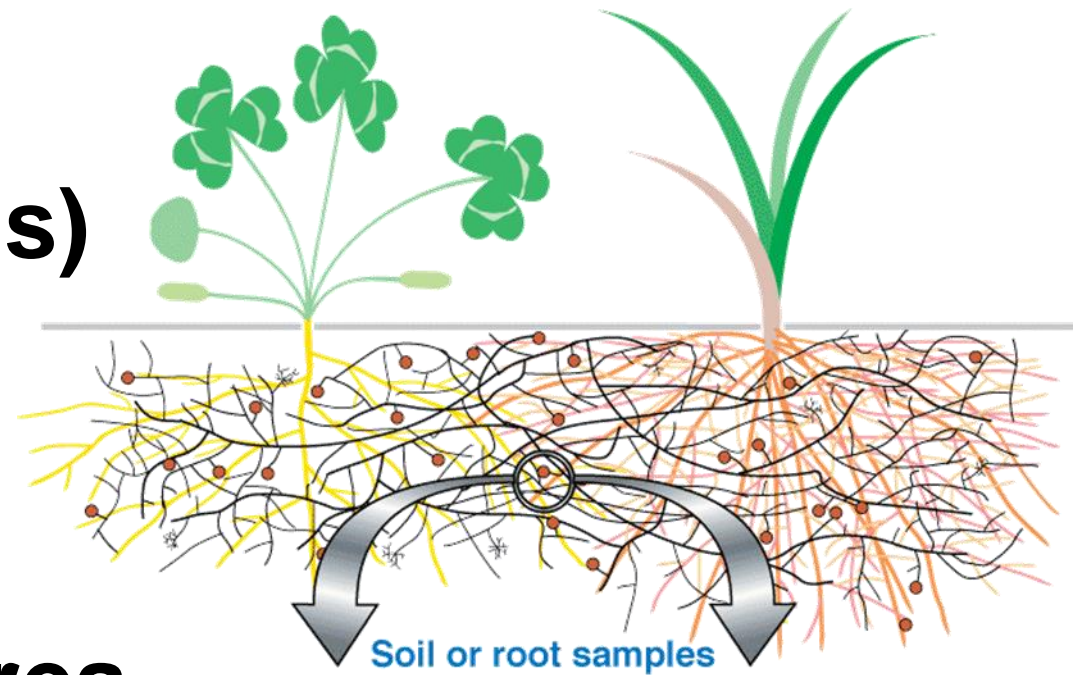
# Biological Sub-Categories

- Nitrogen-Fixing Bacteria – Increase Plant Available N
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- Mycorrhizal Fungi – Extension of the Root System
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# Biological Sub-Categories

## Mycorrhizal Fungi – Extension of the Root System

- Fungi are microorganisms (yeasts, molds, mushrooms)
- Arbuscular Mycorrhizal Fungi (AMF) growth with roots increasing surface area



# Biological Sub-Categories

**Mycorrhizal Fungi – Extension of the Root System**



# Key Takeaways – AMF

- **Seed inoculation of AMF provides the biological with the greatest potential of success by placing the product as close to the seedling as possible**
- **The source of the inoculum does impact efficacy, and the environment/crop in which applied may determine which source is optimal**

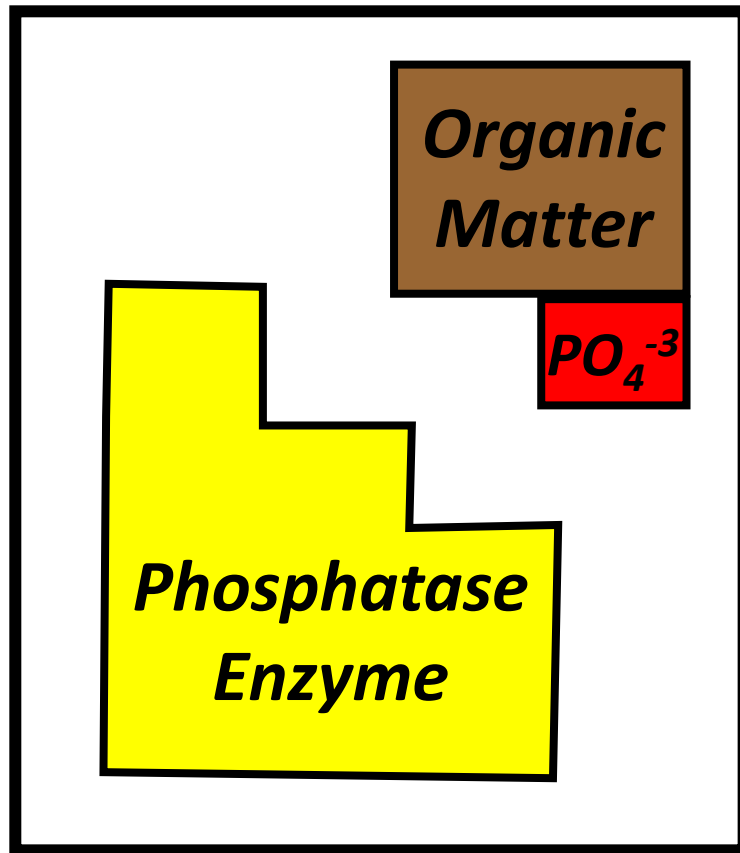
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- **Enzymes (Phosphatases) – Increase Availability of Organic P**
- **Humic/Fulvic Acids**
- **Marine Extracts**
- **Sugars**

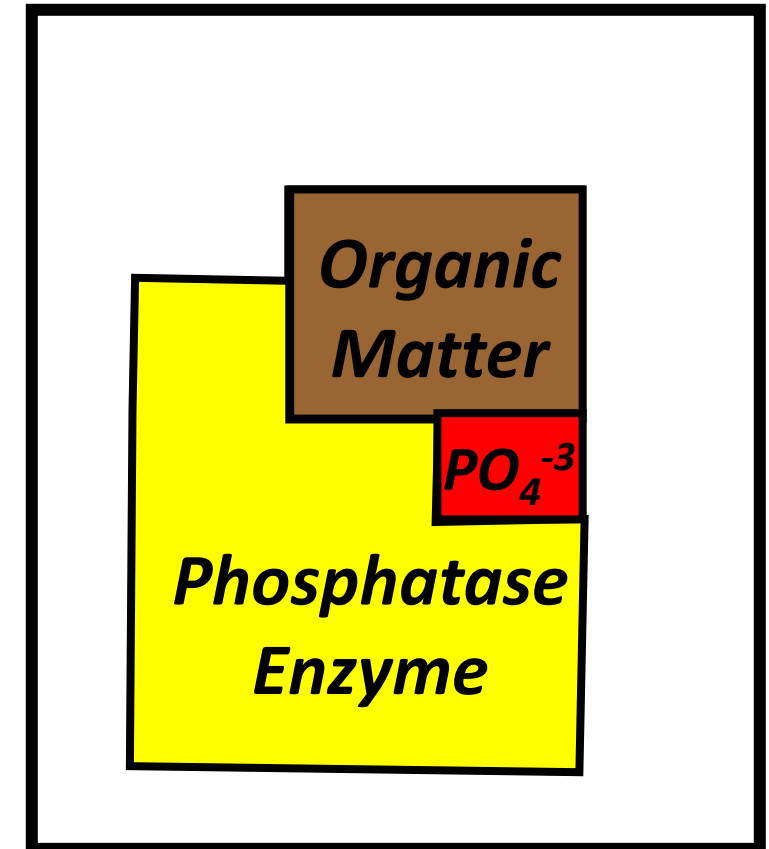
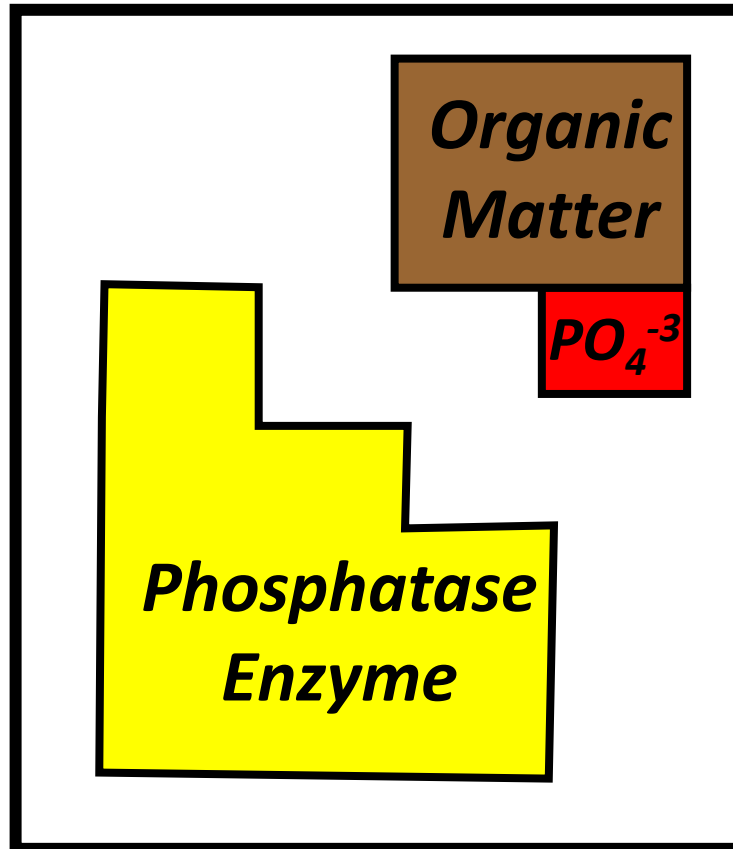
# Biological Sub-Categories

Enzymes (Phosphatases) – Increase Availability of Organic P

*Plant Unavailable*



*Plant Available*



# Are all phosphatases the same?

**Brandt® EnzUp™ Zn**

ALSO CONTAINS NON-PLANT FOOD INGREDIENTS:

Lipase .....  
Mannanase .....

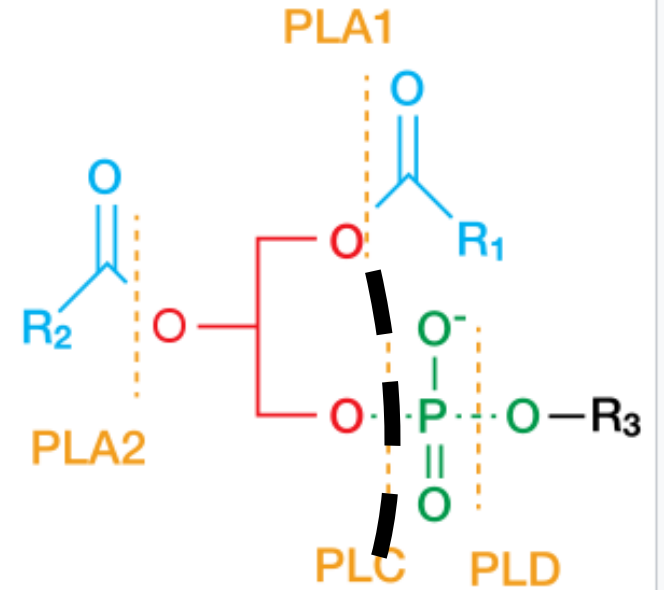
**CHS** Agronomy

**ZYPRO**®

Guaranteed Analysis  
CONTAINS NON-PLANT FOOD INGREDIENT:

Soil Amending Ingredient:  
0.50% ..... Phospholipase C (18,900 µU/Gal (5000 nU/mL))

- **Lipase ?**
- **Phosphatase ?**
- **Phospholipase C**





# Key Takeaways – Phosphatases

- **Phosphatases provide access to organic soil P**
- **Not all phosphatases are the same, and each varies in its targeted organic form of phosphorus**
- **Variations in soil environment regarding native P levels and soil organic matter concentrations determine which enzyme is best for that field**

# Biological Synergy?

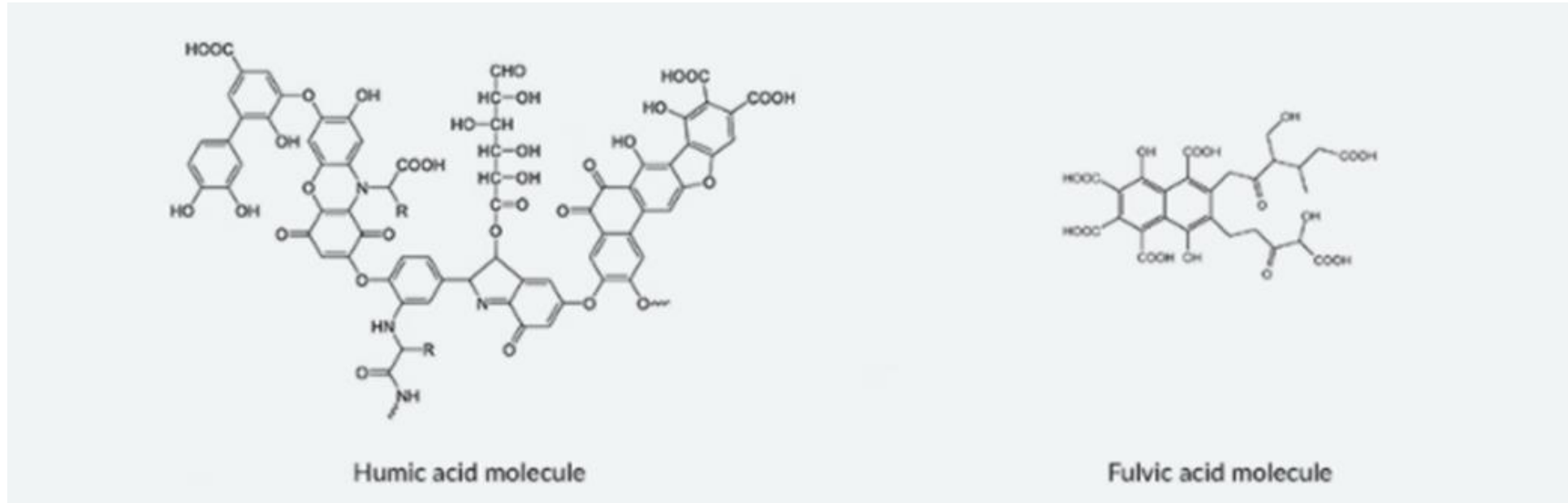
- **Phosphorus solubilizing microbes increase mineral P availability**
- **Phosphatase enzymes increase organic P availability**
- **Two biologicals increasing availability of 2 different P pools – Provides soil P for a crop that is typically not fertilized with synthetic P**

# Biological Sub-Categories

- Nitrogen-Fixing Bacteria – Increase Plant Available N
- P-Solubilizing Bacteria – Increase Availability of Mineral P
- Mycorrhizal Fungi – Extension of the Root System
- Enzymes (Phosphatases) – Increase Availability of Organic P
- **Humic/Fulvic Acids – Chelate Soil Cations and Feed Microbes**
- **Marine Extracts**
- **Sugars**

# Biological Sub-Categories

## Humic/Fulvic Acids – Chelate Soil Cations and Feed Microbes



- Functional groups ( $\text{COO}^{-1}$ ) help chelate cations ( $\text{Ca}^{+2}$ ,  $\text{Al}^{+3}$ ,  $\text{Zn}^{+2}$ )
  - Chelation of cations keeps P available, and supplies Zn
- High carbon content feeds soil microbes, stimulates root zone

# Hydra-Hume<sup>®</sup> A

A LIQUID LEONARDITE ADJUVANT

**ACTIVE INGREDIENTS:**

12.00%	Humic Acids (Derived from Leonardite)
88.00%	<b>INERT INGREDIENTS</b>
100.00%	<b>TOTAL</b>

# NuTex<sup>™</sup> EDA

Fertilizer Micro-Nutrient for Fruits, Nuts, Vegetables, Field Crops, Turf and Ornamentals

**GUARANTEED ANALYSIS:**

Zinc (Zn)	0.5%
0.5% Chelated Zinc (Zn)	
Derived from: Zinc EDTA	

# Baccarat<sup>®</sup>

A Concentrated Mixture of Humic Acid

# Humitech<sup>®</sup> LMW Humic Acid

CONTAINS NON-PLANT FOOD INGREDIENT:

ACTIVE INGREDIENT:

Humic Acids	0.05%
Other ingredients	99.95%

Derived from Leonardite

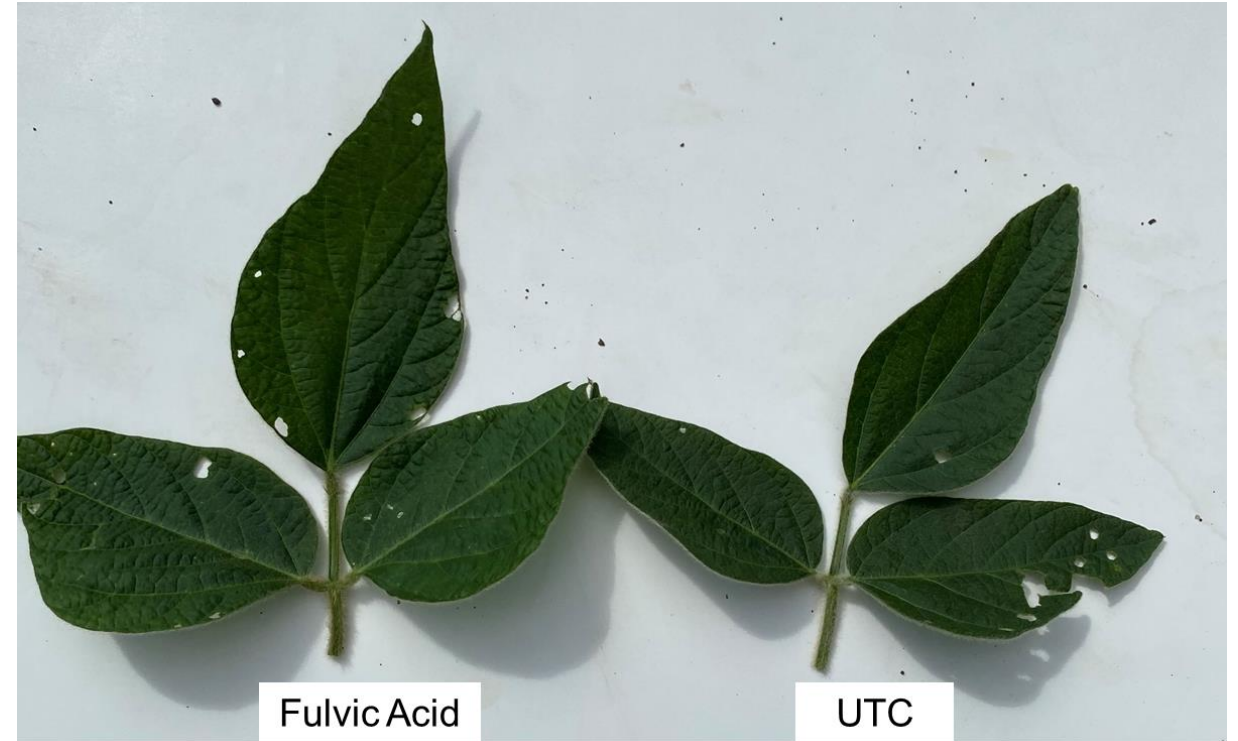
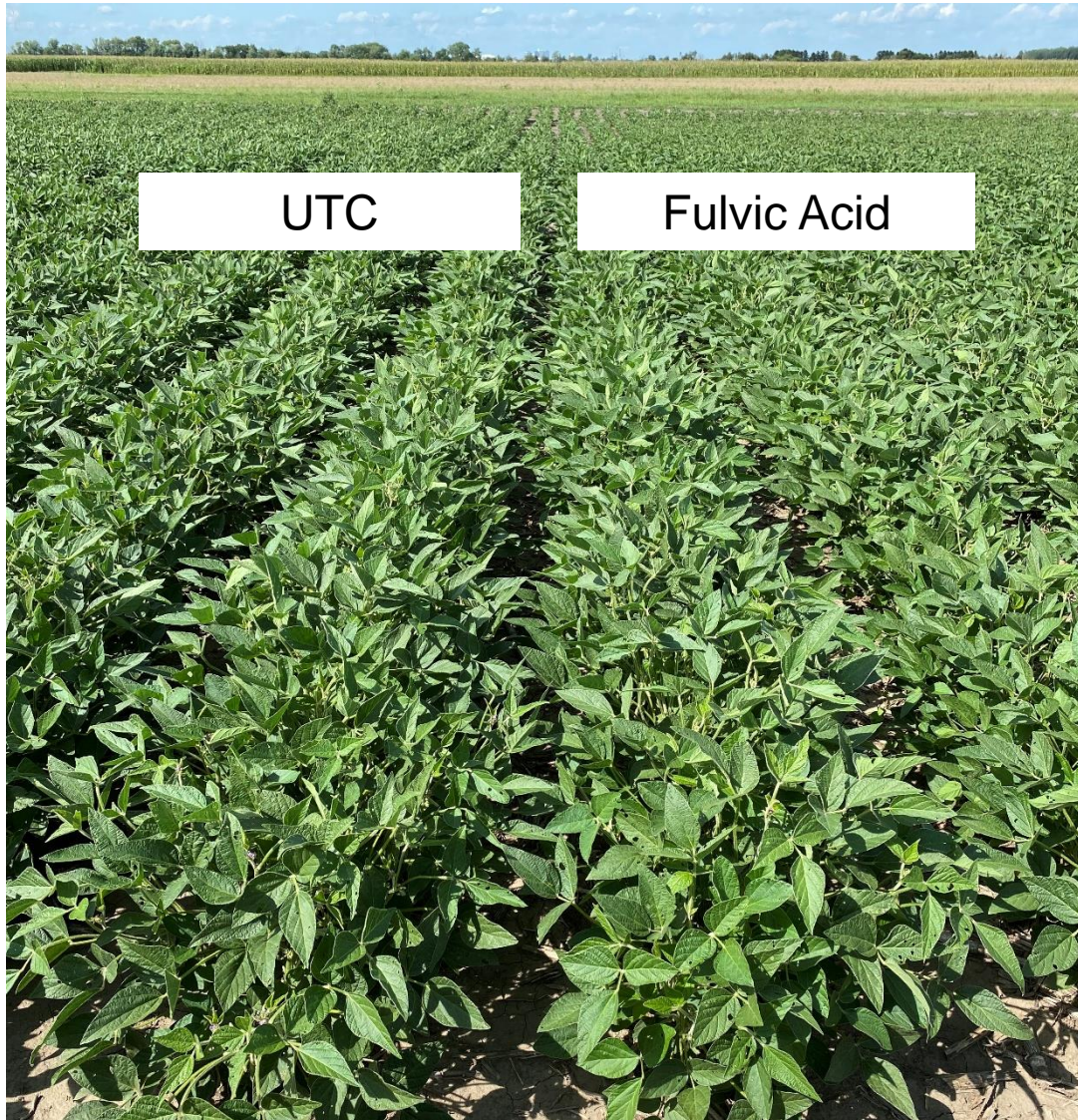


Crop  
Physiology

# Effect of Humic/Fulvic Acids on Soybean Grain Yield

Treatment	Yield	$\Delta$
	———— bushels per acre ————	
Untreated Control	53.5	
In-Furrow Fulvic Acid	52.8	-0.7
Soil Broadcast Fulvic Acid	55.4	+1.9
In-Furrow Humic Acid	54.4	+0.9
Soil Broadcast Humic Acid	54.2	+0.7

# Untreated (left rows) vs Fulvic Acid In-furrow (right rows)



# Key Takeaways – Humic/Fulvic Acids

- **Humic/Fulvic acids applied to the soil can benefit soybean grain yields**
- **Interactions with soil nutrients and microbial communities promotes greater crop growth**
- **Larger leaves and quicker row closure optimizes sunlight interception for better yields**



# Biological Sub-Categories

- Nitrogen-Fixing Bacteria – Increase Plant Available N
  - P-Solubilizing Bacteria – Increase Availability of Mineral P
  - Mycorrhizal Fungi – Extension of the Root System
  - Enzymes (Phosphatases) – Increase Availability of Organic P
  - Humic/Fulvic Acids – Chelate Soil Cations and Feed Microbes
  - **Marine Extracts**
  - **Sugars**
- Soil Applied Stimulates Microbes and Roots**
- Foliar Applied Mitigates Stresses (Drought)**

# Biological Sub-Categories

Marine Extracts – Soil or Foliar Applied – Plant Health

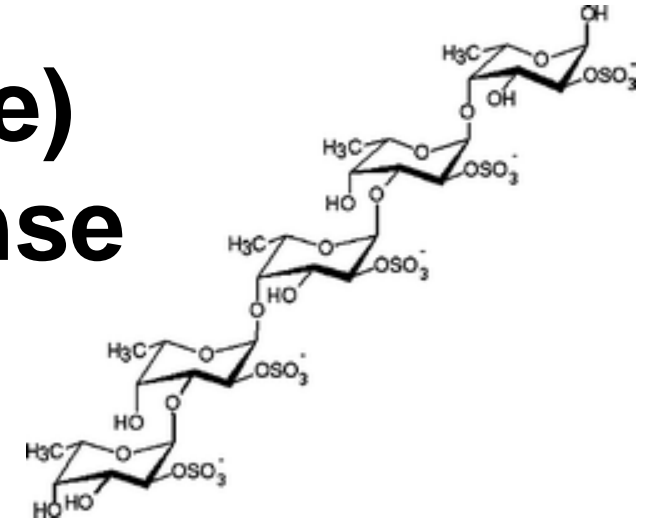
- Sources vary from algae, to seaweed, to kelp
- Most common is *Ascophyllum nodosum* (brown seaweed)
- Others are red or green algae
- All contain multiple biomolecules (amino acids, carbohydrates, plant hormones...)

# Marine Extracts - Mechanism

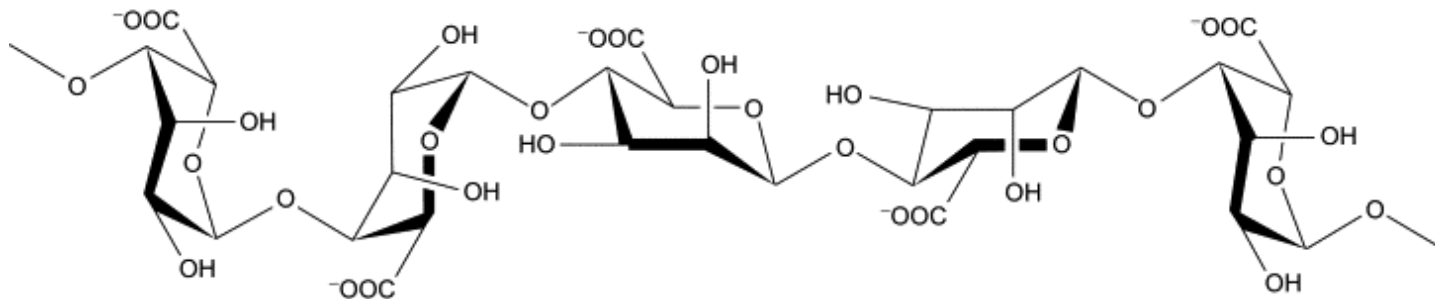
- **Multiple compounds means multiple modes of action**
- **Impossible to know which is having the primary influence in a given environment**
- **In general, can be interpreted as an “espresso” shot to the root zone when soil applied**

# Marine Extracts - Components

- **Fucoidans (sulfated carbohydrate)**
  - **Known to increase plant defense**



- **Alginate (negatively charged carbohydrate)**
  - **Accounts for ~ 40% of algae biomass**
  - **Known to stimulate plant growth**



# toggle

0 - 0 - 1

Guaranteed Analysis

Soluble Potash (K<sub>2</sub>O) 1%

Derived from *Ascophyllum nodosum*

F000148

  
**Acadian**  
**Plant Health.**  
Sustainably Empowering Plants.

**Toggle™** is derived exclusively from *Ascophyllum nodosum* marine plants harvested from the North Atlantic coastal waters of Nova Scotia, Canada. It is a source of naturally occurring major and minor nutrients, carbohydrates, amino acids and natural substances that enhance crop vigor, nutrition and quality resulting in improvements in plant development and yield.

# **Key Takeaways – Marine Extracts**

- **Marine Extracts are complex blends of metabolites providing versatility in their use**
- **When foliar applied they can mitigate drought stress by regulating water use of soybean**
- **Soil applications promote root growth and soil microbial activity for an improved rhizosphere**

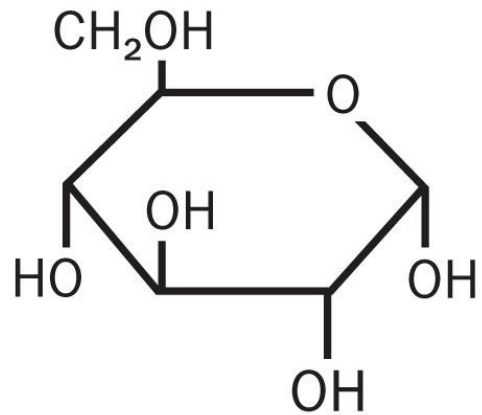
# Biological Sub-Categories

**Sugars – Soil or Foliar Applied – Plant Health**

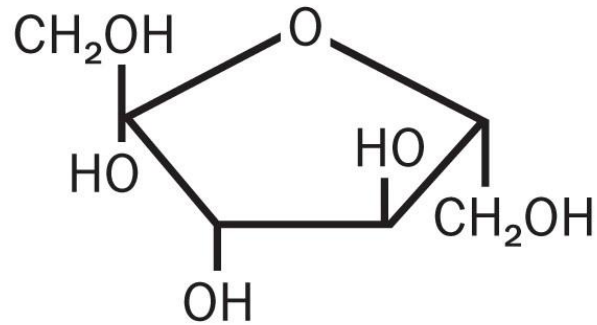
- **Compounds containing carbon, oxygen and hydrogen**
- **Can be individual units (monosaccharide), pairs (disaccharide), or chains (polysaccharide)**
- **Direct energy source for soil microbes, or a signaling molecule in plants**

# Common Sugars

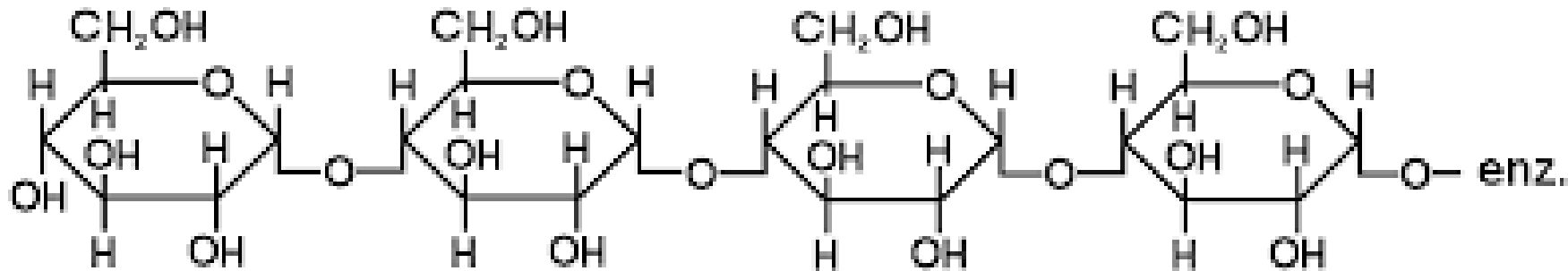
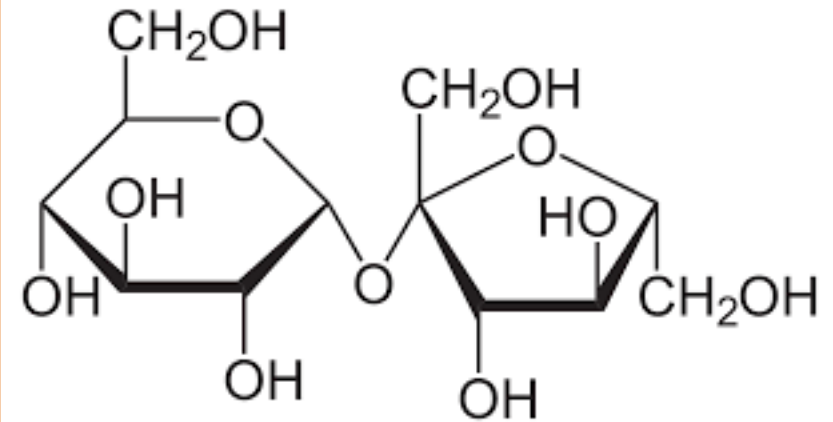
**Glucose**



**Fructose**



**Sucrose**



**Amylose**



# Biologicals Summary

- **Biologicals can be effective at increasing crop grain yields**
- **Biological efficacy depends upon the type of product utilized, placement, and timing**
- **To optimize the benefit it is key to understand how the product of interest works, and where to incorporate it into your system**

# Biologicals Summary

- **The biological market is vast and full of a variety of product options for growers**
- **These multiple products provide many opportunities for better crop management and potential for higher crop grain yields**
- **Each product interacts with the environment in which applied**

# Biologicals Summary

- **While certain biologicals are similar in type (category), each product is unique**
- **It is important to fully understand the product of interest to optimize performance across environments and systems**

# **Traditional View of Biologicals**

**Increase in grain yield**

**Greater nutrient uptake**

**Higher fertilizer use efficiency**

**A Tool For Soil Health?**



USDA Natural Resources Conservation Service

Indicator B	Test ?	Function ?
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# Soil Quality Indicators

## Biological Indicators and Soil Functions

Soil Quality Indicator	
Earthworms	<sup>b,d</sup>
Particulate Organic Matter	<sup>a,c</sup>
Potentially Mineralizable Nitrogen	<sup>a,c</sup>
Soil Enzymes	<sup>a</sup>
Soil Respiration	<sup>a,b,c</sup>

Table 1. Role of soil enzymes

Enzyme	Organic Matter Substances Acted On	End Product	Significance	Predictor of Soil Function
Beta glucosidase	carbon compounds	glucose (sugar)	energy for microorganisms	organic matter decomposition

- **Beta glucosidase is an enzyme that measures soil quality, as well as serves as an indicator of residue decomposition**

# Soil $\beta$ -Glucosidase Activity as Influenced by Biological Treatment and Time

	Days after after Application	
Biological	3	22
	————— $\mu\text{mol pNP / g / h}$ —————	
Untreated	0.55	0.63
Microbial Blend	0.51	0.71
Marine Extract	0.43	0.80
Phosphorus Solubilizer	0.61	0.74

# CPL Perspective on Biostimulants

- **Understand what they do and how they work before trying**
- **Know that they are not a replacement for good crop management**
- **Consider that there may be greater opportunity beyond grain yields**

# Best Chance of Success

**Know your starting point**



**Have a goal on what you wish to achieve**



# Special Thanks to Illinois Soybean Association

For More Information:

**Crop Physiology Laboratory**

**University of Illinois**

<http://cropphysiology.cropsci.illinois.edu>

