

The Six Secrets of Soybean Success: Unleashed!

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WinField United

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

- **US average soybean yields are currently about 50 bushels/acre**
- **World record soybean yield of 171.8 bushels in 2016**
- **Illinois record of 110.94 bushels in 2018**

Quest for 150 bu. Soybean Yield

Variety	Management				
	Standard	— Intensive —			
	Plant Population (plants acre ⁻¹)				
	160K	120K	180K	240K	Avg.
	————— Bushels acre ⁻¹ —————				
AG4135	83.9	94.4	110.2	113.5	100.5
AG44X6	76.0	94.1	90.3	101.6	90.5
RX3896	75.5	90.9	101.2	107.6	93.8
RX4316s	71.9	84.6	91.0	93.1	85.1
S39-C4	75.4	93.2	91.2	105.5	91.3
Average	76.5	91.4	96.8	104.2	88.3

Lsd (0.1) for Variety=5.6, Population=5.0, Variety x Population=11.1

Champaign, IL 2017

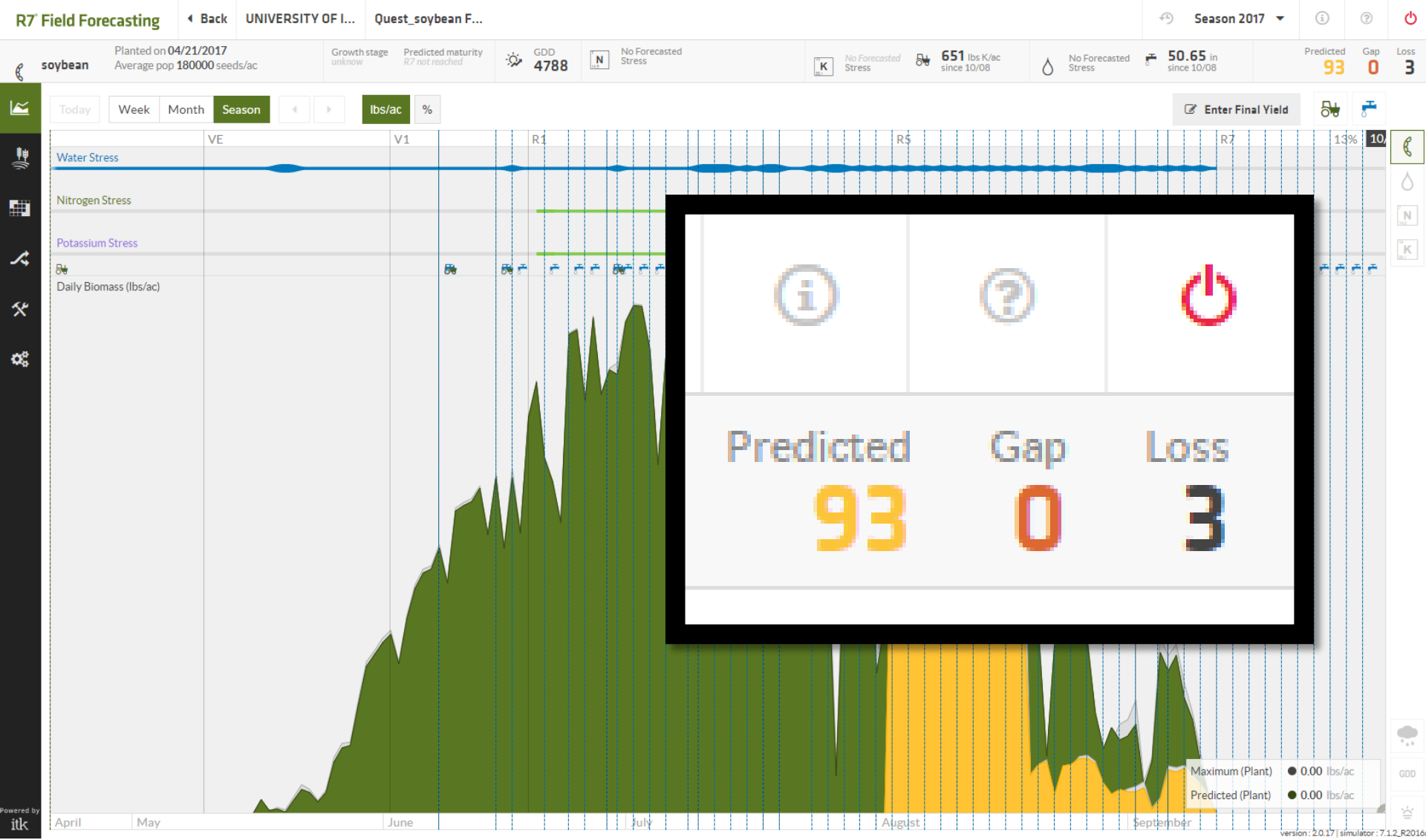
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Champaign, IL 2017

R7 Field Forecasting Tool



The Six Secrets of Soybean Success

What Factors Have the Biggest Impact on Soybean Yield?



Not Secrets of Soybean Success, but Important to Overall Crop Productivity

- **Corn yields 25 bu better when it follows soybean and needs 40-50 lbs less nitrogen fertilizer**

Not Secrets of Soybean Success, but Important to Overall Crop Productivity

- Soybean improves soil tilth compared to corn**
- Soybean root system is a taproot while corn roots are fibrous**

Soybean Improves Soil Tilth

CORN

SOYBEAN



Crucial Prerequisites, but not Secrets of Success

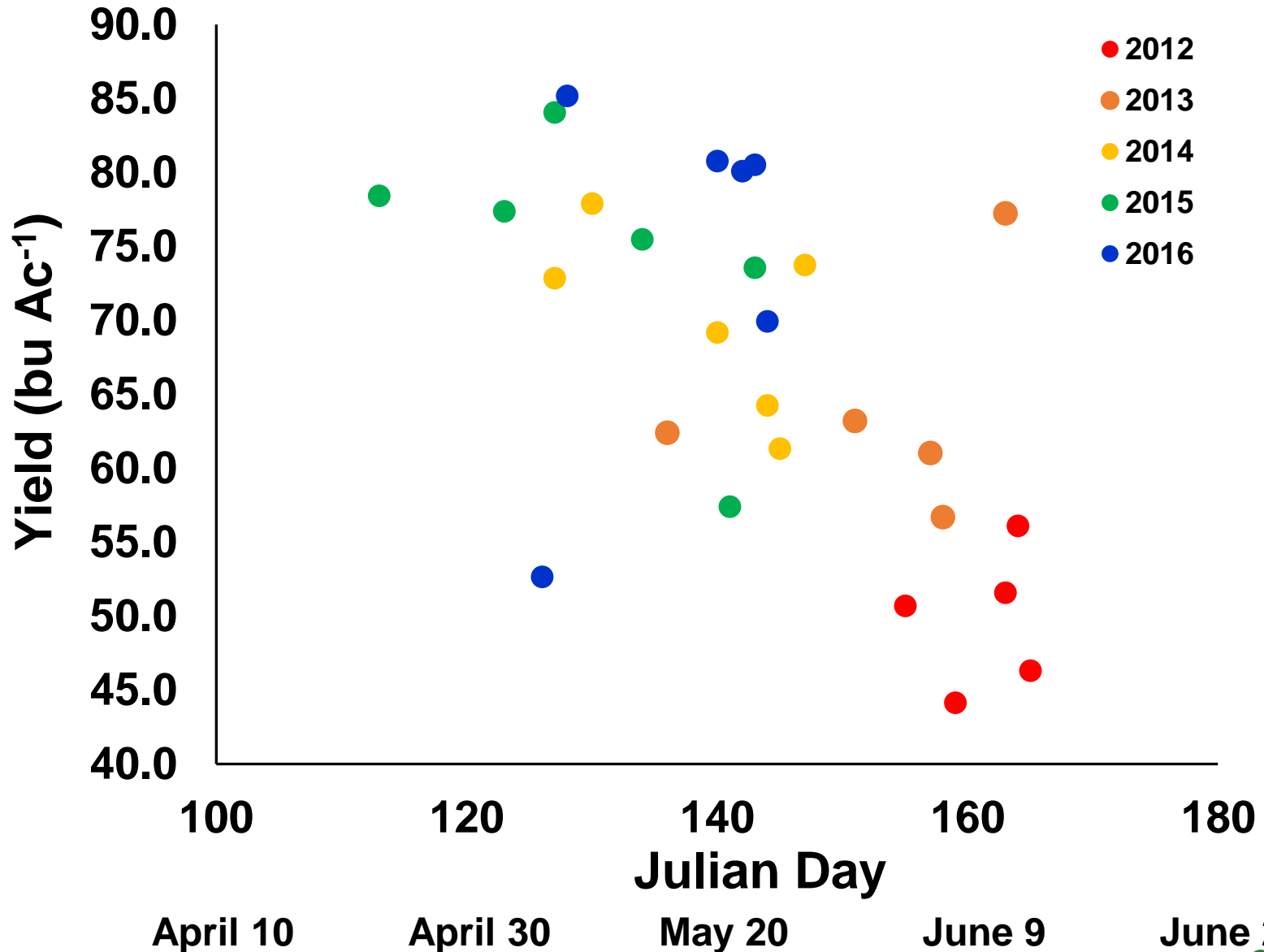
- **Drainage**
- **Weed Control**
- **Proper Soil pH**

The Six Secrets of Soybean Success

Rank	Factor
1	Weather
2	
3	
4	
5	
6	

Given key prerequisites

Soybean Yield by Planting Date



Yield of control plots over last five years

The Six Secrets of Soybean Success

Rank	Factor
1	Weather
2	Fertility
3	
4	
5	
6	

Given key prerequisites

Soybean Gets Some N from Fixation by Nodules



Test Your Knowledge of High Yield Soybean

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

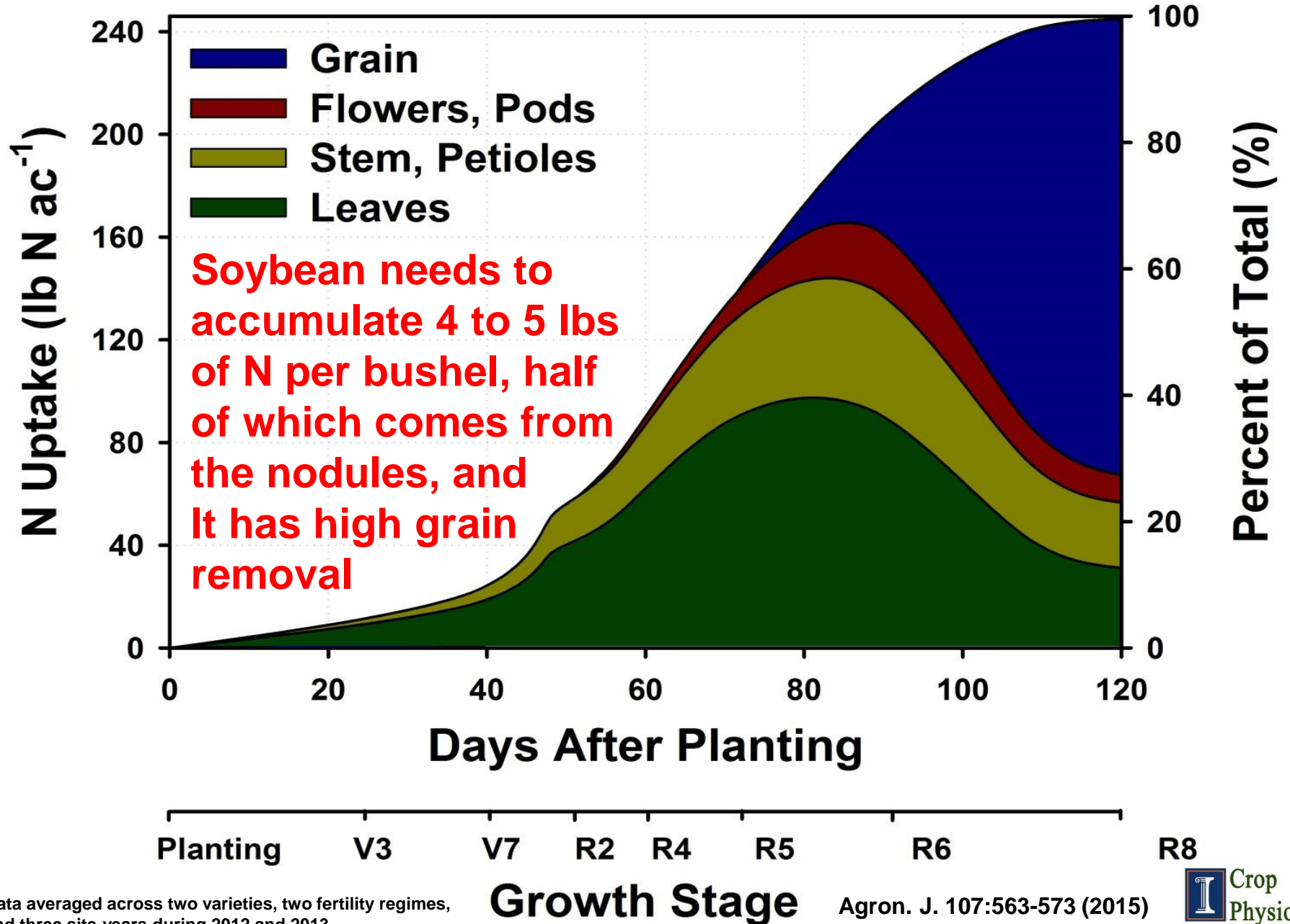
About half or 50%

Test Your Knowledge of High Yield Soybean

- How much N does soybean need to accumulate per bushel?

4 to 5 lbs of N per Bushel

N Uptake & Partitioning for 60 Bushel Soybean



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

Nitrogen Needs and Removal by 60 Bushel Soybean Crop

Amount Required	*Amount from Nodules	Removed with Grain	Net Removal from Soil
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lb acre⁻¹

245

123

179

56

* Assuming 50% of total N accumulation supplied by N fixation from nodules

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

Facts about Soybean and N

- **There is no such thing as a soybean N credit**
- **Soybean removes about a pound of N from the soil for each bushel that it produces**

The Six Secrets of Soybean Success

Rank	Factor
1	Weather
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3	
4	
5	
6	

Given key prerequisites

Typical Fertilization for Corn and Soybean in Illinois

- **180 lbs N, 90 lbs P₂O₅ and 100 lbs K₂O per acre applied to corn. No S or micronutrients**
- **No fertilizer applied to soybean**

Nutrient Uptake and Removal by 60 Bushel Soybean

Nutrient	Required to Produce	Removed with Grain	Harvest Index
	lbs per acre		%
N	245	179	73
P ₂ O ₅	43	35	81
K ₂ O	170	70	41
S	17	10	61
Zn (oz)	4.8	2.0	44
B (oz)	4.6	1.6	34

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

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

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Typical Fertilization for Corn and Soybean in Illinois

- **180 lbs N, 90 lbs P_2O_5 and 100 lbs K_2O per acre applied to corn. No S or micronutrients**
- **No fertilizer applied to soybean**

P and K Uptake and Removal by 60 bu Soybean vs 230 bu Corn

Nutrient	Required to Produce		Removed with Grain		Remain in Stover	
	Corn	Soy	Corn	Soy	Corn	Soy
	lbs per acre					
P₂O₅	101	43	80	35	21	8

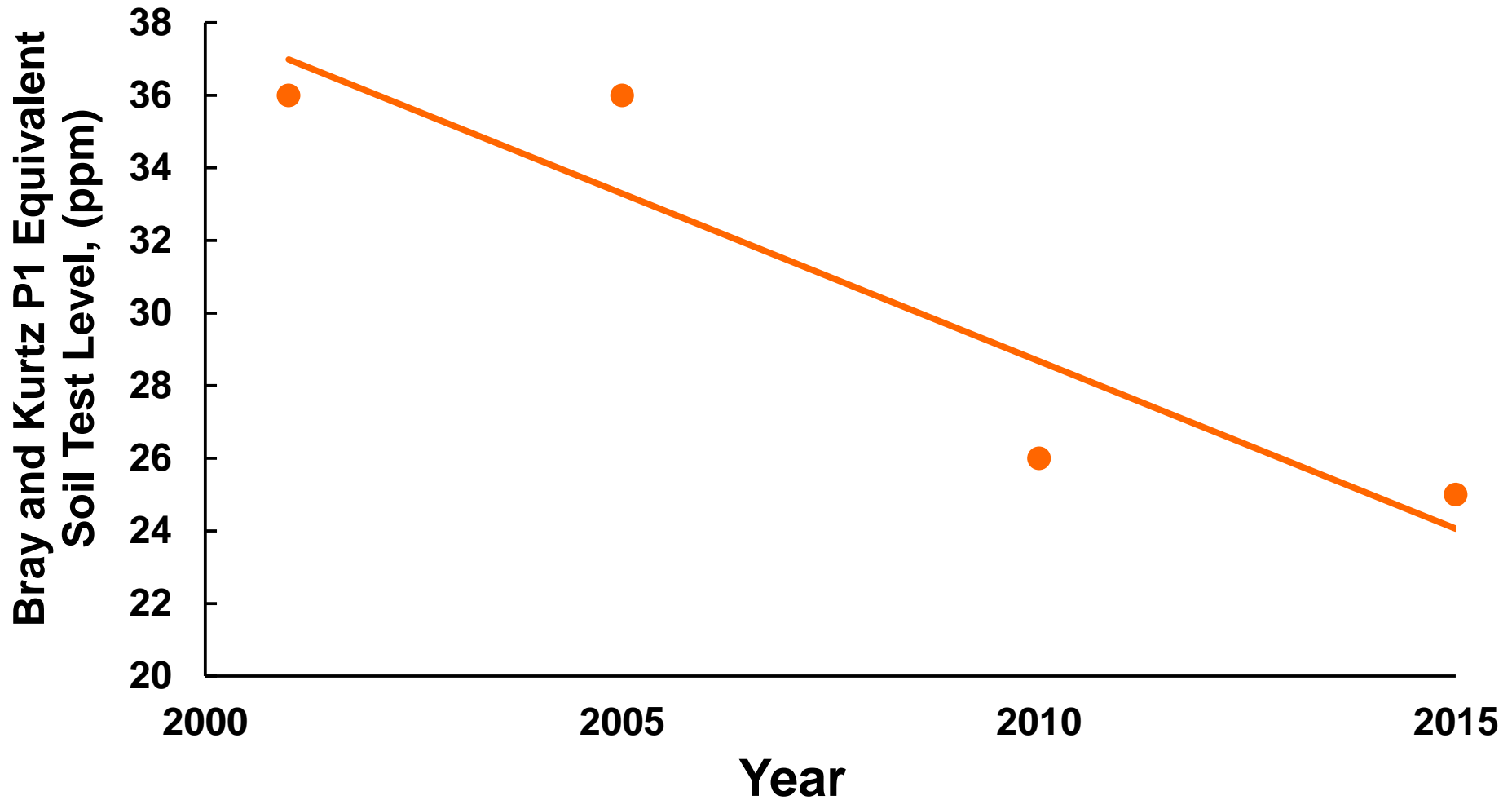
Corn data from Agron J. 105:161-170 (2013); Soybean data from Agron. J. 107:563-573 (2015)

P and K Uptake and Removal by 60 bu Soybean vs 230 bu Corn

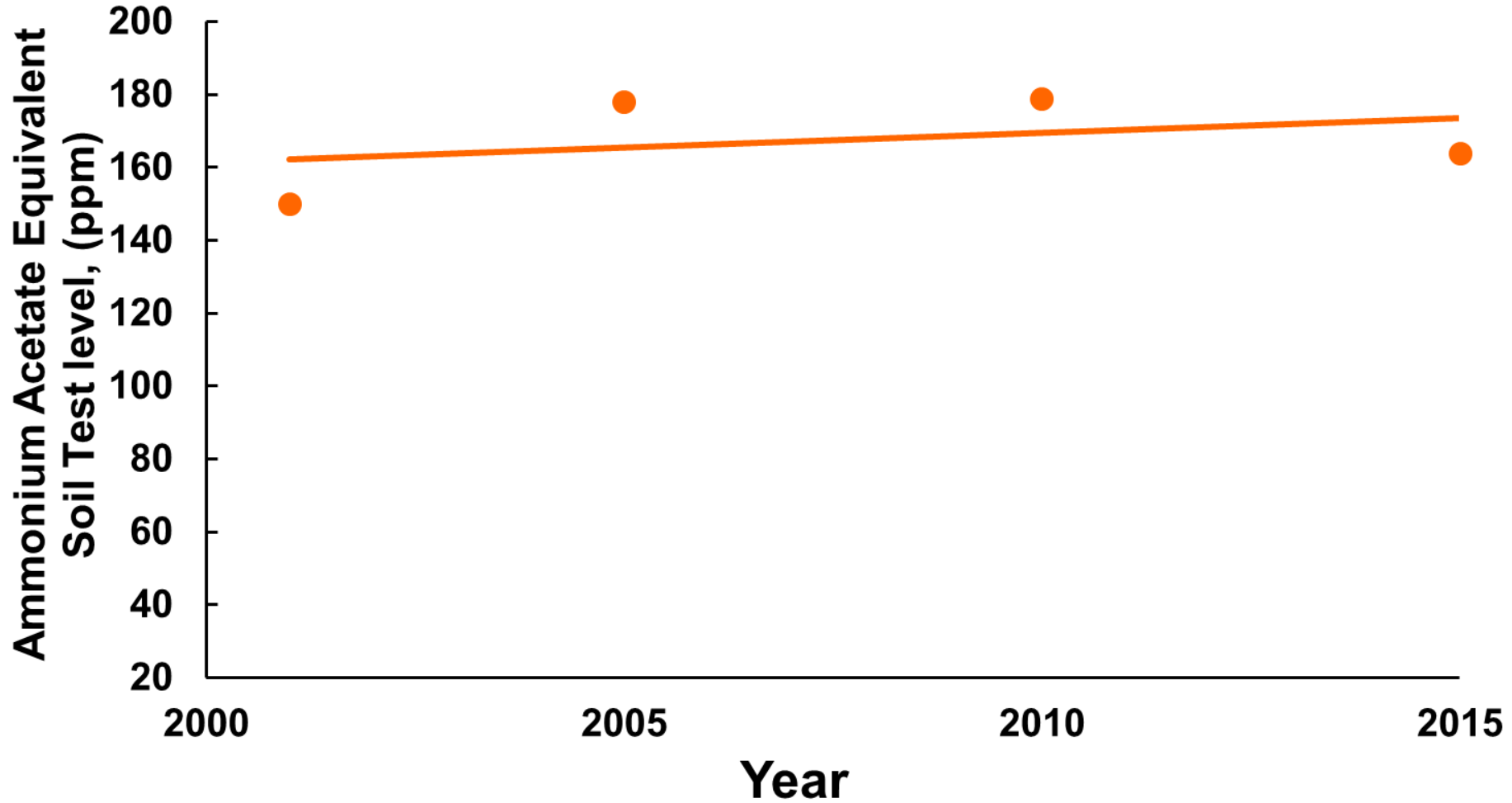
Nutrient	Required to Produce		Removed with Grain		Remain in Stover	
	Corn	Soy	Corn	Soy	Corn	Soy
	lbs per acre					
P_2O_5	101	43	80	35	21	8
K_2O	180	170	56	70	124	100

Corn data from Agron J. 105:161-170 (2013); Soybean data from Agron. J. 107:563-573 (2015)

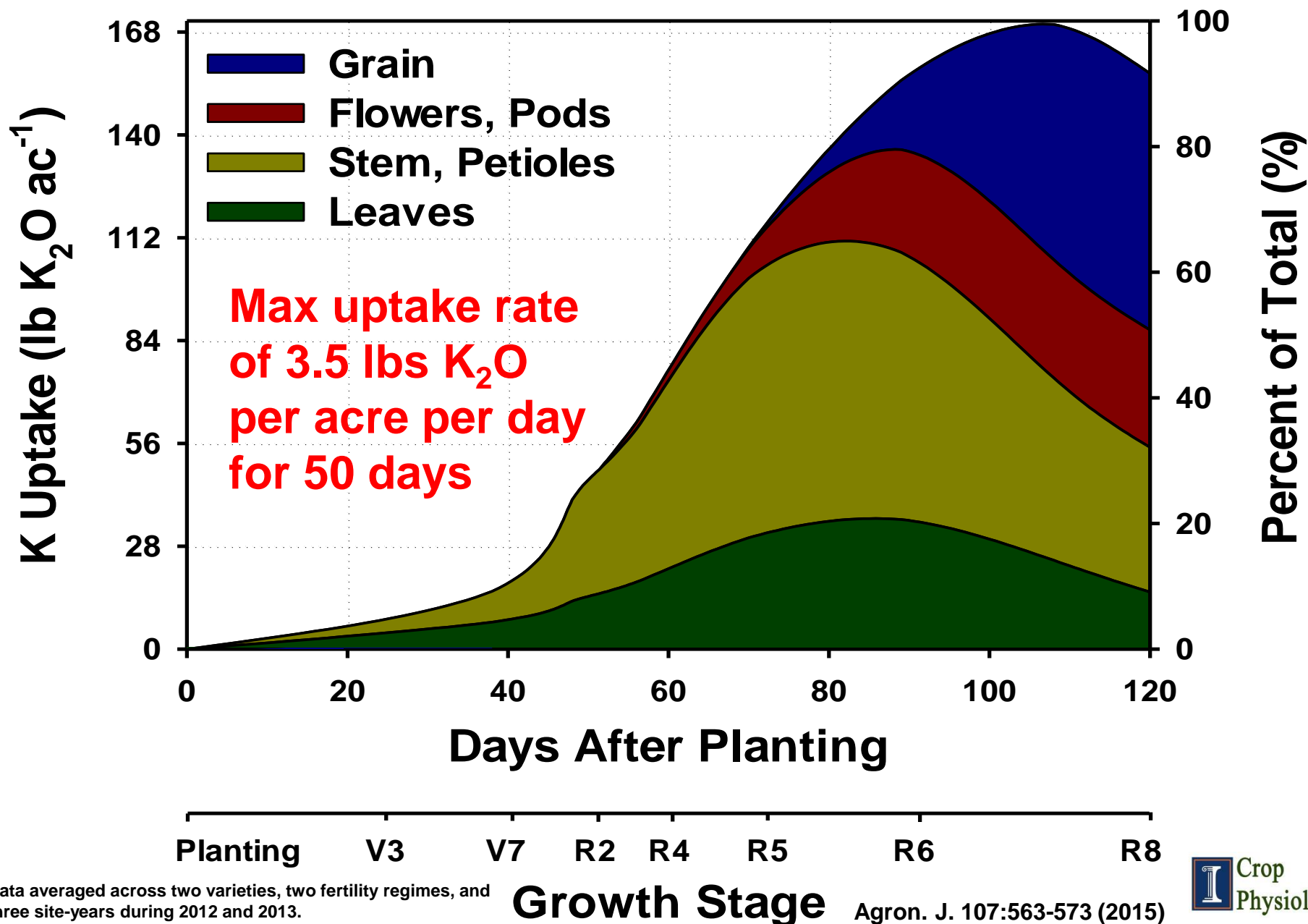
Illinois P Soil Test Decline-Are We Fertilizing Correctly?



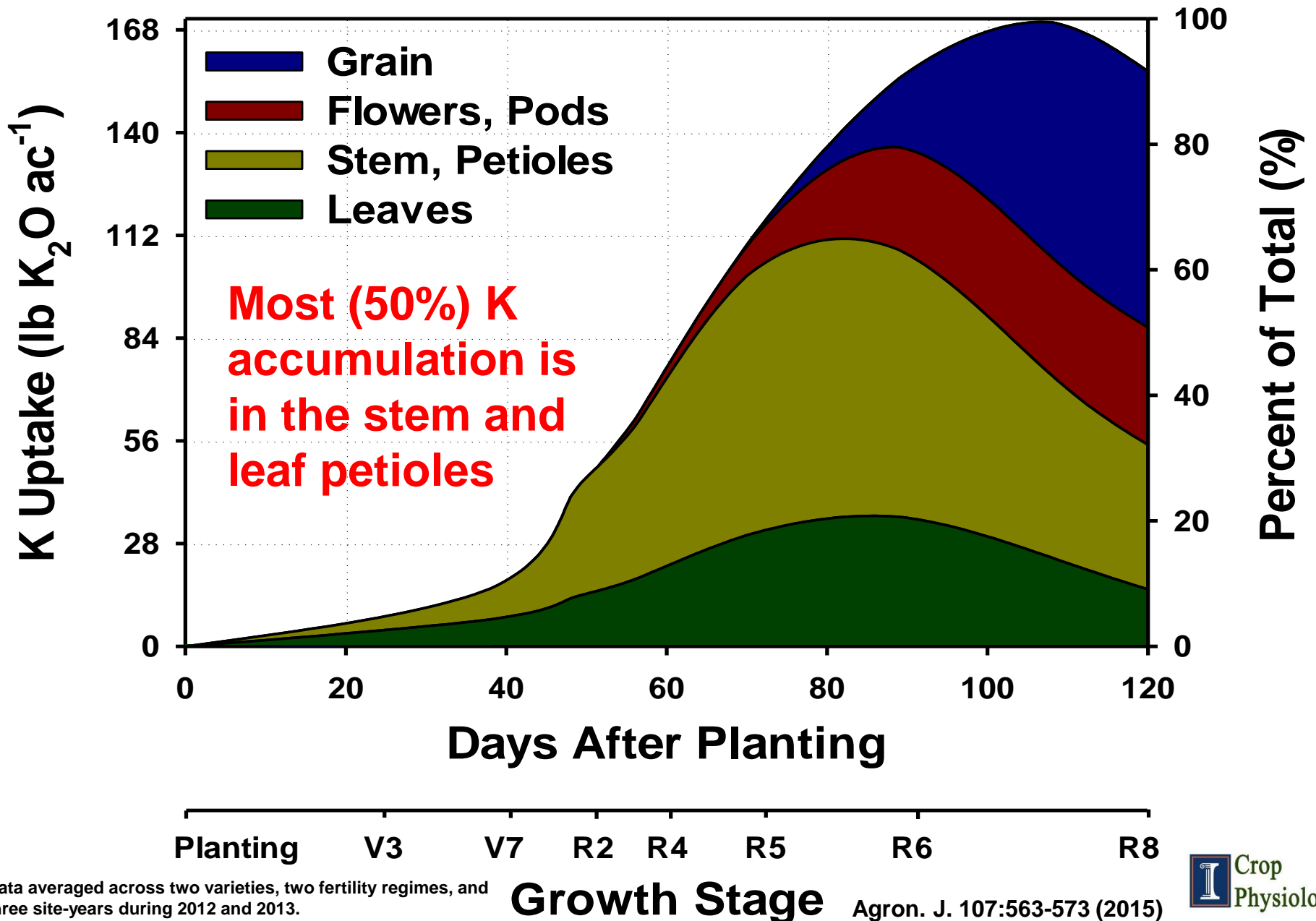
Illinois K Soil Test Levels Are Relatively Stable



K Uptake & Partitioning for 60 Bushel Soybean

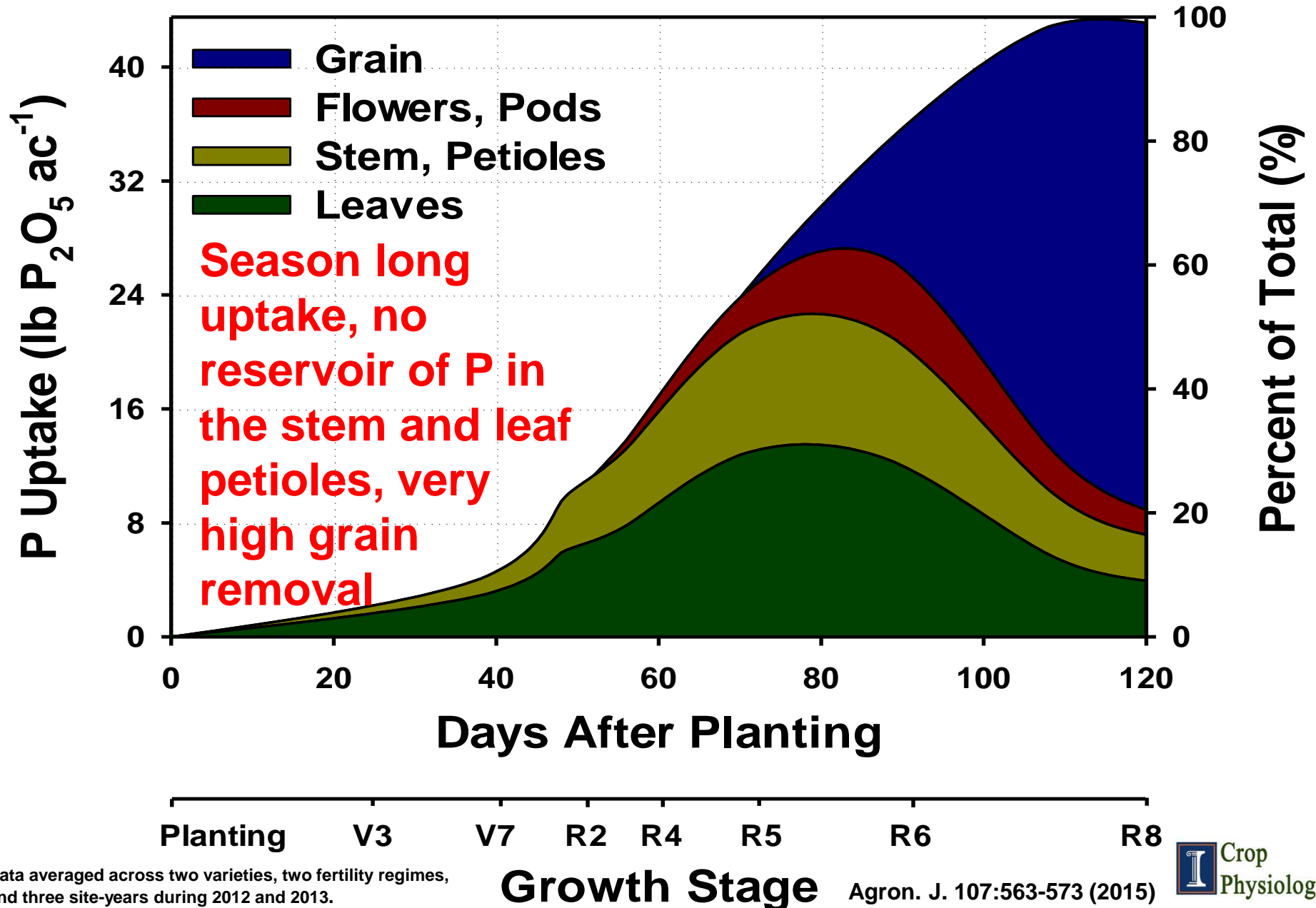


K Uptake & Partitioning for 60 Bushel Soybean



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

P Uptake & Partitioning for 60 Bushel Soybean

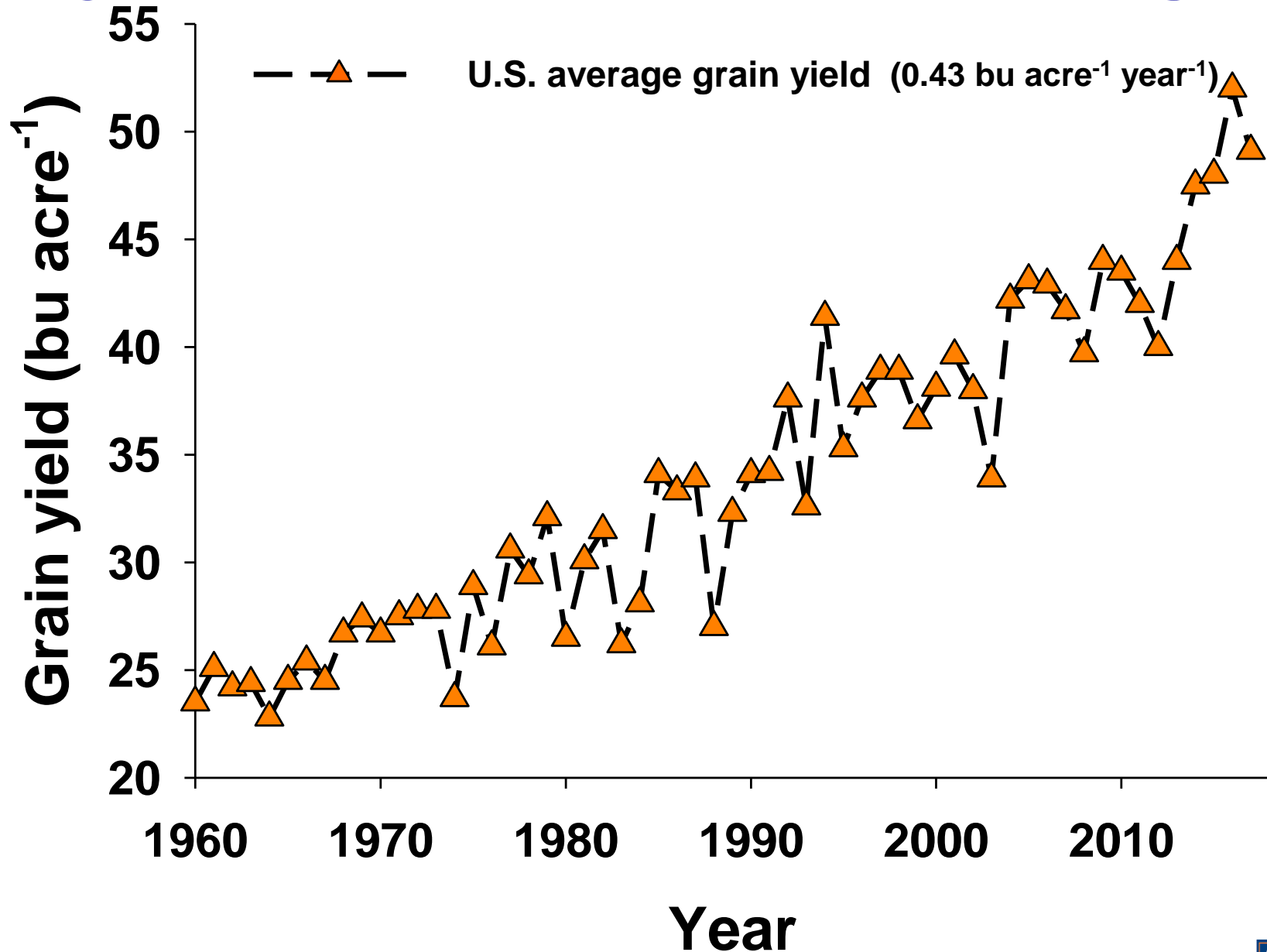


The Six Secrets of Soybean Success

Rank	Factor
1	Weather
2	Fertility
3	Genetics/Variety
4	
5	
6	

Given key prerequisites

Soybean Yields Haven't Stagnated



Source: USDA

All Soybean Varieties are Not Created Equal

Variety	Yield	Variety	Yield	Variety	Yield
	bu acre ⁻¹		bu acre ⁻¹		bu acre ⁻¹
1	80.4	7	72.6	13	62.5
2	79.4	8	70.5	14	60.3
3	79.1	9	70.5	15	60.1
4	75.6	10	68.8	16	59.3
5	75.0	11	67.0	17	57.8
6	72.7	12	65.2		

17 varieties with standard management at Champaign in 2015

All Soybean Varieties are Not Created Equal

MG	Yield	MG	Yield	MG	Yield
	bu acre⁻¹		bu acre⁻¹		bu acre⁻¹
3.3	80.4	3.7	72.6	2.5	62.5
3.9	79.4	3.8	70.5	2.9	60.3
3.8	79.1	3.7	70.5	3.1	60.1
3.5	75.6	2.9	68.8	2.5	59.3
3.6	75.0	3.0	67.0	2.8	57.8
3.1	72.7	2.6	65.2		

17 varieties with standard management at Champaign in 2015

Soybean Yield Components

$$\text{Yield} = \text{Pod number/acre} \times \text{Seeds per pod} \times \text{Weight per seed}$$

The Legendary 5 Bean Pod



Champaign, 2013

The Six Secrets of Soybean Success

Rank	Factor
1	Weather
2	Fertility
3	Genetics/Variety
4	Foliar Protection
5	
6	

Given key prerequisites

Soybean is Indeterminate



- Flower and leaf development at the same time
- Closest leaf provides most of the energy for pods at that node
- Typical plant has 20 nodes

Soybean Yield Components

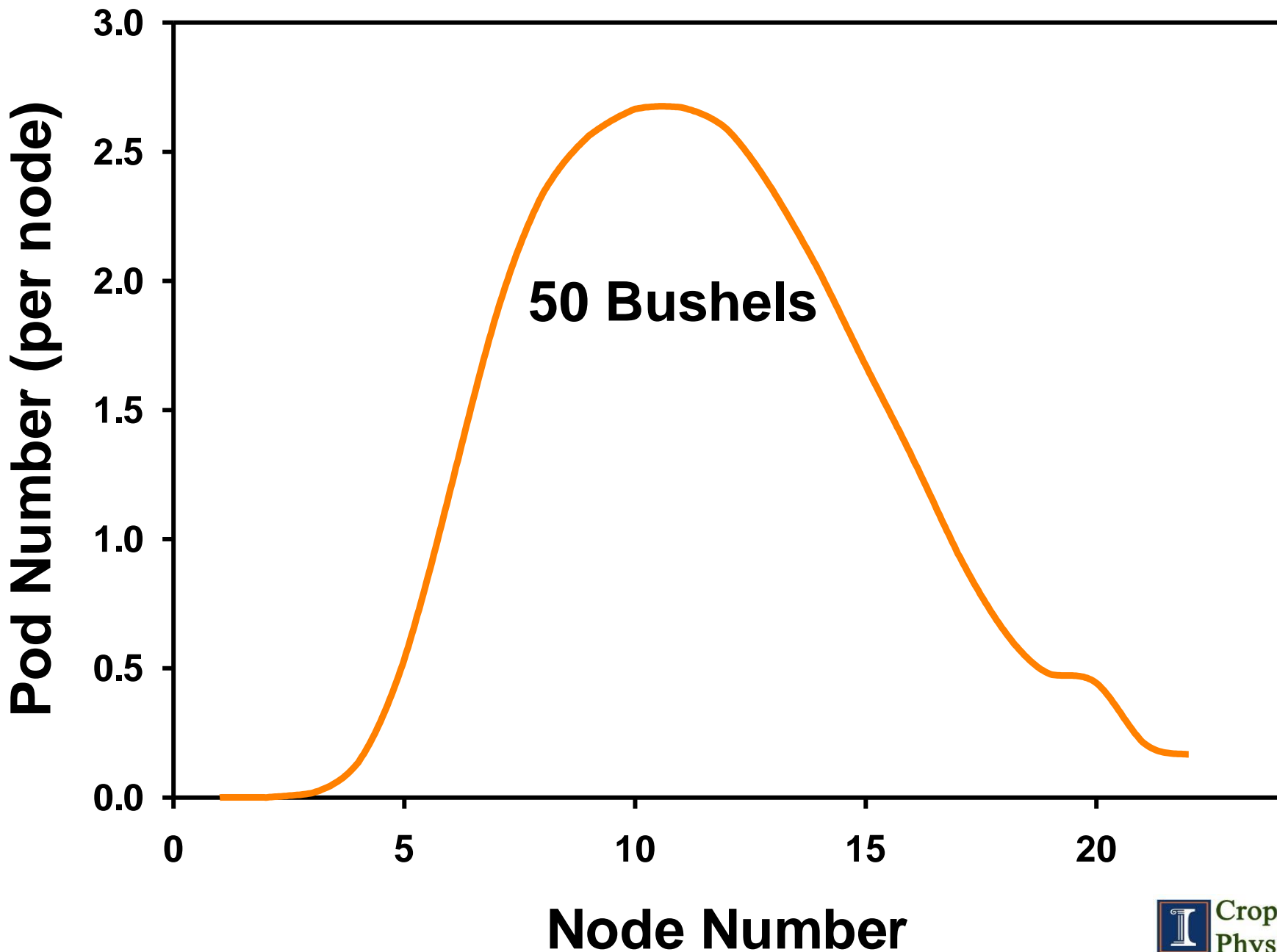
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Test Your Knowledge of High Yield Soybean

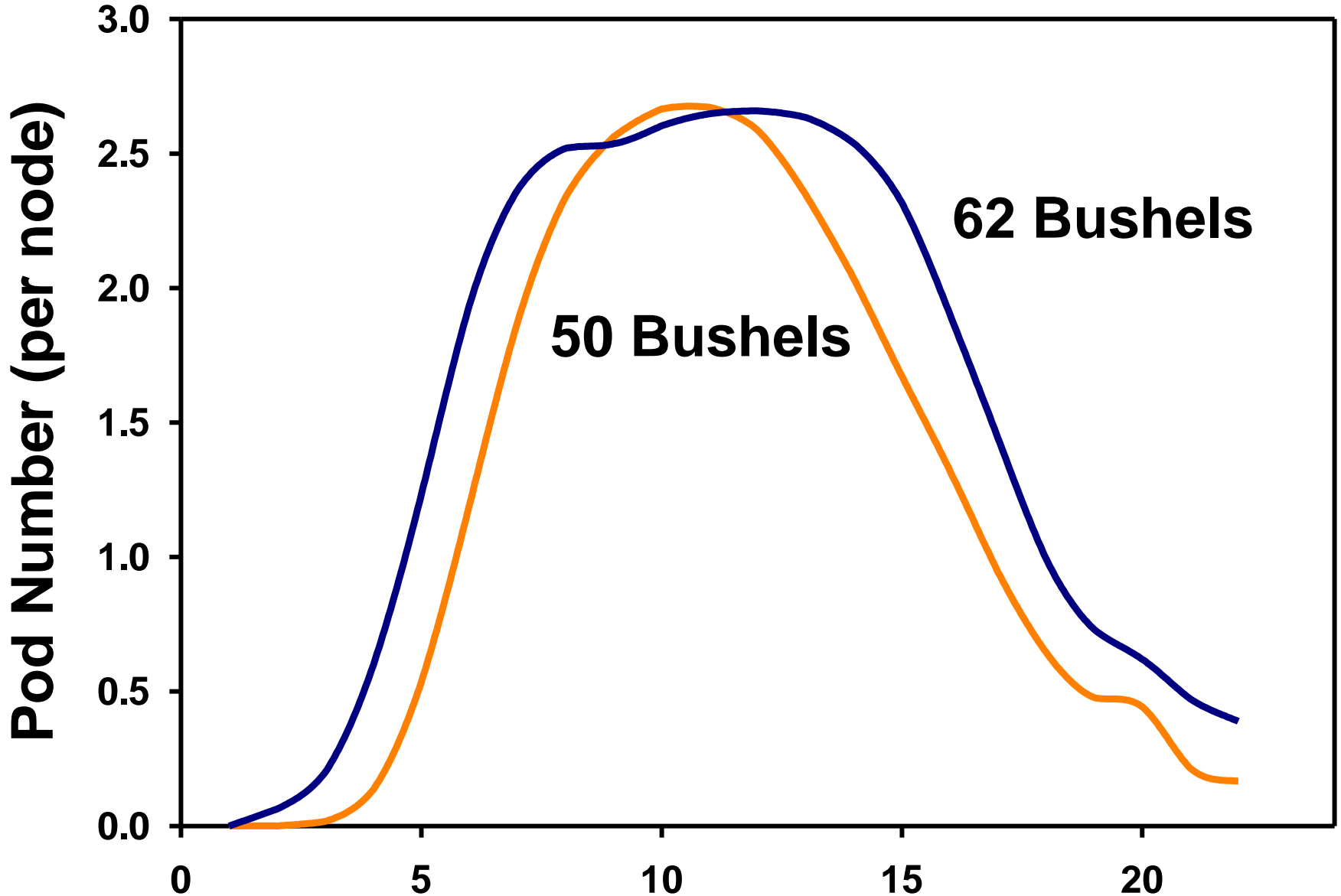
- **Where is the majority of the yield on a soybean plant?**

Middle 1/3 of the plant

How Does Pod Number Effect Soybean Yield



How Does Pod Number Effect Soybean Yield



Node Number

The Six Secrets of Soybean Success

Rank	Factor
1	Weather
2	Fertility
3	Genetics/Variety
4	Foliar Protection
5	Seed Treatment
6	

Given key prerequisites

Impact of Seed Treatment on Emergence



Untreated



**Fungicide, Insecticide,
Nematicide**

Impact of Seed Treatment on Soybean Growth



Fungicide only

**Fungicide, Insecticide,
Nematicide**

R2 growth stage, Champaign, IL 2012

Impact of Seed Treatment on Soybean Growth



Plants at growth stage R2 at Champaign, IL 2012

The Six Secrets of Soybean Success

Rank	Factor
1	Weather
2	Fertility
3	Genetics/Variety
4	Foliar Protection
5	Seed Treatment
6	Row Spacing

Given key prerequisites

Row Spacing Affects Light Interception And Canopy Air Movement



30" Rows



20" Rows

Soybean Management Trials

Which Management Factors Have the Greatest Impact on Soybean Yields?

3 sites in Illinois with:

- 11 trials (4 in 2014, 7 in 2015) at 3 locations
- Different company seed (Asgrow, Syngenta, Croplan), seed treatments and foliar protection products: BASF or Syngenta

Evaluation of five management practices:

- Banded P, Broadcast K or both at planting
- Foliar Protection
- Seed Treatment
- Row Spacing
- Relative Maturity



Soybean Most Influential Management Factors

Standard vs High Input

Phosphorus

No additional P

Potassium

No additional K

P and K

No additional P or K

Foliar Protection

No foliar protection

Seed Treatment

Untreated or Fungicide only

Row Spacing

30 inch row spacing

Evaluated across 2 varieties during 11 site-years

Soybean Most Influential Management Factors

Standard vs High Input

Phosphorus

No additional P

**75 lbs P₂O₅ as MESZ (N, P, S, & Zn)
Banded 4-6" under row at planting**

Potassium

No additional K

**75 lbs K₂O as Aspire (K & B)
Broadcast at planting**

P and K

No additional P or K

MESZ and Aspire applied as above

Foliar Protection

No foliar protection

Fungicide and Insecticide at R3

Seed Treatment

Untreated or Fungicide only

Fungicide, Insecticide, Nematicide

Row Spacing

30 inch row spacing

20 inch row spacing

Evaluated across 2 varieties during 11 site-years

Grower Question

- **Do your ‘Neighbors’ fertilize their soybean crop?**

My WI Soil



Illinois Soil



Banding P Fertilizer 4-6 inches Deep Directly Under the Future Crop Row



Broadcast, K Applications



Seeding Soybean Directly Over the Phosphorus Fertilizer Band



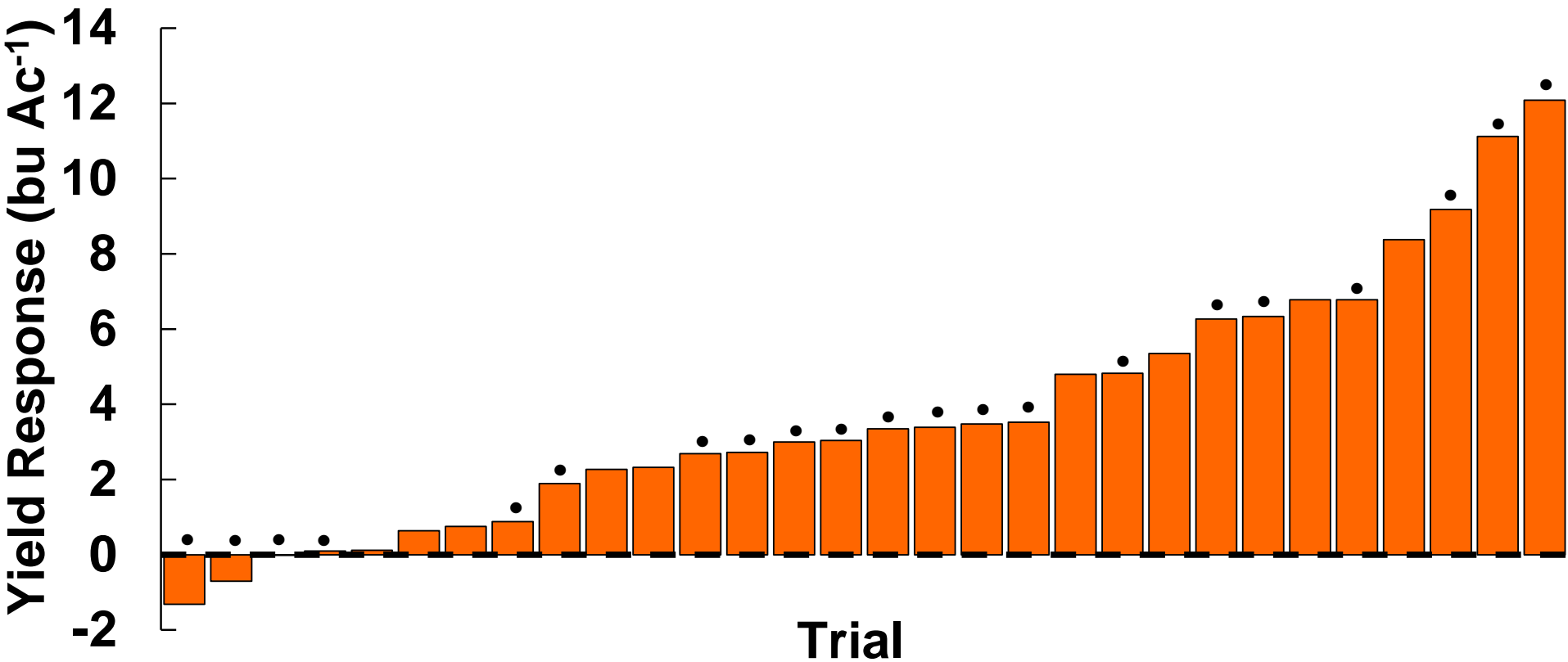
Strong Start From Banded Fertility



**Without
banded fertility**
but with adequate
soil test values

**With banded
fertility to provide**
75 lbs P₂O₅, 23 lbs N, 19
lbs S, 2 lbs Zn per acre

Soybean Yield Response from P Fertilizer



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

Standard vs High Input System

Phosphorus

P based on soil test values

75 lbs P_2O_5 as MicroEssentials-SZ (23 N 19 S, & 2 Zn) banded 4-6 inches under the row at planting

Potassium

K based on soil test values

75 lbs K_2O as Aspire (0.6 B) broadcast

P and K

P & K based on soil test values

MESZ and Aspire applied as above

Foliar Protection

No foliar protection

Fungicide and Insecticide applied at R3

Seed Treatment

Untreated or Fungicide only

Fungicide, Insecticide, Nematicide

Row Spacing

30 inch row spacing

20 inch row spacing

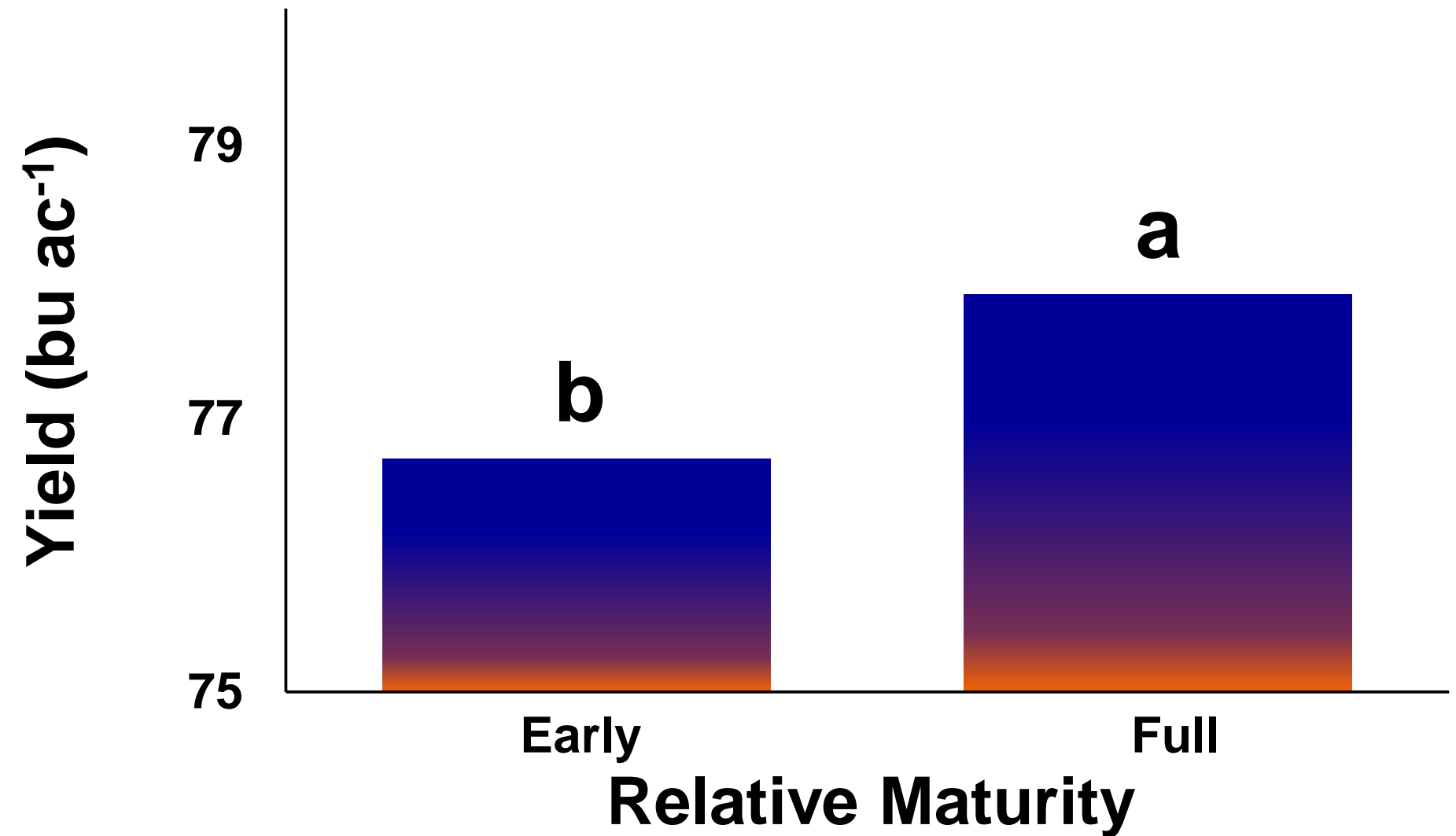
Evaluated with 2 relative maturities and 6 replications per site

Soybean Omission Plot Design

		MANAGEMENT FACTORS				
Treatment		Phosphate	Potassium	P & K	Foliar	Seed Trt.
HIGH INPUT		Yes	Yes	Yes	Yes	Full
Decrease Management	-Phosphate	None	Yes	Yes	Yes	Full
	-Potassium	Yes	None	Yes	Yes	Full
	-P and K	Yes	Yes	None	Yes	Full
	-Foliar Protection	Yes	Yes	Yes	None	Full
	-Seed Treatment	Yes	Yes	Yes	Yes	Basic
STANDARD		None	None	None	None	Basic
Add Management	+Phosphate	Yes	None	None	None	Basic
	+Potassium	None	Yes	None	None	Basic
	+P and K	None	None	Yes	None	Basic
	+Foliar Protection	None	None	None	Yes	Basic
	+Seed Treatment	None	None	None	None	Full

Treatments evaluated in 20 and 30 inch row spacings
 Treatments averaged across two relative maturities per trial

Effect of Relative Maturity



Yields with different letters differ ($P \leq 0.0001$).
Evaluated with 2 row spacings across 11 site years

Soybean Omission Plot Design

		MANAGEMENT FACTORS				
Treatment		Phosphate	Potassium	P & K	Foliar	Seed Trt.
HIGH INPUT		Yes	Yes	Yes	Yes	Full
Decrease Management	-Phosphate	None	Yes	Yes	Yes	Full
	-Potassium	Yes	None	Yes	Yes	Full
	-P and K	Yes	Yes	None	Yes	Full
	-Foliar Protection	Yes	Yes	Yes	None	Full
	-Seed Treatment	Yes	Yes	Yes	Yes	Basic
STANDARD		None	None	None	None	Basic
Add Management	+Phosphate	Yes	None	None	None	Basic
	+Potassium	None	Yes	None	None	Basic
	+P and K	None	None	Yes	None	Basic
	+Foliar Protection	None	None	None	Yes	Basic
	+Seed Treatment	None	None	None	None	Full

Treatments evaluated in 20 and 30 inch row spacings

Add One Enhanced Factor to Standard Management

Add One Enhanced Factor	Standard System	
	Yield	Δ
	bu acre ⁻¹	
Standard Management	70.4	
+Phosphorus (also N, S, Zn)	75.1	+4.7*
+Potassium (also B)	69.9	-0.4
+Phosphorus & Potassium	74.5	+4.2*
+Foliar Protection (R3 Fung. & Insect.)	73.3	+3.0*
+Seed Treatment (Complete)	71.8	+1.4
+Row Spacing (20 inch rows)	74.7	+4.3*

*Significantly different from standard at $P \leq 0.05$.

Average of 11 trials over 2014 and 2015 with two relative maturities in each trial

Soybean Omission Plot Design

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HIGH INPUT		Yes	Yes	Yes	Yes	Full
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	-Potassium	Yes	None	Yes	Yes	Full
	-P and K	Yes	Yes	None	Yes	Full
	-Foliar Protection	Yes	Yes	Yes	None	Full
	-Seed Treatment	Yes	Yes	Yes	Yes	Basic
STANDARD		None	None	None	None	Basic
Add Management	+Phosphate	Yes	None	None	None	Basic
	+Potassium	None	Yes	None	None	Basic
	+P and K	None	None	Yes	None	Basic
	+Foliar Protection	None	None	None	Yes	Basic
	+Seed Treatment	None	None	None	None	Full

Treatments evaluated in 20 and 30 inch row spacings

Omit One Enhanced Factor from High Input System

Omit One Enhanced Factor	High Input System	
	Yield	Δ
	bu acre ⁻¹	
High Input all Six Factors	84.8	
-Phosphorus (fertility based on soil test)	80.1	-4.7*
-Potassium (fertility based on soil test)	84.9	+0.1
-Phosphorus & Potassium	80.3	-4.5*
-Foliar Protection (None)	81.7	-3.1*
-Seed Treatment (None or Base)	82.7	-2.1*
-Row Spacing (30 inch rows)	77.1	-7.8*

*Significantly different from standard at $P \leq 0.05$.

Average of 11 trials over 2014 and 2015 with two relative maturities in each trial

Standard vs. High-Input Management

Factor	Standard		High Input	
	Yield	Δ	Yield	Δ
	————— bu acre ⁻¹ —————			
None or All	70.4		84.8	
Phosphate	75.1	+4.7*	80.1	-4.7*
Potassium	69.9	-0.4	84.9	+0.1
P & K	74.5	+4.2*	80.3	-4.5*
Foliar Protection	73.3	+3.0*	81.7	-3.1*
Seed Treatment	71.8	+1.4	82.7	-2.1*
Row Spacing	74.7	+4.3*	77.1	-7.8*

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Standard vs. High-Input Management

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Row Spacing	74.7	+4.3*	77.1	-7.8*

*Significantly different at $P \leq 0.05$.

Average of 11 trials over 2014 and 2015 with two relative maturities in each trial

Conclusions- Soybean

- Soybean yield can be increased with better crop management
- Soil fertility, particularly phosphorus is one of the most important management factors for increasing soybean yields
- Variety makes a big difference and usually the fullest maturity gives the highest yield

Conclusions - Soybean

- **60% of soybean yield comes from nodes 7-13, so it is important to protect leaves at those nodes, which would occur with an R3 spray**
- **Adding one more pod to each soybean plant increases yield by two bushels per acre**

Conclusions - Soybean

- Each of the six secrets can increase yield and when combined into a system they can act synergistically

Special Thanks to Dan Davidson & Illinois Soybean Association

For More Information:

Crop Physiology Laboratory

University of Illinois

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

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