Continuing the Quest for High Yield Soybean

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University of Illinois at Urbana-Champaign

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Agronomy Conference
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Crop Physiology

Do Growers Adequately Manage Soybean?

Crop Physiology

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 108.3 bushels in 2015

Crop Physiology

The Six Secrets of Soybean Success

What Factors Have the Biggest Impact on Soybean Yield?

Crop Physiology

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

Crucial Prerequisites, but not Secrets of Success

- Drainage
- Weed Control
- Proper Soil pH

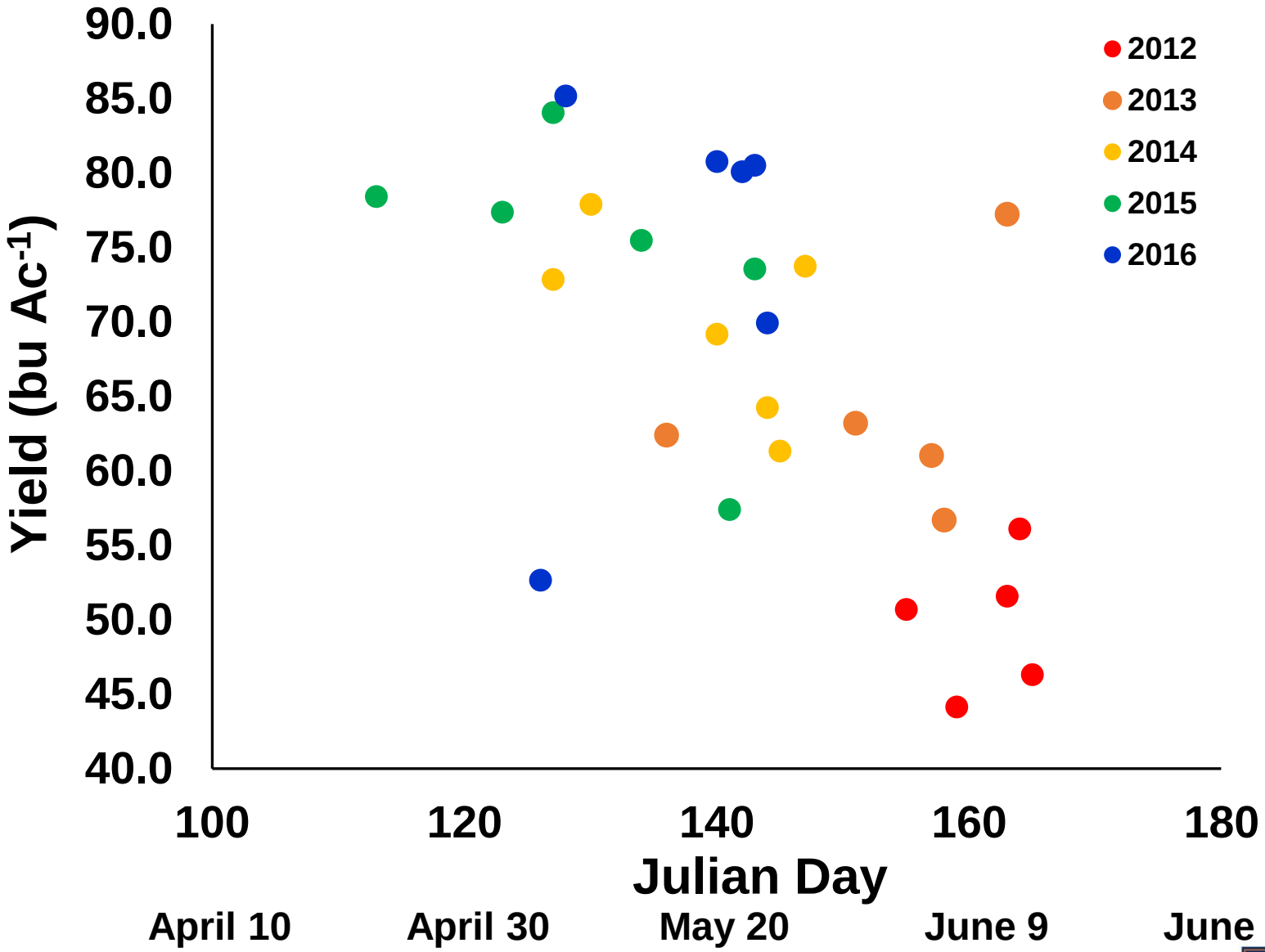
The Six Secrets of Soybean Success

Rank	Factor
1	Weather
2	
3	
4	
5	
6	

Given key prerequisites

Crop Physiology

Soybean Yield by Planting Date



Yield of control plots over last five years

Crop Physiology

The Six Secrets of Soybean Success

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Given key prerequisites

Crop Physiology

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?**

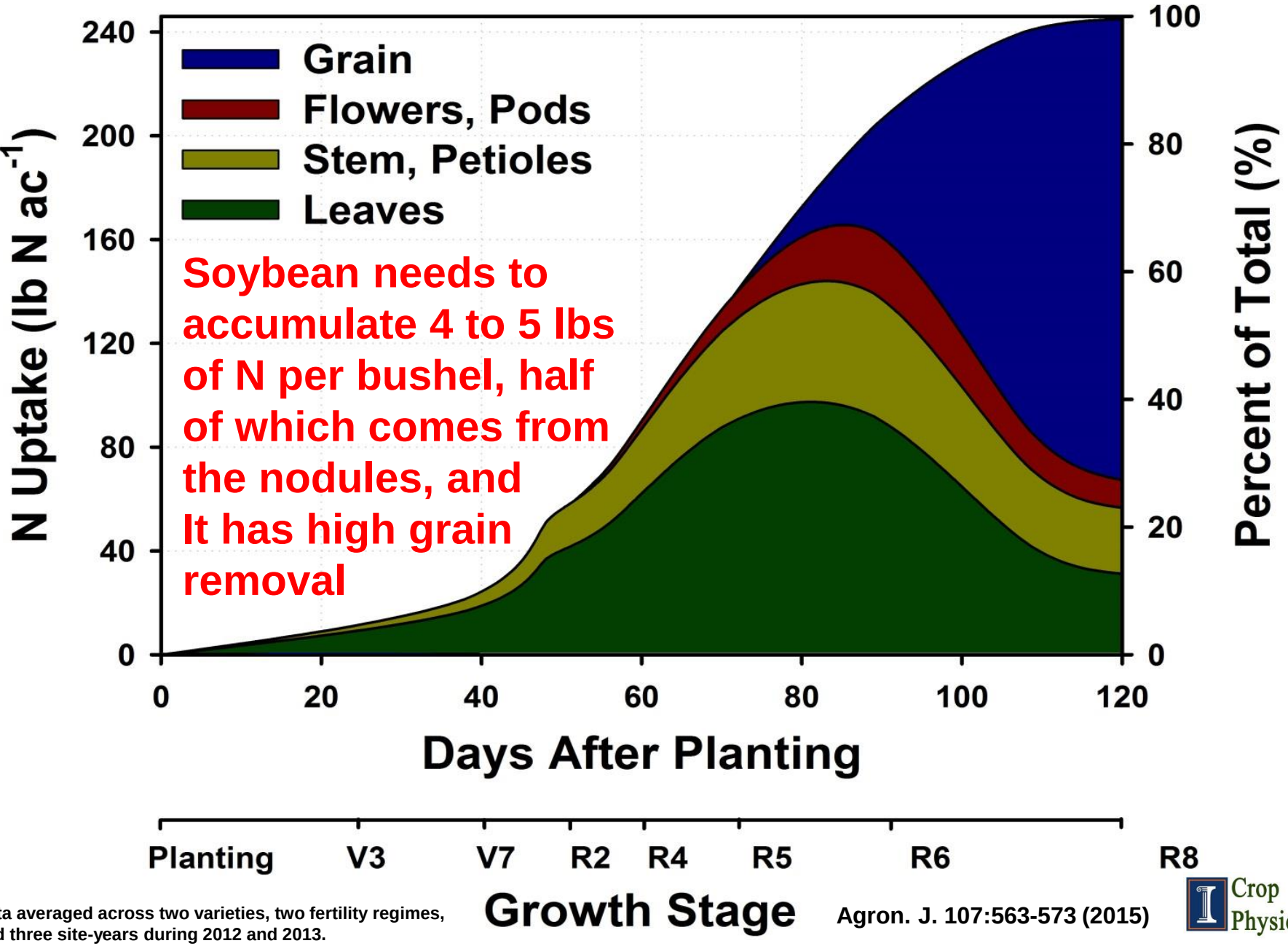
About half or 50%

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.

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

Crop Physiology

Nitrogen Needs and Removal by 60 Bushel Soybean Crop

Amount Required	*Amount from Nodules	Removed with Grain	Net Removal from Soil
lb acre^{-1}			
245	123	179	56

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

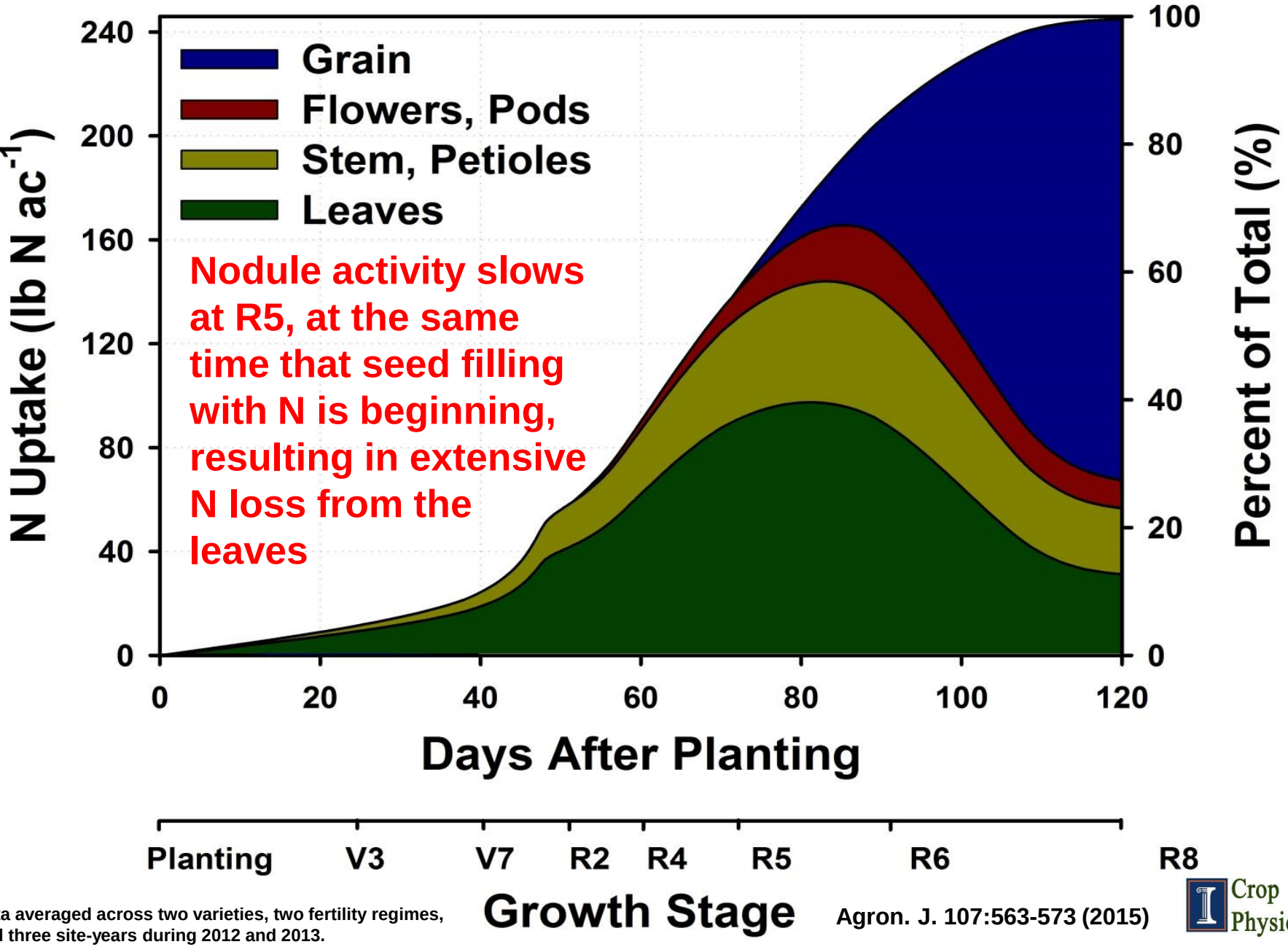
Data averaged across two varieties, two fertility regimes, and three site-years during 2012 and 2013

Crop Physiology

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

Should Supplemental N be Applied to Soybean?



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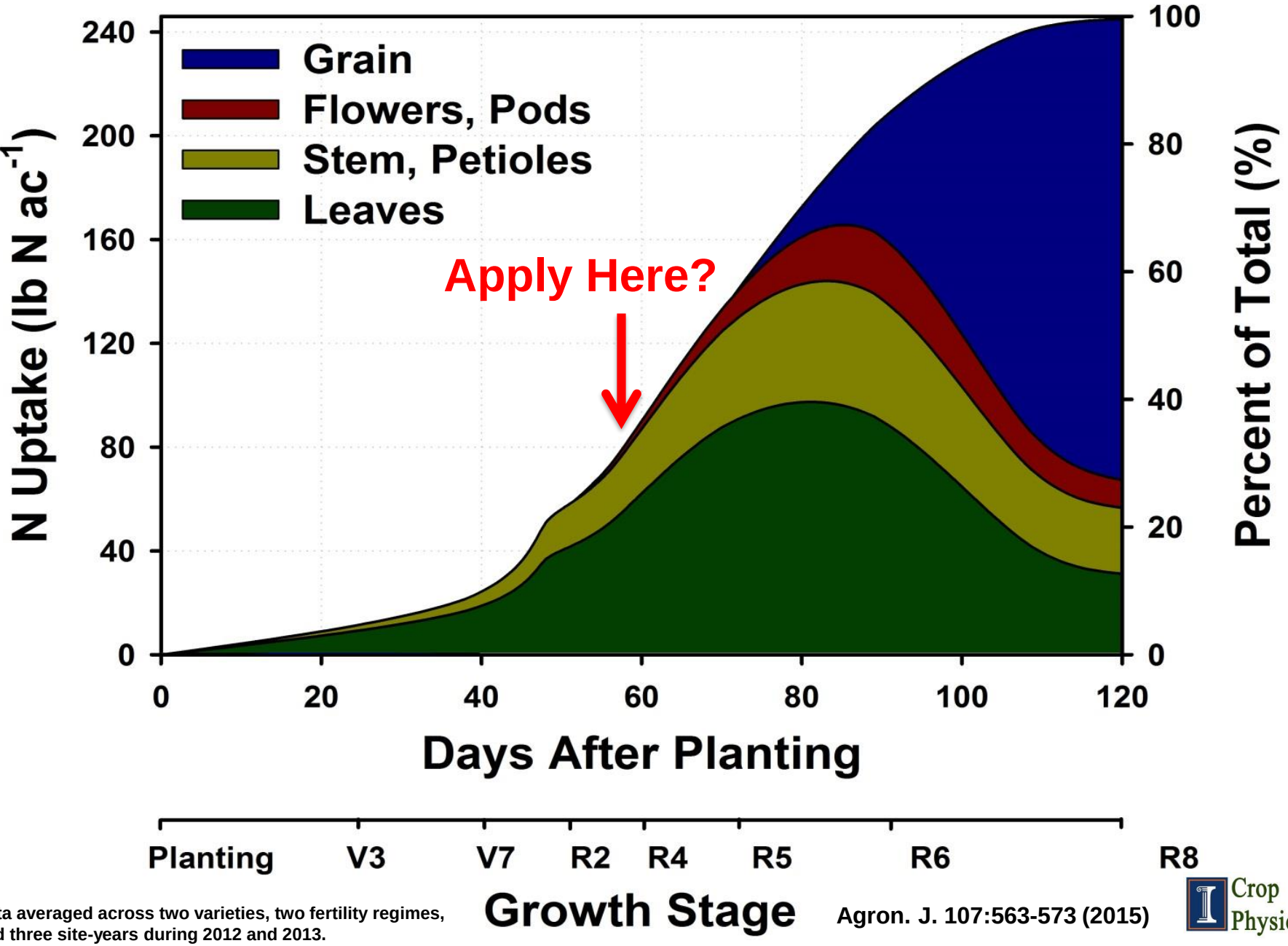
Crop Physiology

When Should Supplemental N be Applied to Soybean?



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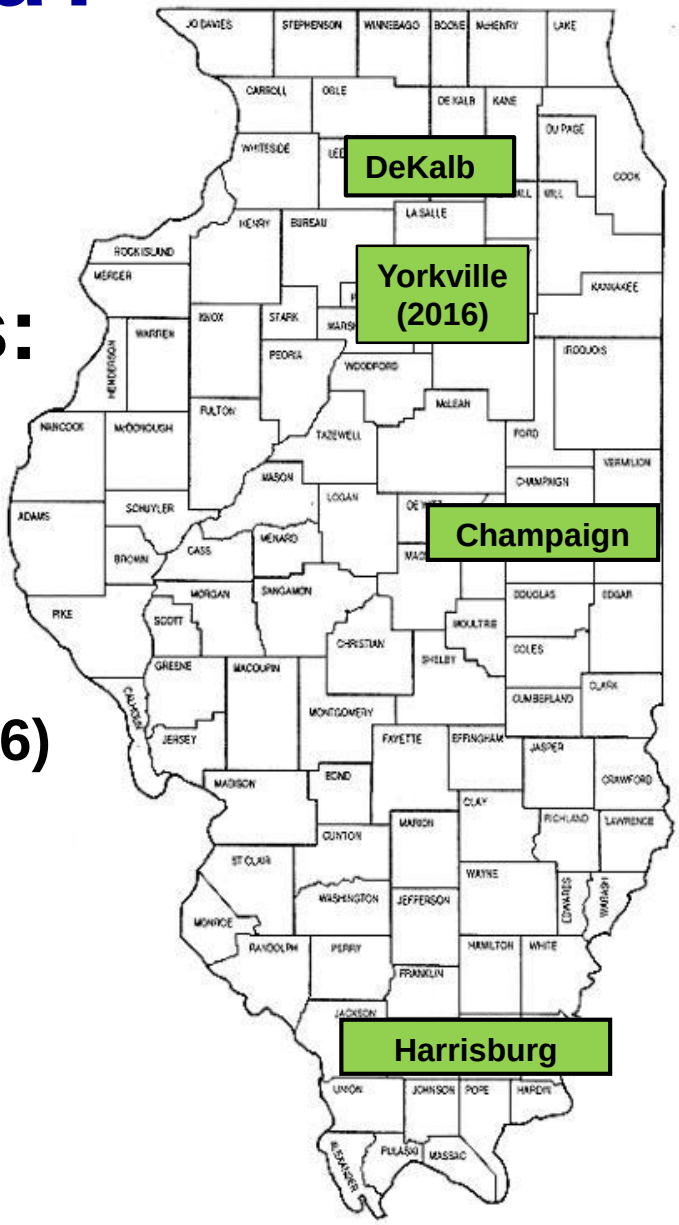
Crop Physiology

What Source of N Should be Applied?

Fertilizer N Source	Conventional wisdom on potential effectiveness
Ammonium nitrate	no
Ammonium sulfate	maybe
Urea/ammonium nitrate	no
Urea	maybe
Urea + urease inhibitor	yes
ESN (controlled release)	yes

Can Supplemental Fertilizer N Increase Soybean Yield?

- **Conducted at DK, CU, HB Illinois in 2014, 2015, 2016**
- **Evaluated Eight N Sources:**
  1.) Unfertilized Control
  2.) Ammonium Nitrate (AN)
  3.) Ammonium Sulfate (AMS)
  4.) Urea Ammonium Nitrate (UAN)
  5.) Urea
  6.) Urea + Limus (2015 & 2016)
  7.) AN + KNO_3 (KN) + AMS (2015 & 2016)
  8.) Environ. Smart Nitrogen (ESN)
- **Applied at 100 lbs N/acre**
- **Broadcast applied before planting, and at V3, R1, R3**



Response to N on Soybean- 2014-2016
Average of 9 Locations (100 lbs of N applied)

Source	Preplant	V3	R1	R3
	changes in bushels acre^{-1}			
AN	3.9*	2.8*	3.2*	3.1*
AMS	2.3	1.4	2.2	1.9
UAN	3.7*	3.3*	2.9*	2.2
Urea	2.7*	2.2	1.9	2.4
Urea + Limus	1.2	2.0	2.2	2.6*
AN+KN+AMS	2.7*	1.2	2.6*	1.9
ESN	4.0*	2.9*	3.2*	2.2

Control = 72.5 *significantly different than control

Crop Physiology

The Six Secrets of Soybean Success

Rank	Factor
1	Weather
2	Fertility
3	
4	
5	
6	

Given key prerequisites

Crop Physiology

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

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_2O_5	43	35	81
K_2O	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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Crop Physiology

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

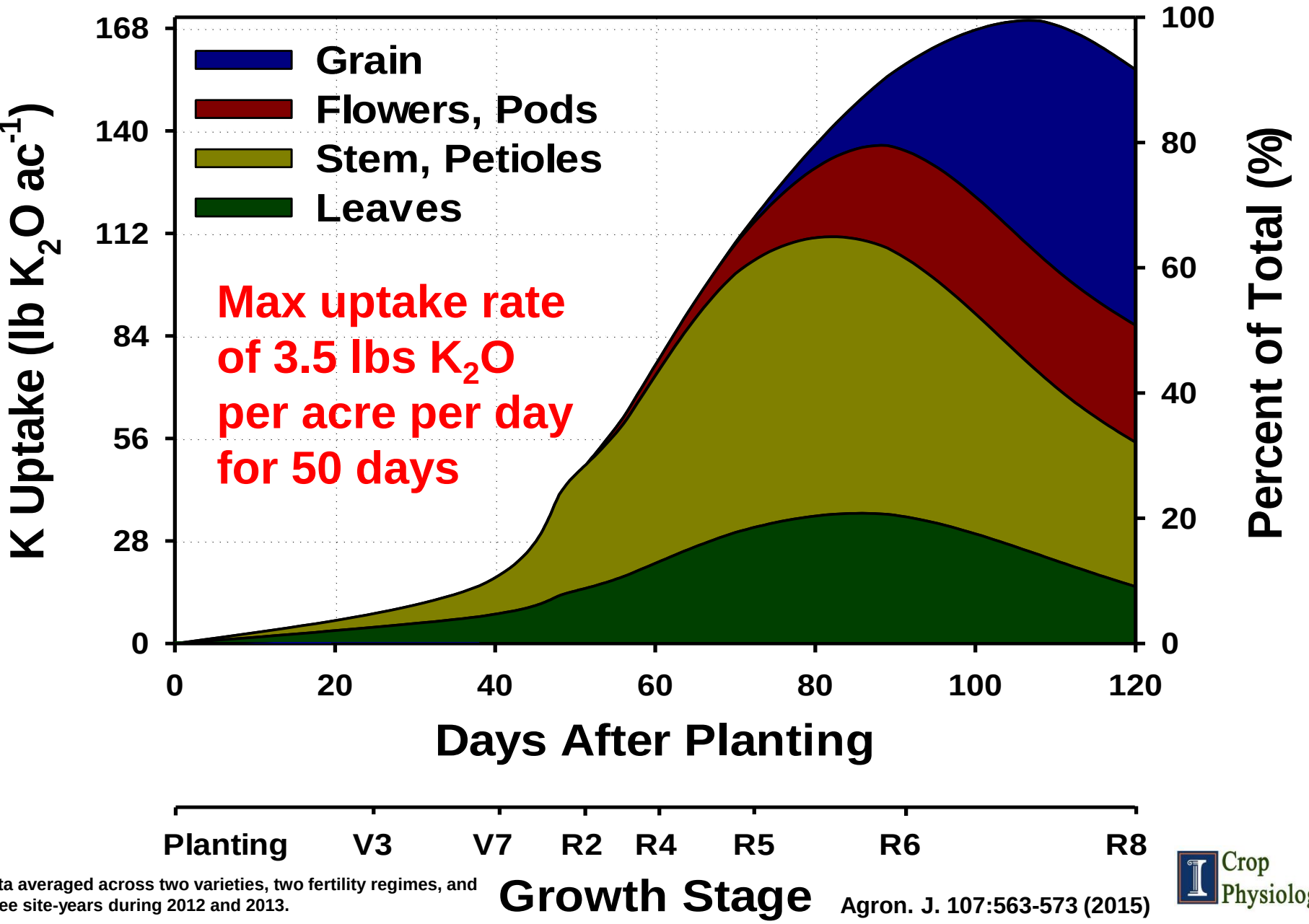
- No fertilizer applied to soybean

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					
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)

K Uptake & Partitioning for 60 Bushel Soybean



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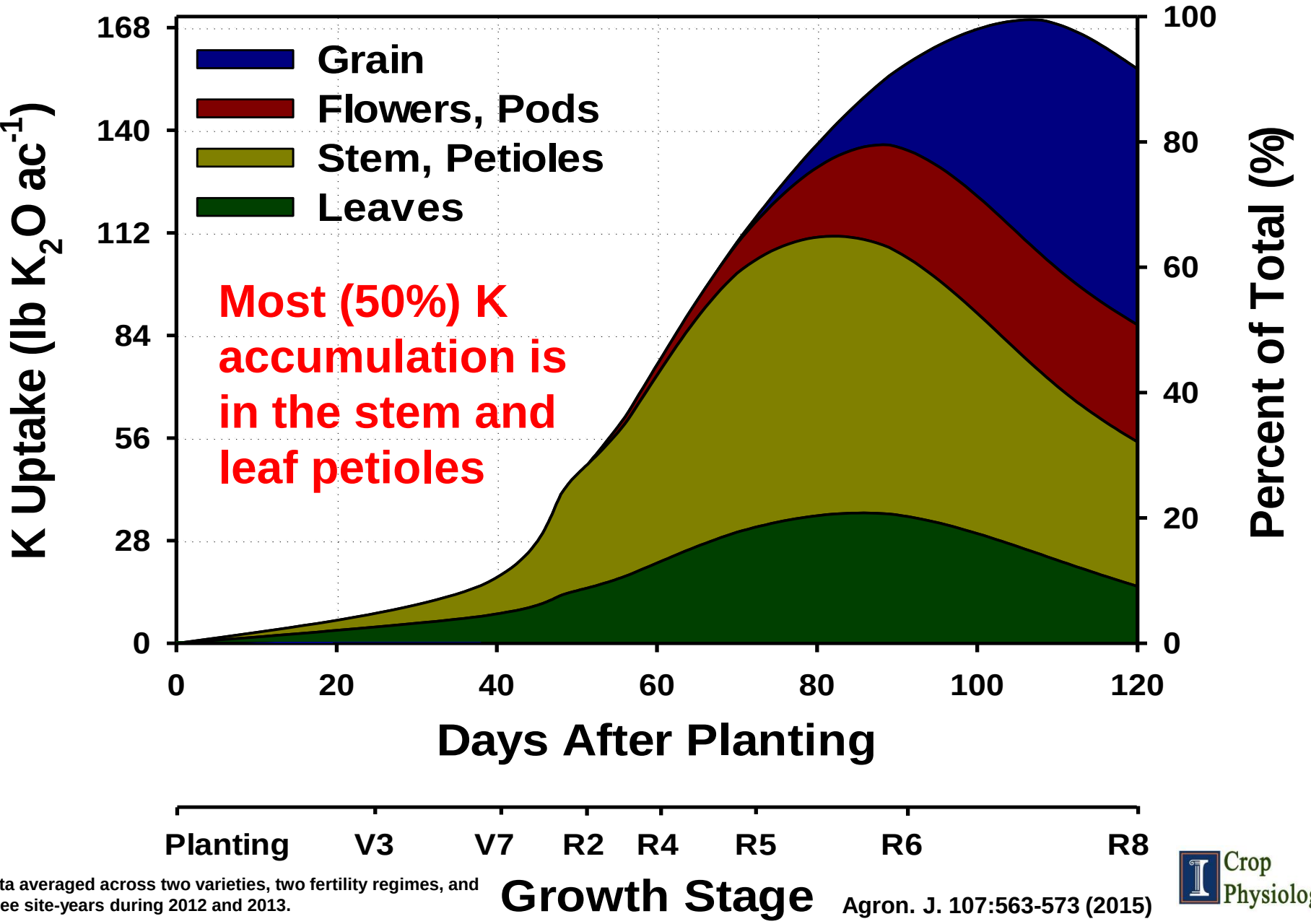

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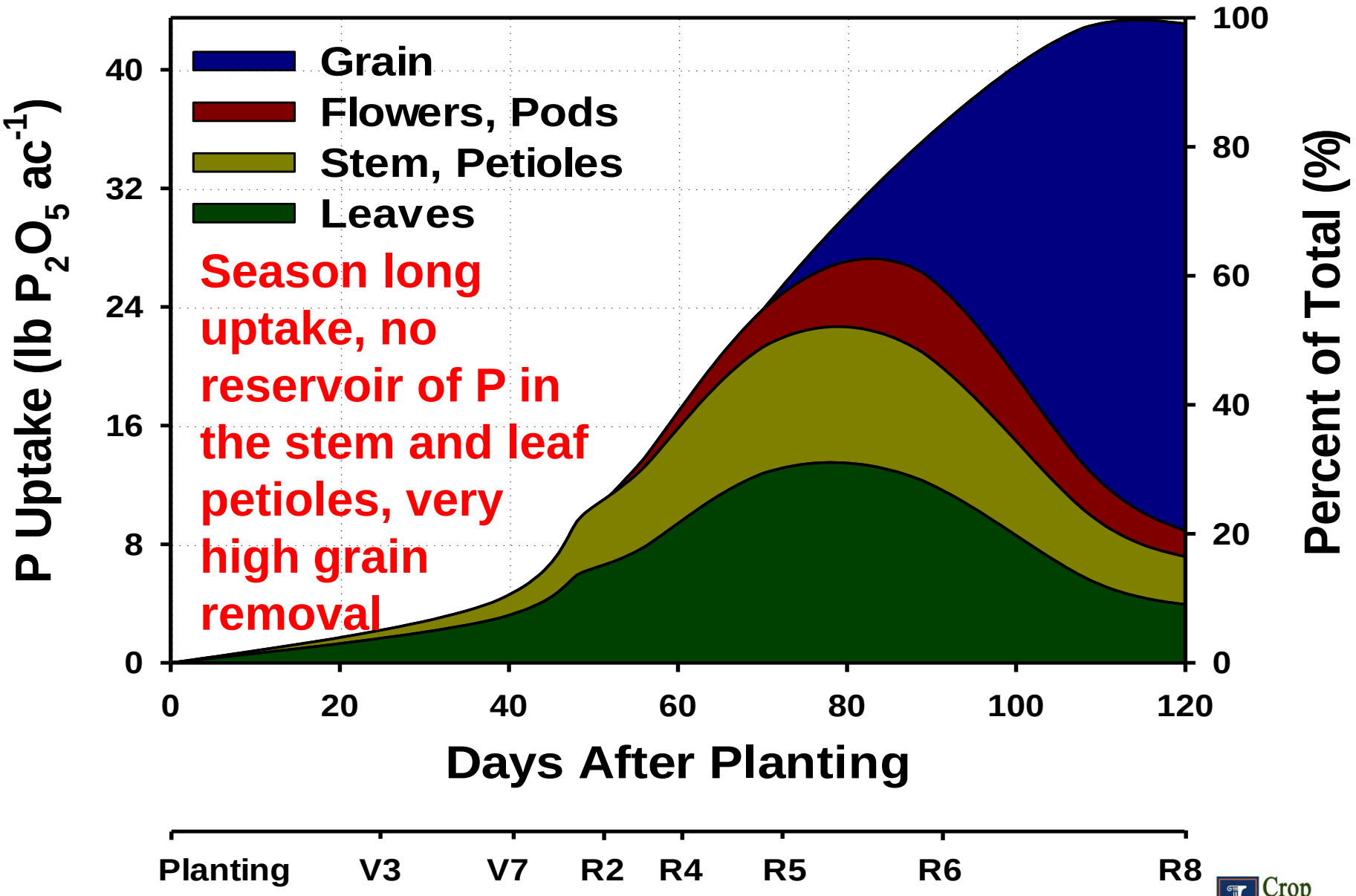

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Crop Physiology

The Six Secrets of Soybean Success

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

Given key prerequisites

Crop Physiology

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

Crop Physiology

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		

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Crop Physiology

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Given key prerequisites

Crop Physiology

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

Source: Fig. 14 from Pedersen, 2009, Soybean Growth and Development.

The Six Secrets of Soybean Success

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

Given key prerequisites

Crop Physiology

Soybean Yield Components

Yield = Pod number/acre x

Seeds per pod x

Weight per seed

The Legendary 5 Bean Pod

Champaign, 2013

Crop Physiology

Soybean Yield Components

Yield = Pod number/acre x

Seeds per pod x

Weight per seed

The Six Secrets of Soybean Success

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Given key prerequisites

Crop Physiology

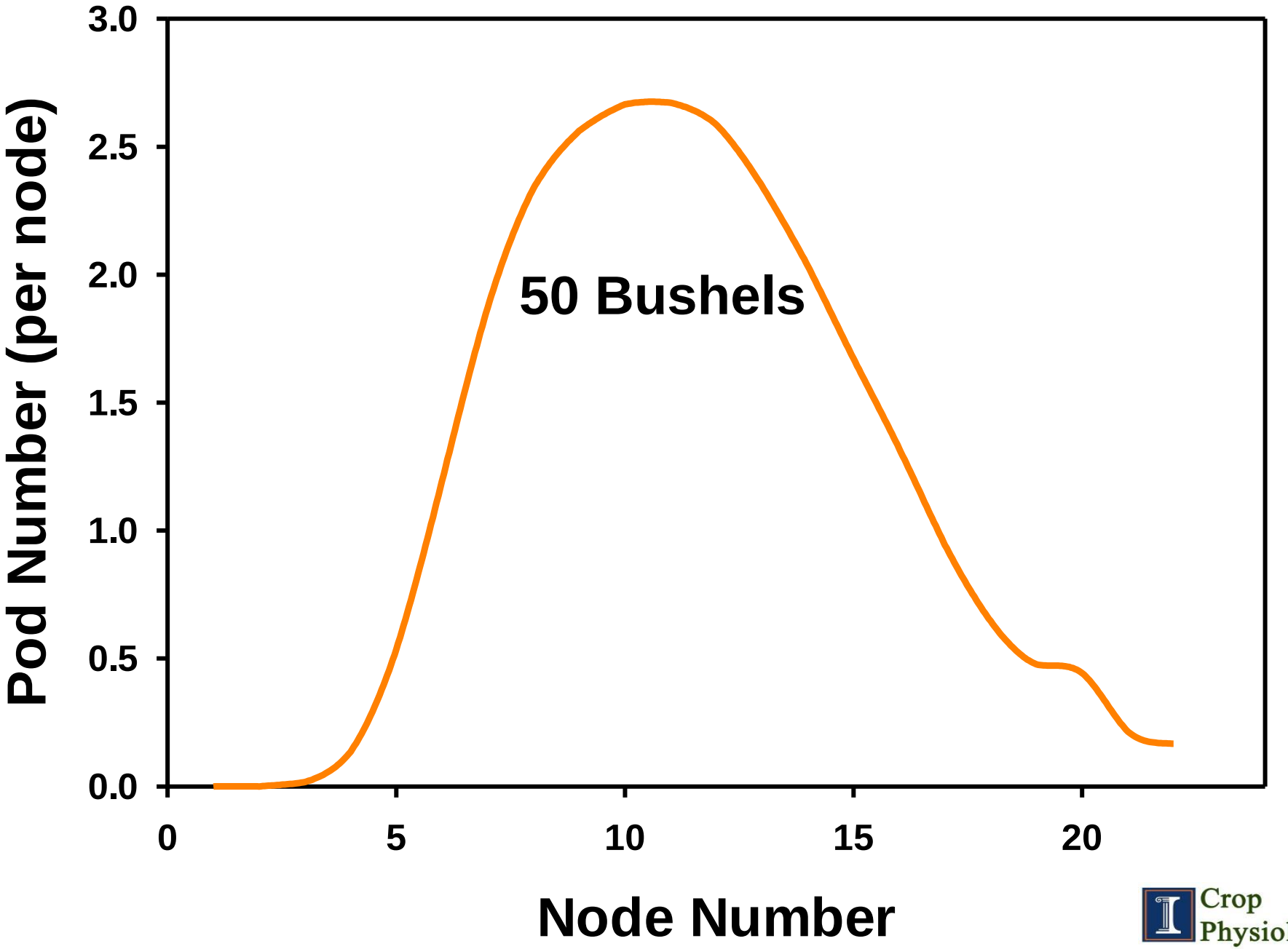
Soybean Yield Components

Yield = Pod number/acre x

Seeds per pod x

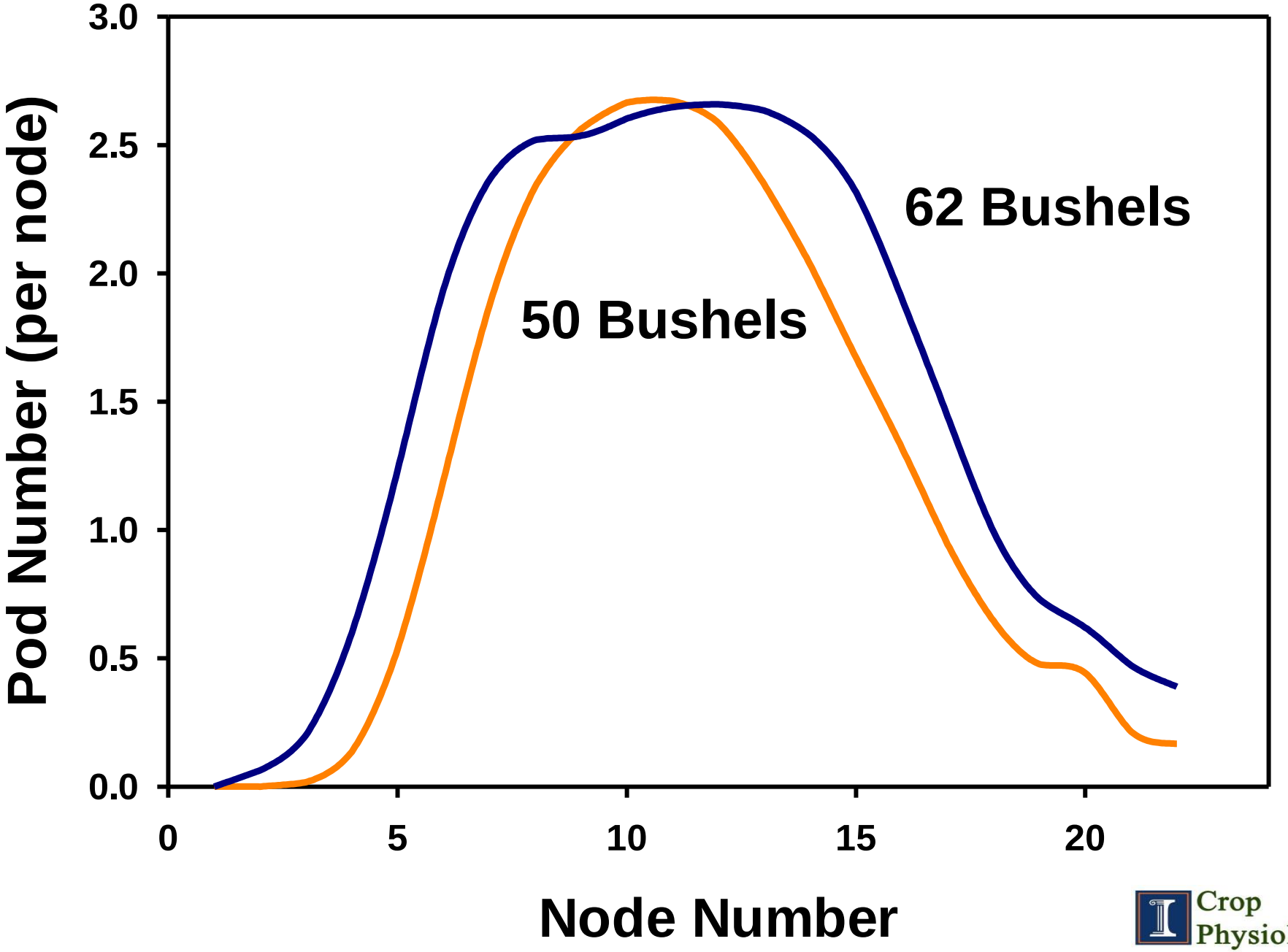
Weight per seed

How Does Pod Number Effect Soybean Yield



Crop Physiology

How Does Pod Number Effect Soybean Yield



Crop Physiology

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

Crop Physiology

Impact of Seed Treatment on Emergence

Untreated

Fungicide, Insecticide, Nematicide

Photos courtesy of AJ Woodyard, BASF

Crop Physiology

Impact of Seed Treatment on Soybean Growth

Fungicide only

Fungicide, Insecticide, Nematicide

R2 growth stage, Champaign, IL

Crop Physiology

Impact of Seed Treatment on Soybean Growth

Plants at growth stage R2 at Champaign, IL

Crop Physiology

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

Crop Physiology

Row Spacing Affects Light Interception
And Canopy Air Movement

30” Rows

20” Rows

Champaign, IL

Crop Physiology

Standard vs High Tech System 2014-15

Phosphorus	**P applied year before to corn** **75 lbs P_2O_5 as MESZ (N, P, S, & Zn)** **Banded 4-6” under row at planting**
Potassium	**K applied year before to corn** **75 lbs K_2O as Aspire (K & B)** **Broadcast and incorporated at planting**
P and K	**P & K applied year before to corn** **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**

Crop Physiology

Strong Start with Banded Fertility

Standard vs High Tech System 2014-15

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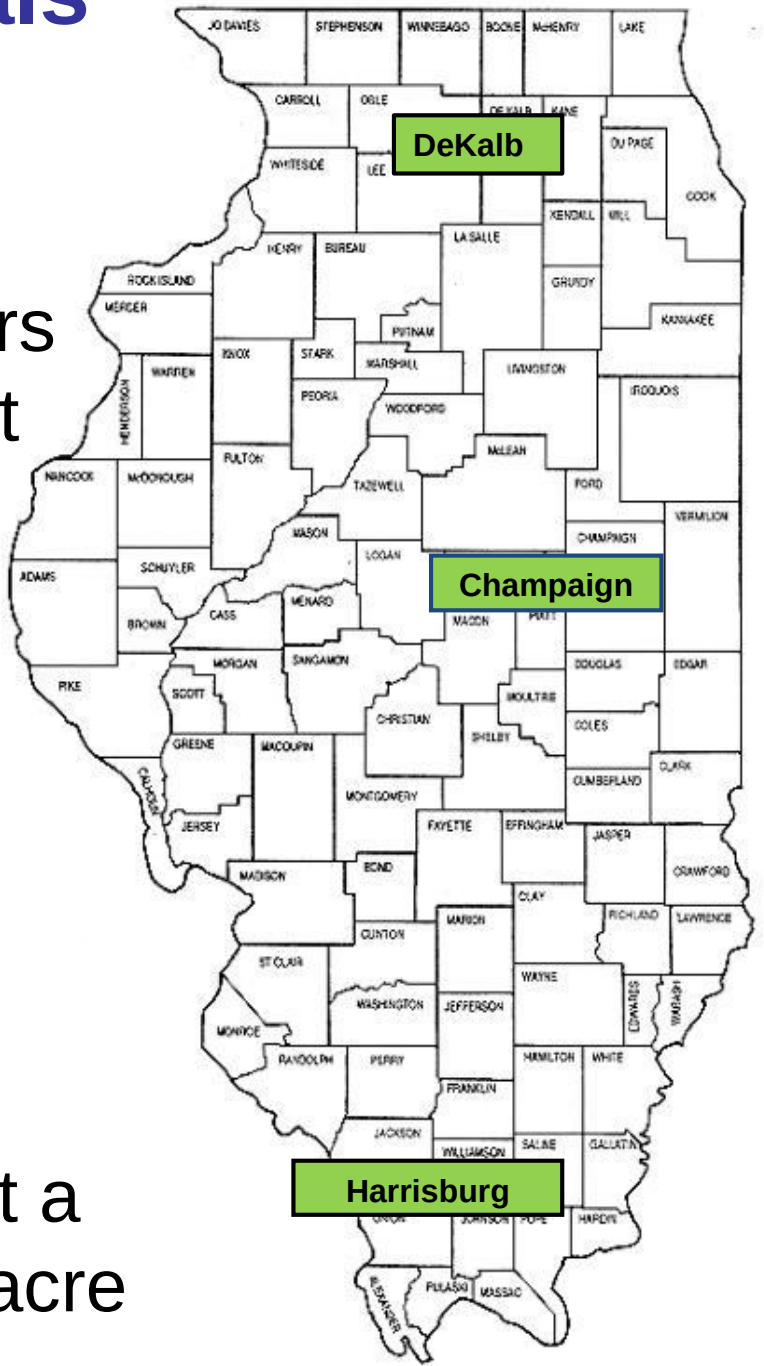
Crop Physiology

Soybean Management Trials 2014 and 2015

3 sites in Illinois with:

- 2 trials at 3 locations in two years
- Banded phosphate or broadcast potassium, or both at planting
- Different company seed (Asgrow, Syngenta, Croplan) and foliar protection products: BASF or Syngenta
- Normal and full maturity variety
- All in 30 inch vs 20 inch rows, at a seeding rate of 160,000 plants/acre



Yield Response to Management 2014-15

Location	Standard	High Tech	Δ
	bushels acre^{-1}		
DeKalb	63.0	76.4	+13.4*
Champaign	78.4	98.2	+19.8*
Harrisburg	68.3	78.0	+9.6*
Average	70.0	84.2	+14.2*

*Significant at $P \leq 0.05$. Average of 12 trials in 2014 and 2015, with two varieties in each trial

Crop Physiology

Standard vs High Tech System 2014-15

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Crop Physiology

Soybean Omission Plot Design

	MANAGEMENT FACTORS					
	Treatment	Phosphate	Potassium	P & K	Foliar Protec	Seed treatment
	HIGH TECH	Yes	Yes	Yes	Yes	Full
Decrease Technology	-Phosphate	None	Yes	Yes	Yes	Full
Decrease Technology	-Potassium	Yes	None	Yes	Yes	Full
Decrease Technology	-P and K	Yes	Yes	None	Yes	Full
Decrease Technology	-Foliar Protection	Yes	Yes	Yes	None	Full
Decrease Technology	-Seed Treatment	Yes	Yes	Yes	Yes	Basic
	TRADITIONAL	None	None	None	None	Basic
Add Technology	+Phosphate	Yes	None	None	None	Basic
Add Technology	+Potassium	None	Yes	None	None	Basic
Add Technology	+P and K	None	None	Yes	None	Basic
Add Technology	+Foliar Protection	None	None	None	Yes	Basic
Add Technology	+Seed Treatment	None	None	None	None	Full

Treatments evaluated in 30 and 20 inch row spacing

Crop Physiology

Add One Enhanced Factor to Standard Management

Add One Enhanced Factor	Standard System Yield	Δ
	bushels acre^{-1}	
Standard Management	70.0	
+Phosphorus (as MESZ also N,S, Zn)	74.7	+4.7*
+Potassium (as Aspire also B)	69.6	-0.4
+Phosphorus & Potassium	74.4	+4.4*
+Fungicide & Insecticide (R3)	72.6	+2.6*
+Seed Treatment (at planting)	71.4	+1.4
+Row Spacing (20 inch rows)	74.2	+4.2*

*Significantly different from standard at $P \leq 0.05$.
Average of 12 trials over 2014 and 2015 with two varieties in each trial

Crop Physiology

Omit One Enhanced Factor from High Tech System

	High Tech System	
Omit One Enhanced Factor	**Yield**	**Δ**
	bushels acre^{-1}	
High Tech all Six Factors	**84.2**	
-Phosphorus (fertility previous corn)	**78.8**	**-5.4***
-Potassium (fertility previous corn)	**84.8**	**+0.6**
-Phosphorus & Potassium	**78.2**	**-6.0***
-Fungicide & Insecticide	**81.0**	**-3.2***
-Seed Treatment (none or base)	**81.8**	**-2.4***
-Row Space (30 inch rows)	**75.7**	**-8.5***

*Significantly different from standard at $P \leq 0.05$.
Average of 12 trials over 2014 and 2015 with two varieties in each trial

Crop Physiology

Soybean Omission Plots – Ave of 2014 & 2015 Trials

	Standard		High Tech	
Factor	Yield	Δ	Yield	Δ
	bushel acre^{-1}			
None or All	70.0		84.2	
Phosphate	74.7	+4.7*	78.8	-5.4*
Potassium	69.6	-0.4	84.8	+0.6
P & K	74.4	+4.4*	78.2	-6.0*
Fung. + Insect.	72.6	+2.6*	81.0	-3.2*
Seed Treatment	71.4	+1.4	81.8	-2.4*
Row Spacing	74.2	+4.2*	75.7	-8.5*

*Significantly different at $P \leq 0.05$.
Average of 12 trials over 2014 and 2015 with two varieties in each trial

Crop Physiology

Conclusions

- **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**

Crop Physiology

Conclusions

- **No such thing as a soybean N credit as soybean removes more N from the soil than it gets from the nodules**
- **Sometimes nitrogen fertilizer can increase yield with nitrate containing or controlled release sources usually being the most effective**

Conclusions

- **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

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

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- Martín Uribelarrea
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- Kyle Vogelzang
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- Eric Winans
- Peng Yan

Crop Physiology

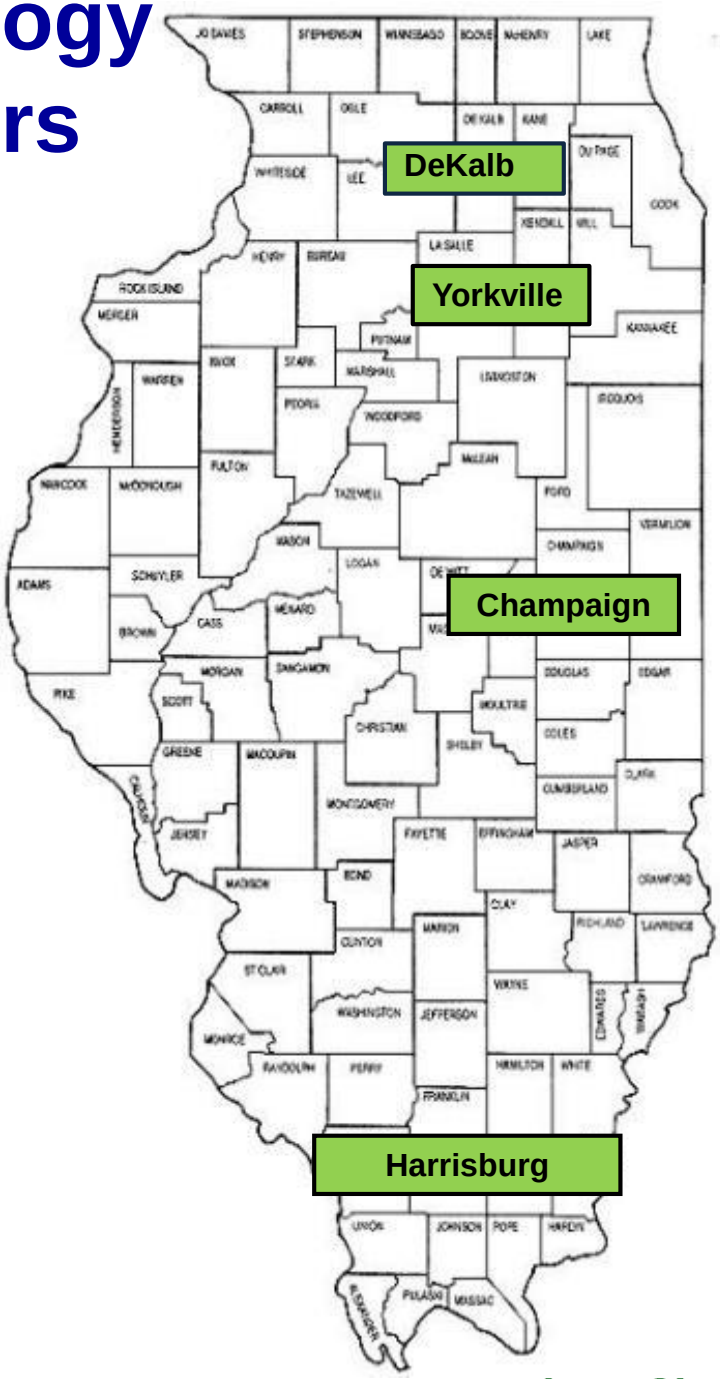
Past & Current Crop Physiology Lab Sites & Farm Cooperators

DeKalb - Eric Lawler
H.B. Babson Farms

Yorkville - Bob Stewart
Stewart Farms LLC

Champaign - UI Research Farm

Harrisburg - Scott Berry
Berry Farms



The Crop Physiology Laboratory

Financial and Product Support for 2017

- Actagro
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- Avunia
- BASF
- Calmer Corn Heads
- Compass Minerals
- Crop Production Services
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- FMC
- Helena Chemical Company
- Illinois Soybean Association
- Illini FS
- Italpollina
- John Deere
- Monsanto
- Mosaic
- Montag Mfg
- Netafim
- QLF
- Rosen's
- Sipcam Bio
- Sirius Minerals
- SoilBiotics
- Solvay
- Syngenta
- Timac Agro
- Valent
- Verdesian
- West Central
- WinField United

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