Enhanced Management for Increased Soybean Yield

Ross Bender, PhD
Senior Agronomist
The Mosaic Company

Louisiana Agricultural Technology and Management Conference; Marksville, LA

Closing the Yield Gap

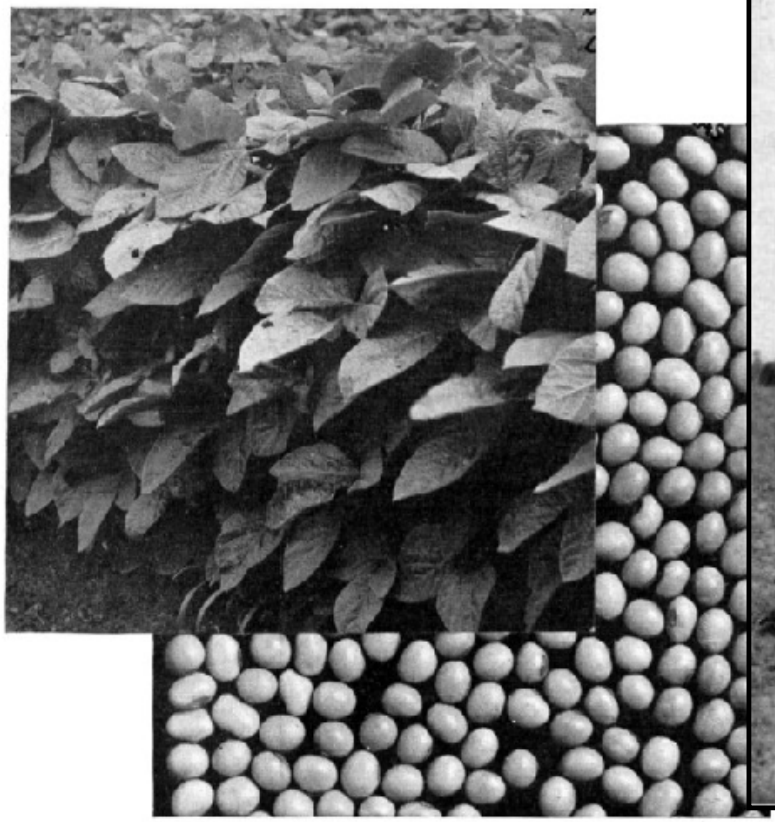
Crop	Yield:* Record	Yield:** US Avg	Yield: 'Gap'
	Yield (Bu Ac^{-1})		
Corn	532	168	364
Soybean	161	48	113
Wheat	246	43	203

*Kip Cullers (MO, USA), David Hula (VA, USA), Tim Lamyman (UK).
**USDA-NASS, 2015.

Mosaic

SOYBEAN PRODUCTION

FOR HAY AND BEANS

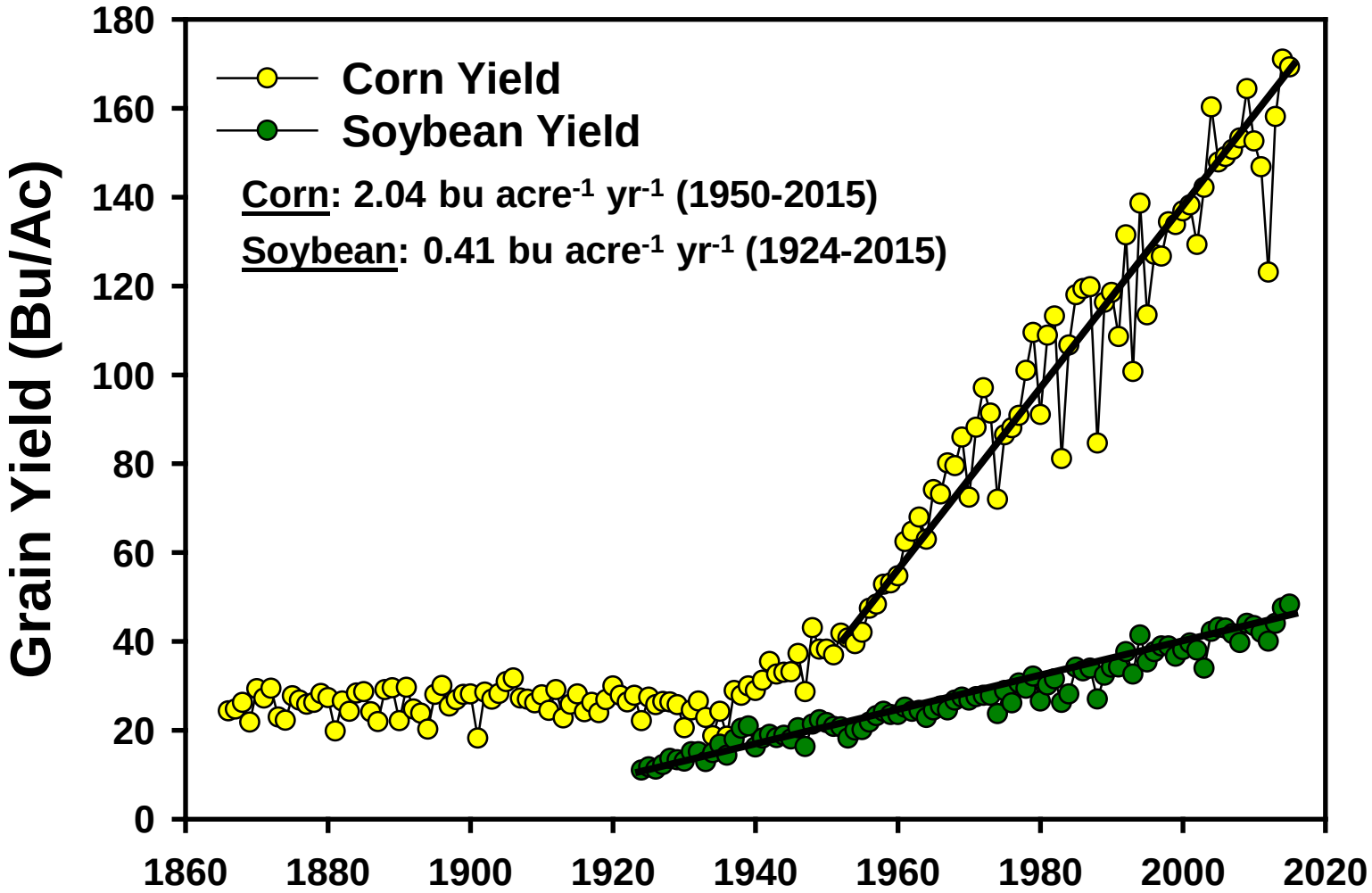


FARMERS' BULLETIN No. 2024

U. S. DEPARTMENT OF AGRICULTURE

Mosaic

Corn and Soybean Yield Progress



Source: USDA-NASS

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

The Six Secrets of Soybean Success

Rank	Factor
1	Weather
2	Fertility
3	
4	
5	
6	

Given key prerequisites

Perception of Soybean Fertilization

Past: **"*from the standpoint of removal … soybeans are 'hard on the land' … and would be classed as a crop that rapidly depletes soil bases*" including K, Ca, and Mg**

Hammond et al., 1951

Current: Often grown in rotation with corn; scavenge residual fertilizer or mine existing soil reserves

Mosaic

Nutrient Uptake & Removal: 60 Bushel Soybean

Nutrient	Required to Produce	Removed with Grain	Harvest Index
	lb acre^{-1}		%
N	245	179	73
P_2O_5	43	35	81
K_2O	170	70	46
S	17	10	61
Zn (oz)	4.8	2.0	44
B (oz)	4.6	1.6	34

Bender et al., 2015. Agronomy Journal (107:563-573)

P and K Uptake & Removal: Soybean vs Corn

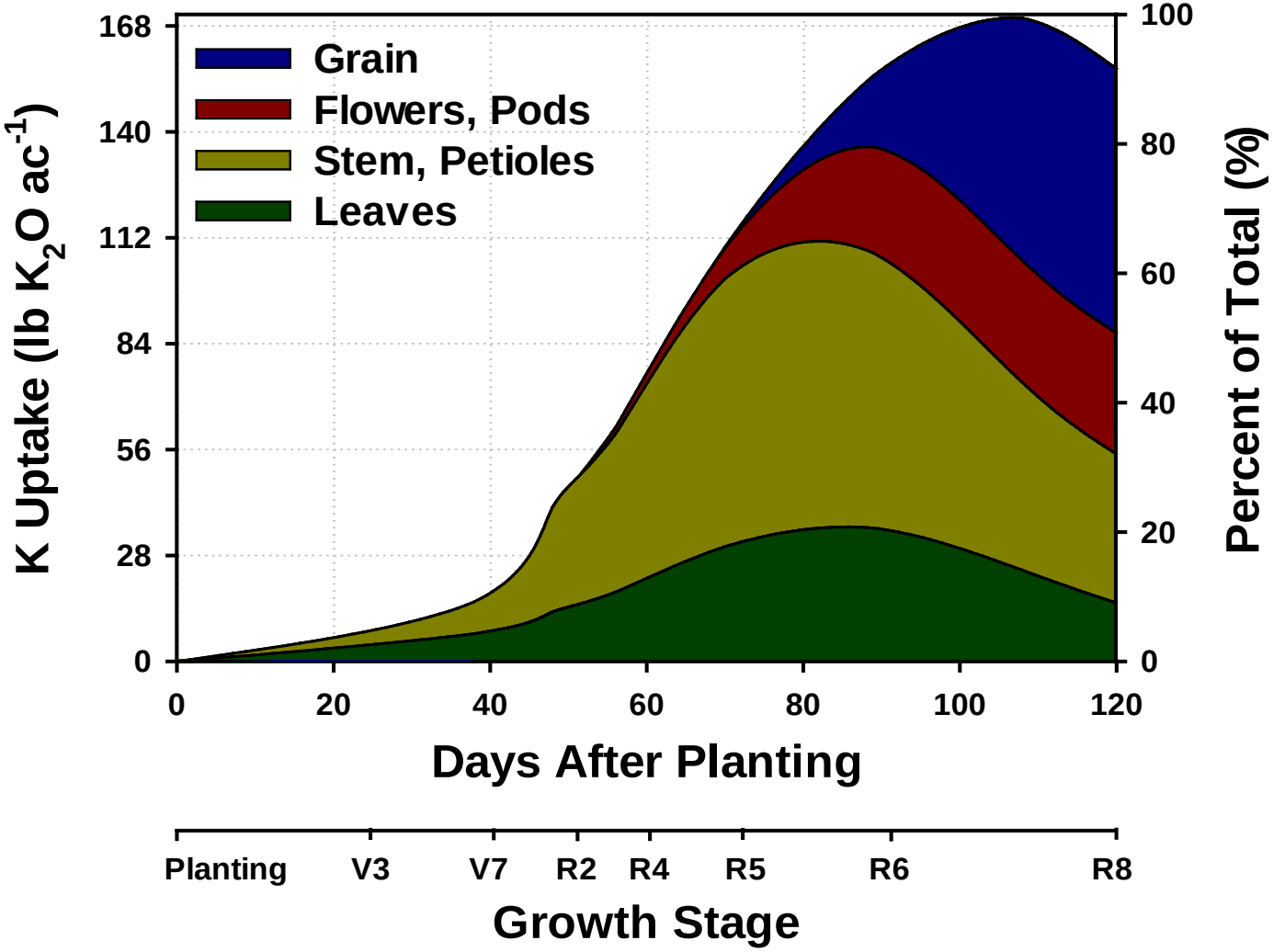
Nutrient	Required to Produce		Removed with Grain		Remain in Stover	
	Corn	Soy	Corn	Soy	Corn	Soy
			lb acre^{-1}			
P_2O_5	101	43	80	35	21	8
K_2O	180	170	56	70	124	100

Crop Physiology

Soybean: Bender et al., 2015. Agronomy Journal (107:563-573)
Corn: Bender et al., 2013. Agronomy Journal (105:161-170)

Mosaic

Potassium Uptake in Soybean: 60 Bu/Ac



Key Points:

- K is critical for enzymes, water relations, etc.
- Max uptake rate of 3.5 lbs K_2O/ Ac/Day (50 days)
- Stems serve as important reservoirs for extra K
- Non-grain K returned to soil

Mosaic

Bender et al., 2015. Agronomy Journal (107:563-573)

P and K Uptake & Removal: Soybean vs Corn

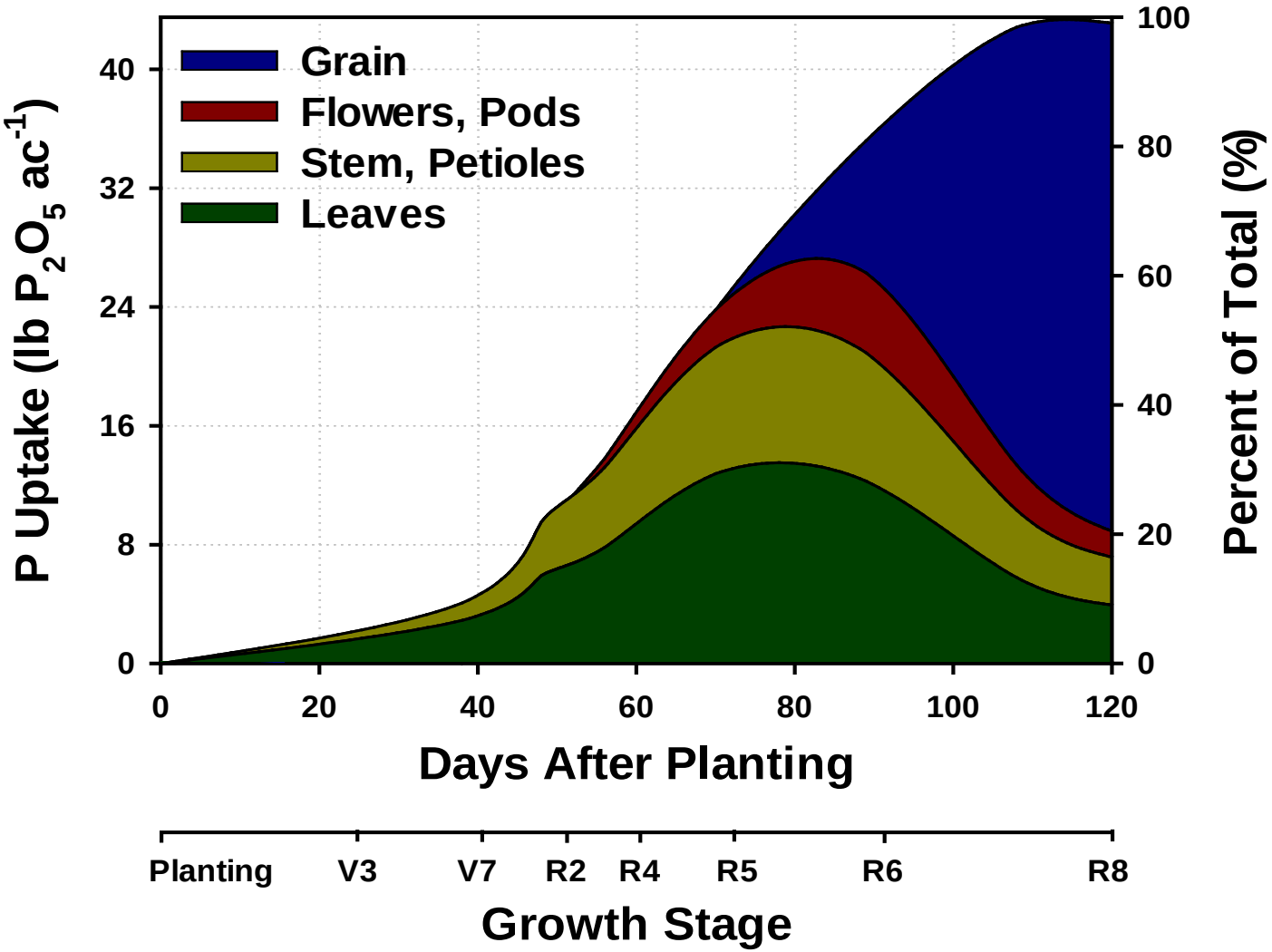
Nutrient	Required to Produce		Removed with Grain		Remain in Stover	
	Corn	Soy	Corn	Soy	Corn	Soy
			lb acre^{-1}			
P_2O_5	101	43	80	35	21	8
K_2O	180	170	56	70	124	100

Crop Physiology

Soybean: Bender et al., 2015. Agronomy Journal (107:563-573)
Corn: Bender et al., 2013. Agronomy Journal (105:161-170)

Mosaic

Phosphorus Uptake in Soybean: 60 Bu/Ac



Key Points:

- 45% of P uptake during seed-fill
- Rapid uptake for 70 days straight
- 80% partitioned to grain, removed
- Large demand for P during seed-fill means soybean needs P each year, not biennially

Mosaic

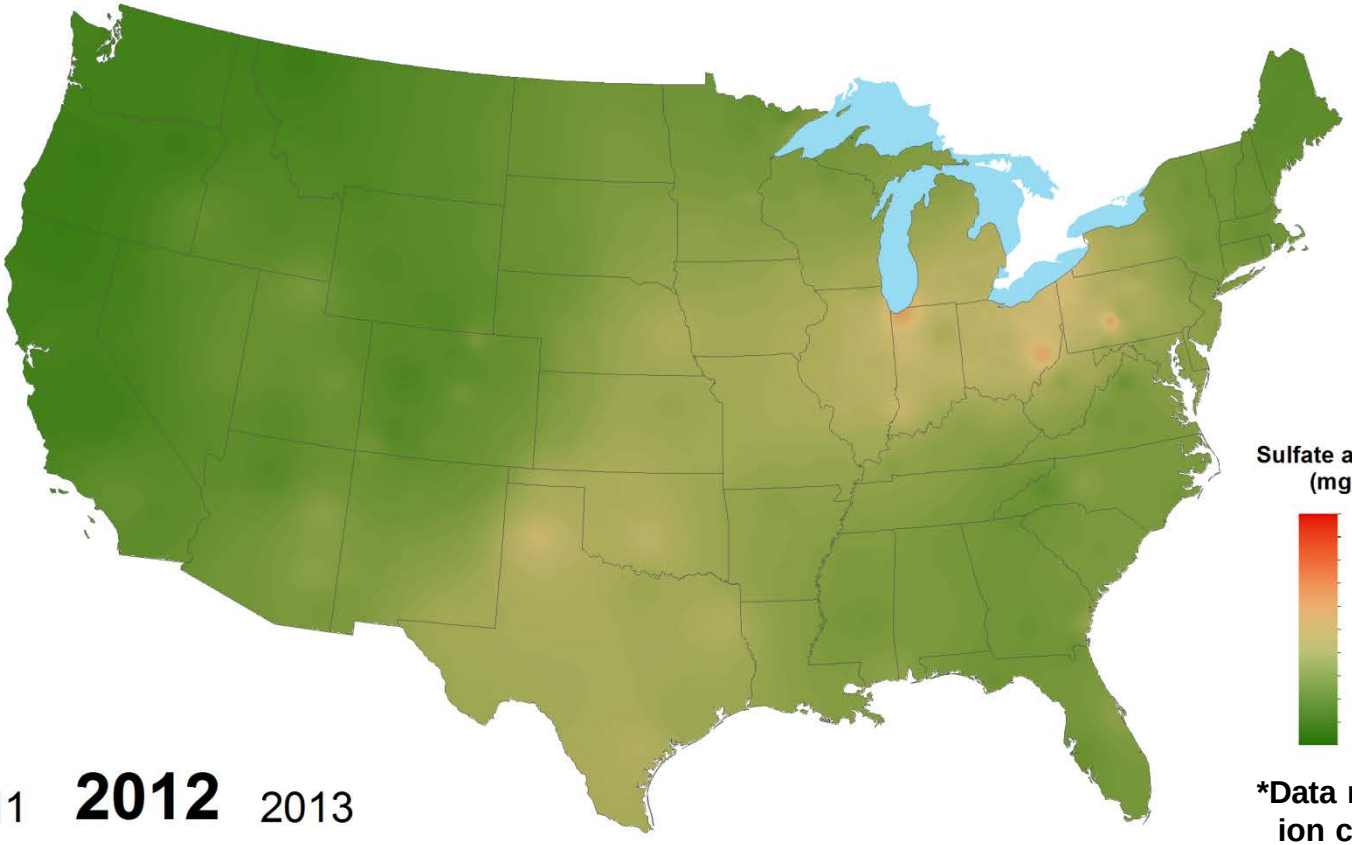
Bender et al., 2015. Agronomy Journal (107:563-573)

Nutrient Uptake & Removal: 60 Bushel Soybean

Nutrient	Required to Produce	Removed with Grain	Harvest Index
	lb acre^{-1}		%
N	245	179	73
P_2O_5	43	35	81
K_2O	170	70	46
S	17	10	61
Zn (oz)	4.8	2.0	44
B (oz)	4.6	1.6	34

Bender et al., 2015. Agronomy Journal (107:563-573)

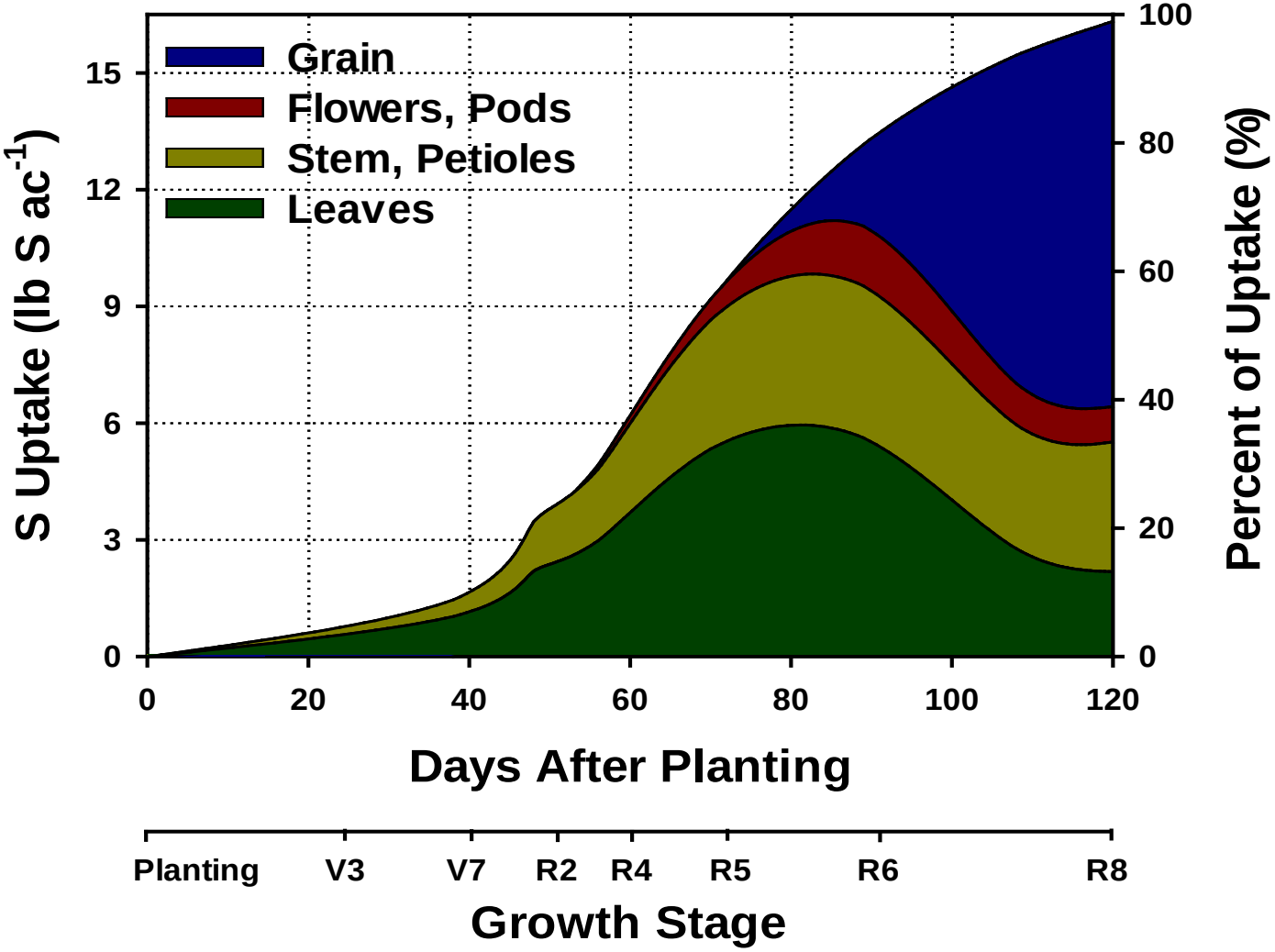
Reduced Atmospheric Deposition of S



*Data represents sulfur ion concentration of precipitation.

Data courtesy of National Atmospheric Deposition Program/National Trends Network (http://nadp.isws.illinois.edu)

Sulfur Uptake in Soybean: 60 Bu/Ac



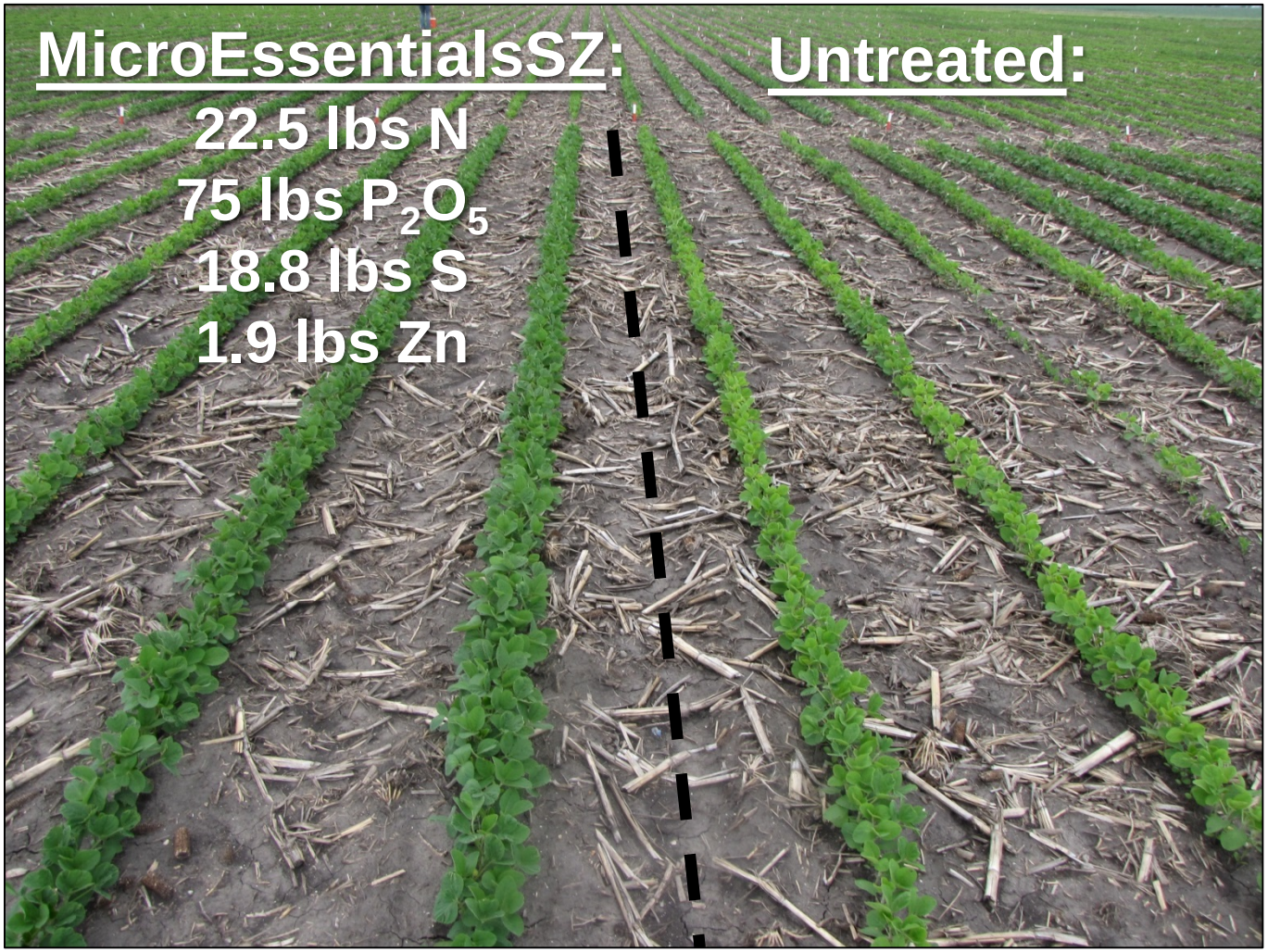
Key Points:

- Season-long uptake of S
- Sulfate S: early season needs; Elemental S: late season needs
- Needed in the grain for amino acid development

Mosaic

Bender et al., 2015. Agronomy Journal (107:563-573)

Soybean Plants Respond to Fertility



Champaign, IL 2014

Crop Physiology

Mosaic

The Six Secrets of Soybean Success

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

Given key prerequisites

Does Variety Selection Matter?

Variety	Yield	Variety	Yield	Variety	Yield
	bu acre^{-1}		bu acre^{-1}		bu acre^{-1}
1	69.5	7	78.4	13	84.8
2	72.7	8	80.1	14	85.5
3	73.6	9	82.3	15	87.1
4	74.9	10	83.1	16	87.5
5	76.5	11	83.3	17	89.0
6	78.4	12	84.1		

17 varieties with high-input management at Champaign, IL 2015.

Crop Physiology

Mosaic

Does Variety Selection Matter?

MG	Yield	MG	Yield	MG	Yield
	bu acre^{-1}		bu acre^{-1}		bu acre^{-1}
3.0	69.5	2.9	78.4	3.9	84.8
2.5	72.7	3.7	80.1	3.8	85.5
2.5	73.6	3.6	82.3	3.8	87.1
2.9	74.9	3.7	83.1	3.3	87.5
2.6	76.5	3.1	83.3	3.5	89.0
2.8	78.4	3.1	84.1		

17 varieties with high-input management at Champaign, IL 2015.

Crop Physiology

Mosaic

The Six Secrets of Soybean Success

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

Given key prerequisites

Soybean Yield Components

Yield = Pod number/acre x

Seeds per pod x

Weight per seed

The Legendary 5-Bean Pod

Soybean Yield Components

Yield = Pod number/acre x

Seeds per pod x

Weight per seed

The Six Secrets of Soybean Success

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

Given key prerequisites

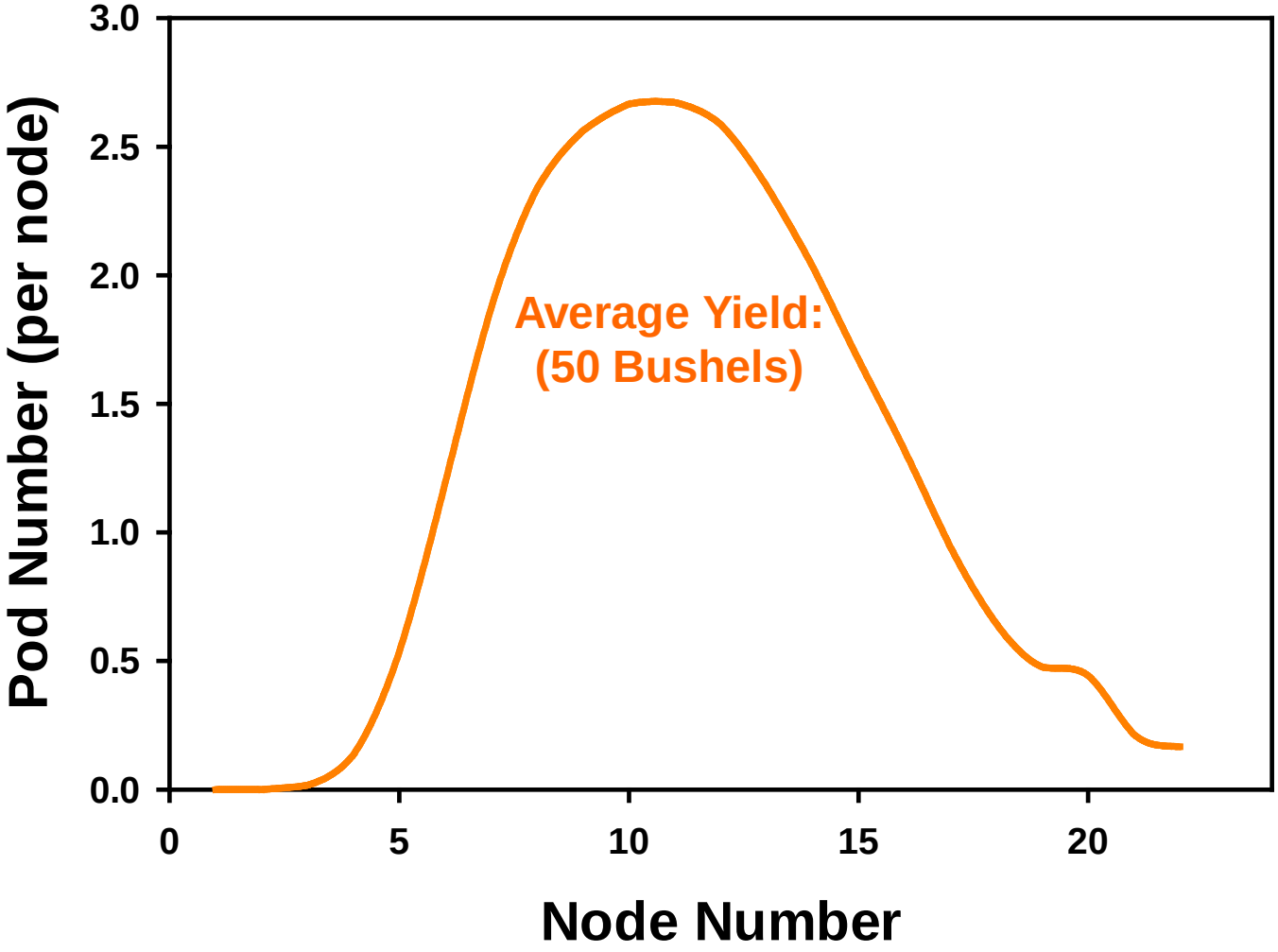
Soybean Yield Components

Yield = Pod number/acre x

Seeds per pod x

Weight per seed

How Does Pod Number Effect Soybean Yield?

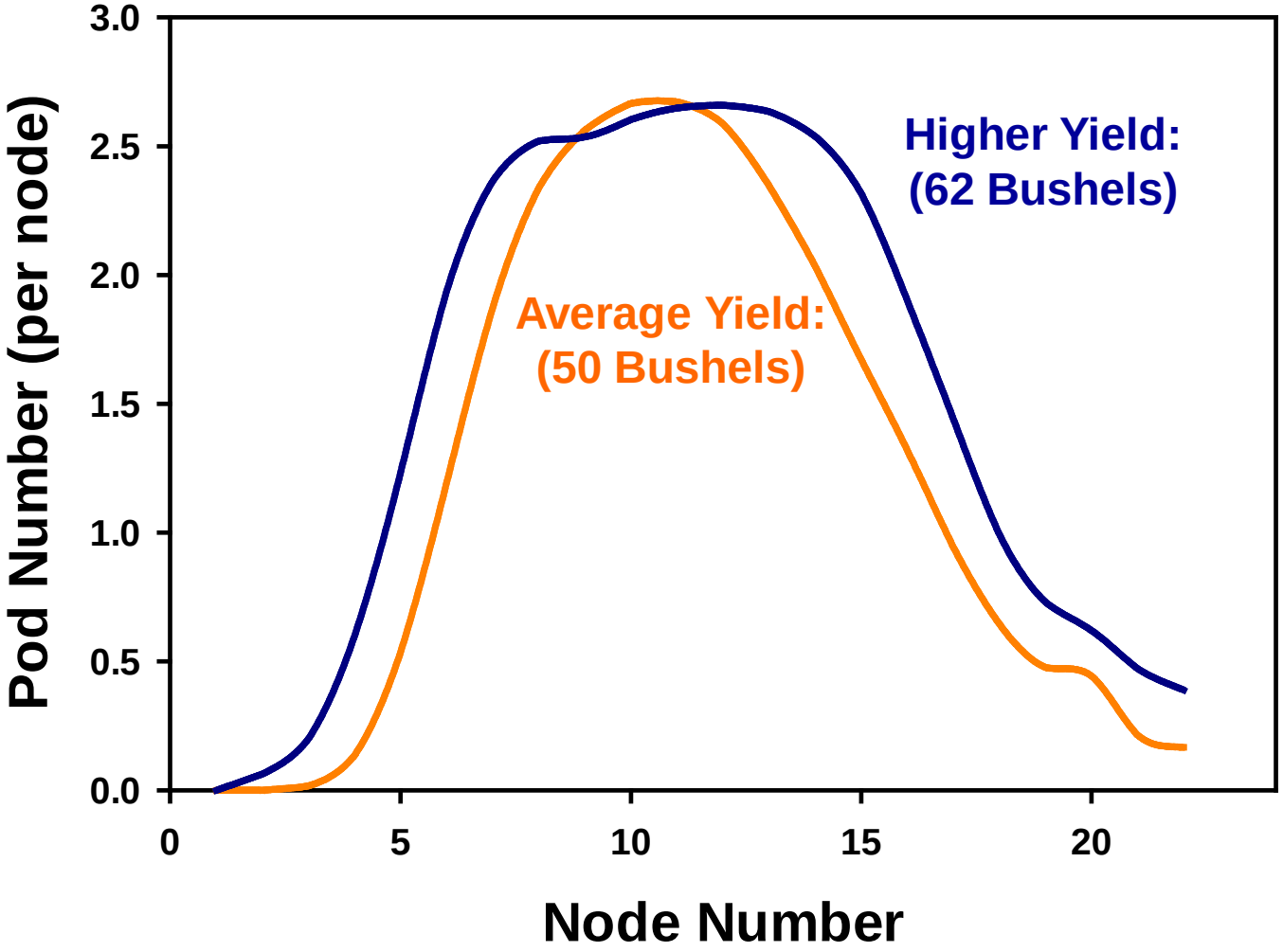


Crop Physiology

Mosaic

Average of two varieties at two Illinois locations during 2012 and 2013.

How Does Pod Number Effect Soybean Yield?



Crop Physiology

Mosaic

Average of two varieties at two Illinois locations during 2012 and 2013.

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

Crop Physiology

Mosaic

Impact of Seed Treatment on Soybean Growth

The Six Secrets of Soybean Success

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

Given key prerequisites

Row Spacing Impacts Light Interception, Air Canopy Movement

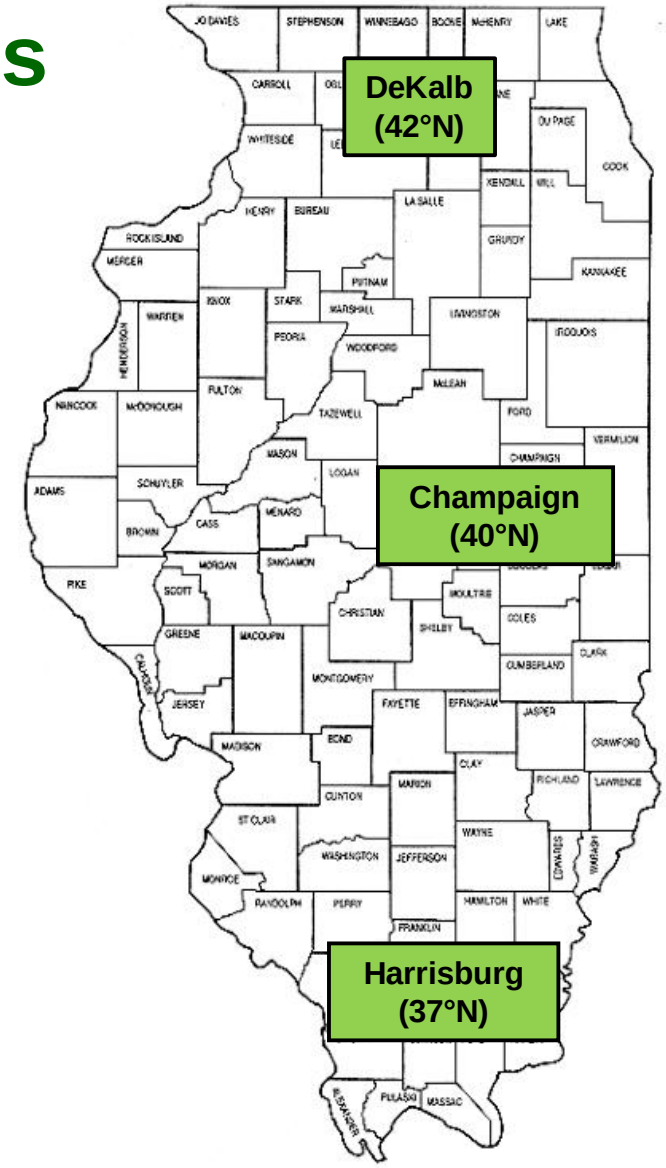
30” Rows

20” Rows

Soybean Management Trials

2015 Research Trials:

- 6-7 plots at 3 locations
  - Reference: (Marksville, LA: 31°N)
- Banded phosphate (Mosaic's MicroEssentials SZ) or broadcast potassium (Mosaic's Aspire), or both
- Different company seed (Monsanto, Syngenta, Winfield) 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



Crop Physiology

Mosaic

Narrow Row Spacing Increases Yield

Location	30”	20”	Δ
	bu Ac^{-1}		
DeKalb	61.7	69.6	+7.9*
Champaign	84.7	93.2	+8.5*
Harrisburg	77.5	80.0	+2.5
Average	74.6	80.9	+6.3*

* Significantly different at *P* ≤ 0.01. Average of 7 Trials at 3 locations during 2015.

Standard vs High Tech System - 2015

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 Arrangement	**30 inch row spacing** **20 inch row spacing**

Crop Physiology

Mosaic

Narrow Rows Magnify Value of Management

Row Space	Standard	High Tech	Increase from Management
inches	bu Ac^{-1}		
30	70.7	77.8	+7.1*
20	74.3	85.4	+11.1*
Increase from 20 inch rows	+3.6*	+7.6*	

* Significantly different at $P \leq 0.01$. Average of 7 Trials at 3 locations during 2015.

Standard vs High Tech System - 2015

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 Arrangement	**30 inch row spacing** **20 inch row spacing**

Crop Physiology

Mosaic

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
	-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
	TRADITIONAL	None	None	None	None	Basic
Add Technology	+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 30 and 20 inch row spacing across two varieties.

Crop Physiology

Mosaic

Yield Increases with Standard Management

Factor	Yield	Δ
	bu Ac^{-1}	
Standard	**70.7**	
+P (MESZ, with S & Zn)	**76.5**	**+5.8***
+K (Aspire, with B)	**70.1**	**-0.6**
+P & K (MESZ + Aspire)	**74.2**	**+3.5***
+Foliar (Fung + Insect)	**73.8**	**+3.1***
+Seed Trt (Fung+Insec+Nem)	**72.3**	**+1.6**

*** Significantly different at *P* ≤ 0.01. Average of 7 Trials at 3 locations during 2015. Responses shown in 30" rows.**

Crop Physiology

Mosaic

Yield Increases with High Tech Management

Factor	Yield	Δ
	bu Ac^{-1}	
High Tech	**85.4**	
-P (MESZ, with S & Zn)	**80.5**	**-4.9***
-K (Aspire, with B)	**87.0**	**+1.6**
-P & K (MESZ + Aspire)	**80.6**	**-4.8***
-Foliar (Fung + Insect)	**82.9**	**-2.5**
-Seed Trt (Fung+Insec+Nem)	**82.6**	**-2.8***

*** Significantly different at *P* ≤ 0.01. Average of 7 Trials at 3 locations during 2015. Responses shown in 20" rows.**

Crop Physiology

Mosaic

Overall Effect of Management in 2015

Factor	Standard		High Tech	
	Yield	Δ	Yield	Δ
	bu Ac^{-1}			
High Tech	70.7		85.4	
-P	76.5	+5.8*	80.5	-4.9*
-K	70.1	-0.6	87.0	+1.6
-P & K	74.2	+3.5*	80.6	-4.8*
-Foliar	73.8	+3.1*	82.9	-2.5
-Seed Trt	72.3	+1.6	82.6	-2.8*

* Significantly different at $P \leq 0.01$. Average of 7 Trials at 3 locations during 2015.

Crop Physiology

Mosaic

Agronomic Management of Soybean - Conclusions

- **For maximum soybean yield, a system's approach is needed which combines genetic, agronomic, and plant nutrition factors with known impacts on soybean productivity.**
- **Nutrients with high requirements for production, high harvest index values, or unique uptake patterns such as N, P, K, S, Zn, and B are critical for high yields.**
- **Not all nutrients are accumulated at the same time or used in the same way.**

Agronomic Management of Soybean - Conclusions

- **Agronomic management interacts with row spacing, with a greater response to crop nutrition in narrow row environments.**
- **Large opportunities exist to increase soybean productivity and require a high yielding variety, positioned for maximum light interception, protected from stress, and fed with the right balance of crop nutrients.**

Sincere Thank You to:

- **Harold Lambert, Denise Wright**
  - **LATMC Participants**
- **Fred Below and Graduate Students**
  - **University of Illinois Crop Physiology Lab**

For more information, please visit:

Crop Nutrition: Mosaic | CropNutrition.com

University of Illinois Crop Physiology Laboratory:
http://cropphysiology.cropsci.illinois.edu