

# Is Sulfur is the “S” in Soybean?

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[www.soybeanstation.org](http://www.soybeanstation.org)

## SOYBEAN STATION

DELIVERING FIRST CLASS SOYBEAN INFORMATION



*Weather*

Variety

Selection

**Intentional  
Soybean  
Management**

Management

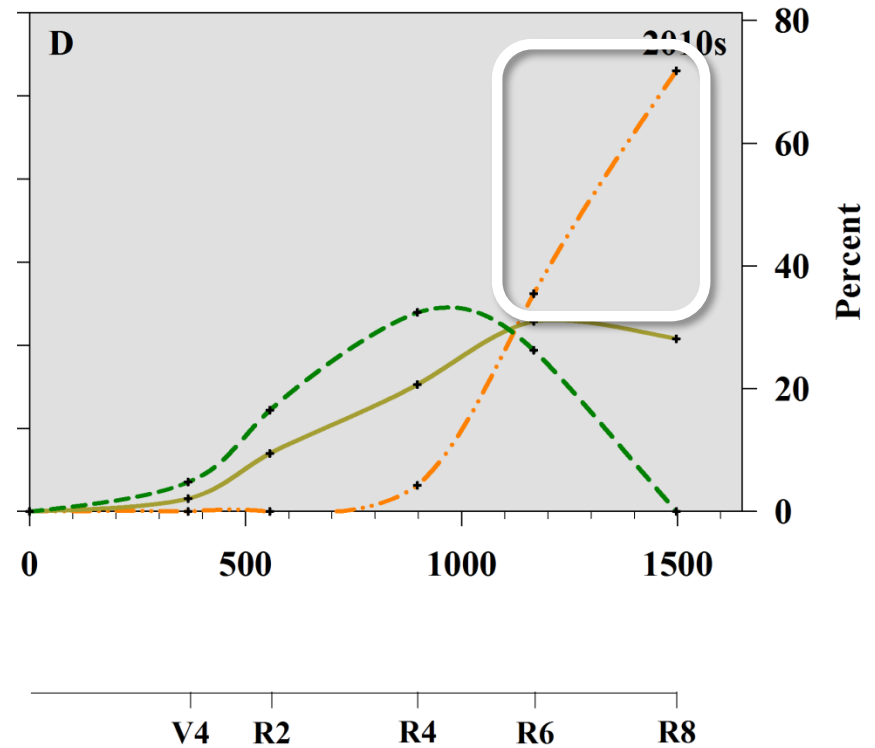
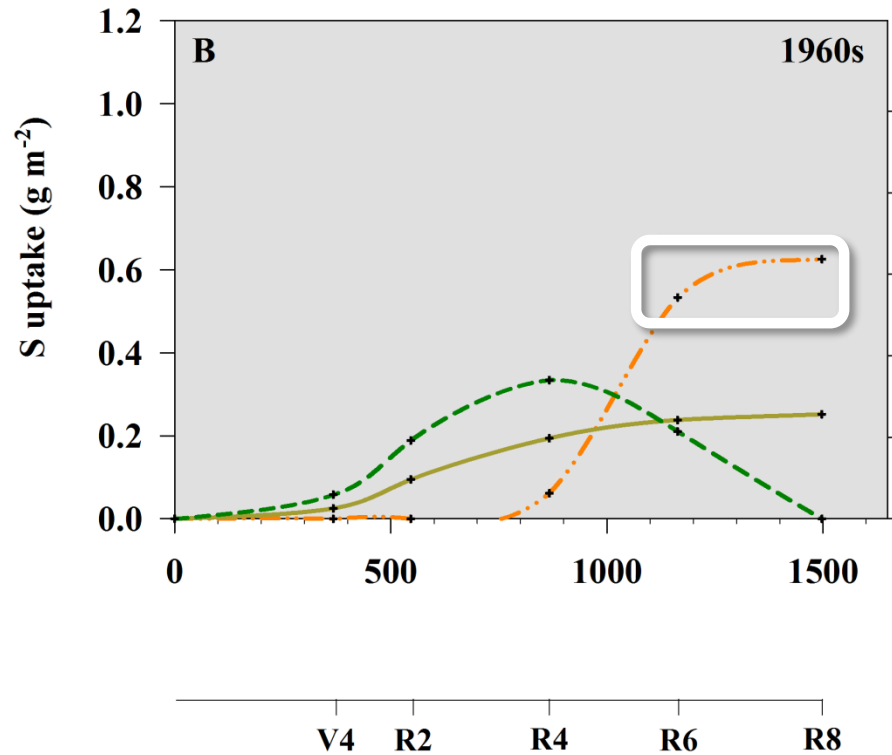
Weeds Early

*Soil*

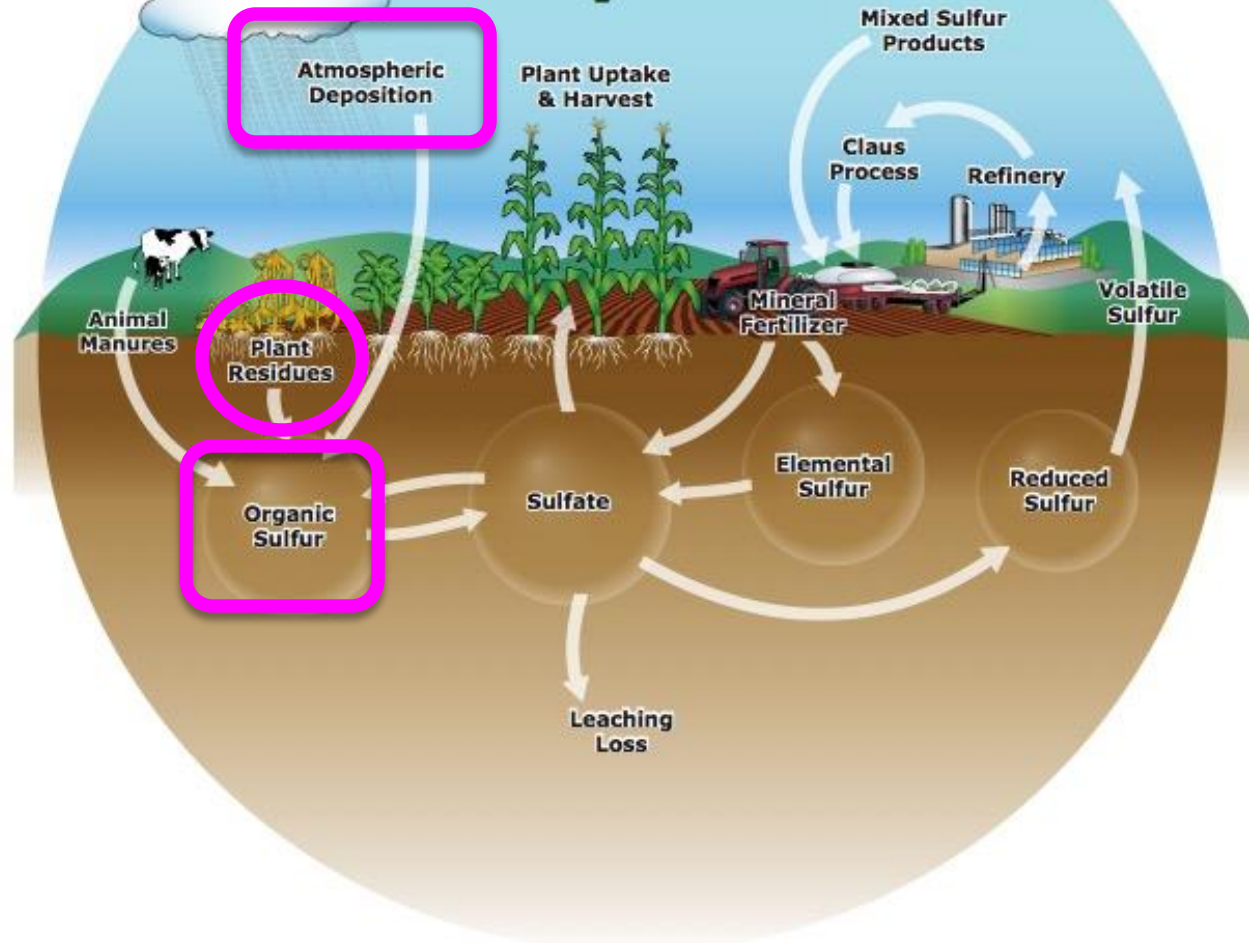


# Maturity Group 2

## S Accumulation: 1960s vs. 2010s

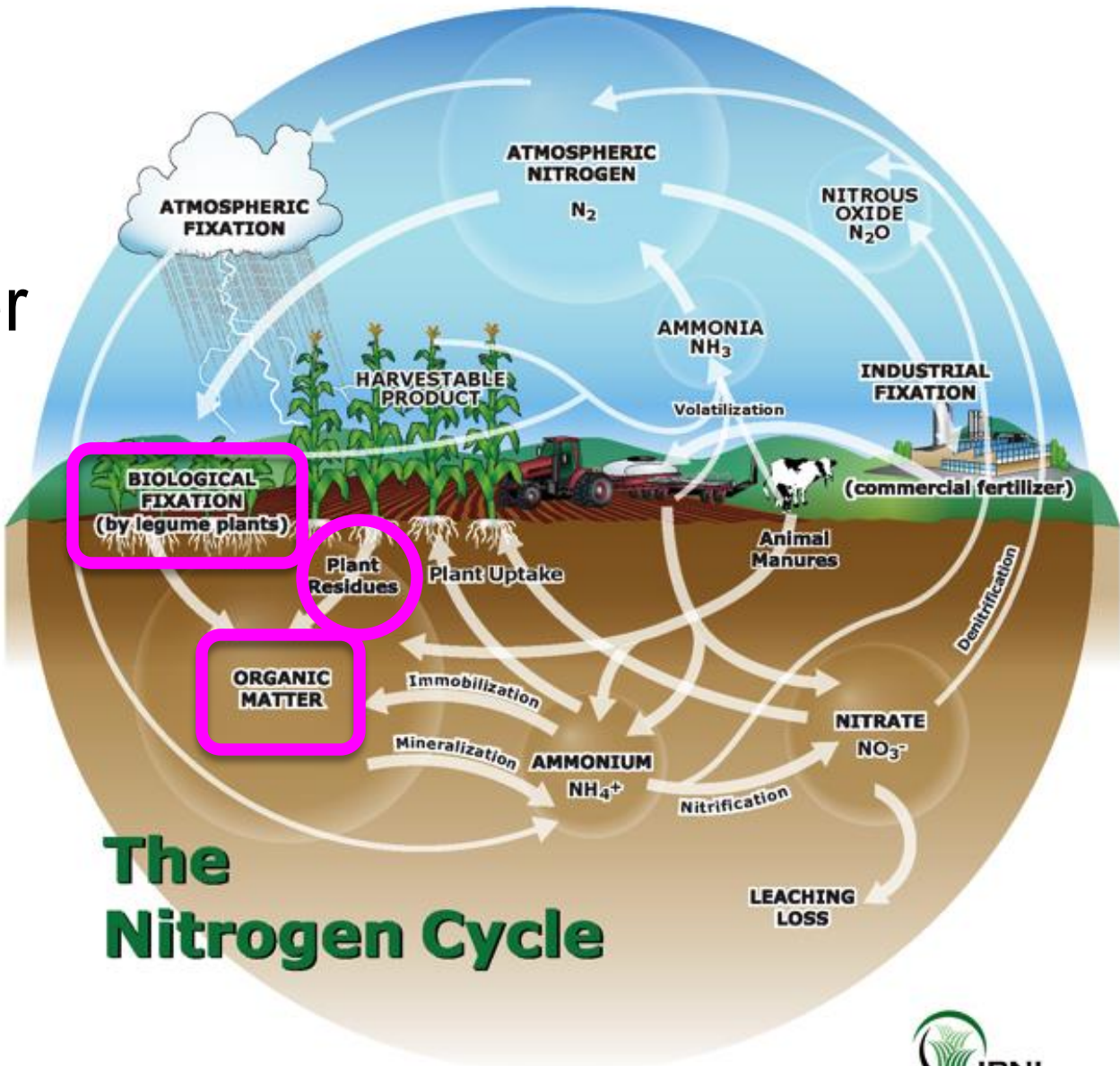


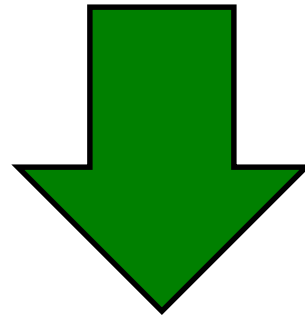
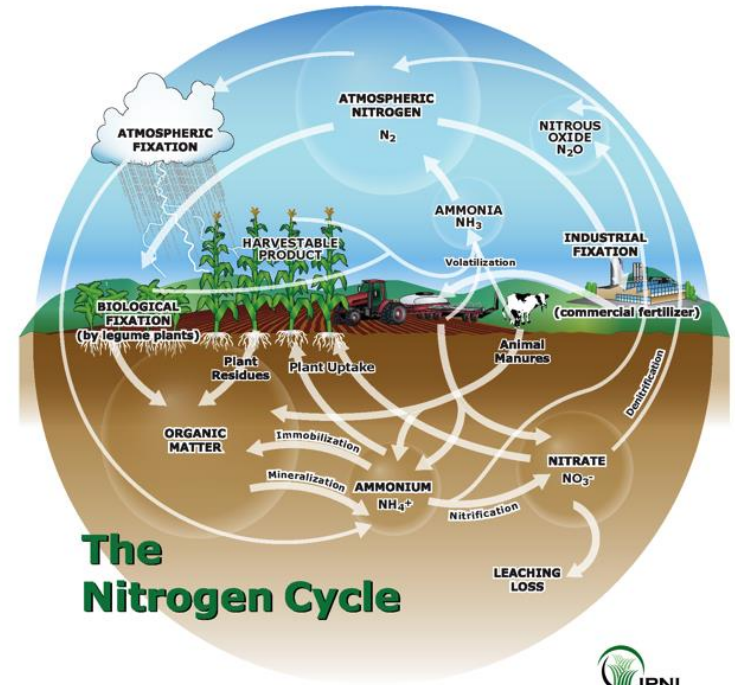
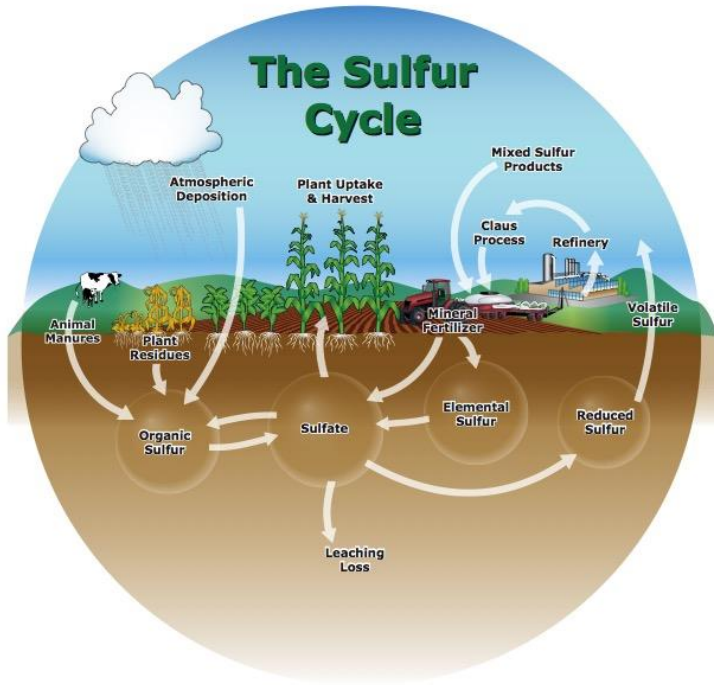
# The Sulfur Cycle



- Atmospheric Deposition
- Organic S
- Plant Residue

- Organic Matter
- Plant Residue
- N Fixation



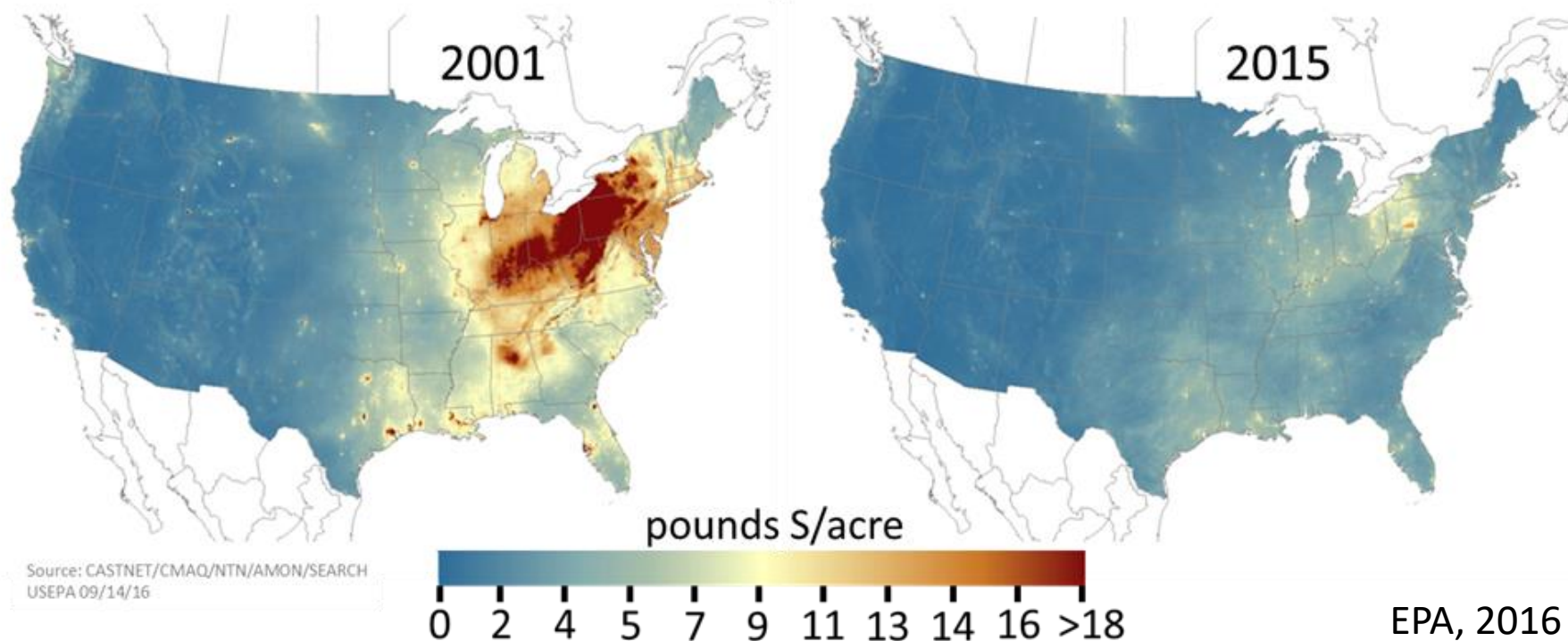


**High Yielding Soybeans!**



# Sulfur: Who Needs It...Maybe You?

Total deposition of sulfur



## Which Crops Should Be the Most Responsive to Sulfur?



# Supplying Sulfur to Our Fields

- ~3-5 lb S/ac mineralized per 1% OM per year
- Plant Residue – Mineralized or Immobilized?
  - C:S Ratio < 200:1 → MINERALIZED SO<sub>4</sub>-S
  - C:S Ratio > 400:1 → IMMOBILIZED SO<sub>4</sub>-S
  - Corn Stover ~350:1
  - Soybean Stover ~125:1
  - Wheat Straw ~300:1
  - Cover Crop? Other Factors?

# How Much S Does CORN Remove?

Grain	lb/bu	180 bu	220 bu	260 bu
Nitrogen	0.67	121	147	174
P <sub>2</sub> O <sub>5</sub>	0.35	63	77	91
K <sub>2</sub> O	0.25	45	55	65
<b>Sulfur</b>	<b>0.08</b>	<b>14</b>	<b>18</b>	<b>21</b>
Total S	0.15	27	33	39

# How Much S Does Soybean Need?

Grain	lb/bu	50 bu	75 bu	100 bu
Nitrogen	3.30	165	248	330
P <sub>2</sub> O <sub>5</sub>	0.73	37	55	73
K <sub>2</sub> O	1.20	60	90	120
<b>Sulfur</b>	<b>0.18</b>	<b>9</b>	<b>14</b>	<b>18</b>
<b>Total S</b>	<b>0.35</b>	<b>18</b>	<b>26</b>	<b>35</b>

# Doing the Math: **Sulfur Needs (lb S/ac)** (Rough Mass Balance)

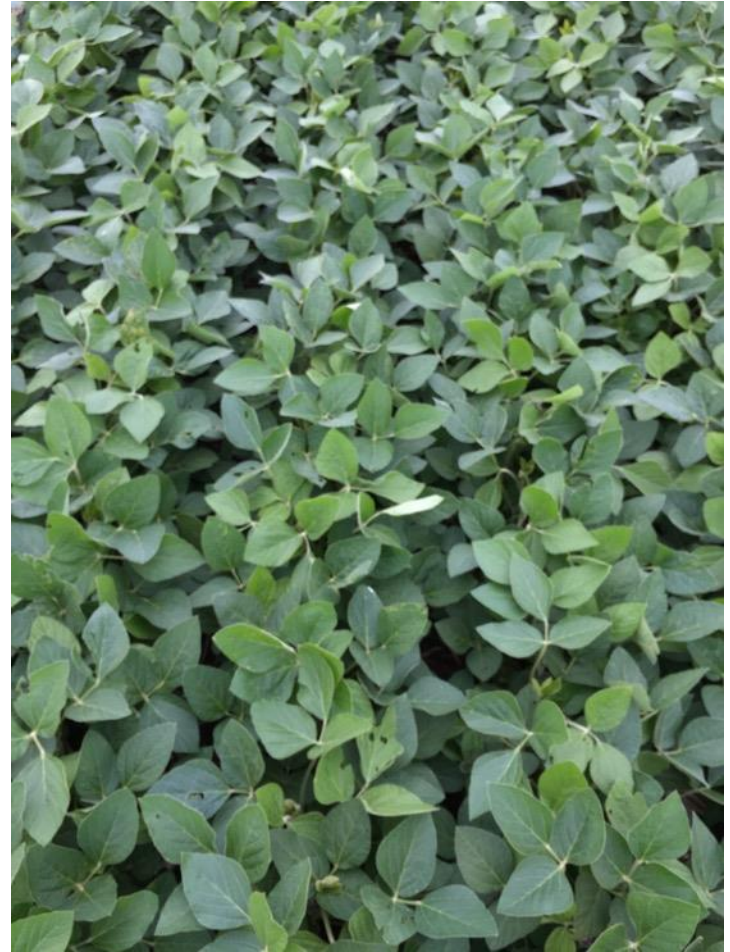
## Soil Organic Matter

Yield	Need	Sky	1%	2%	3%	4%
bu	lb S/ac		~4	~8	~12	~16
50	18	~5	9	5	1	+3
75	26	~5	17	13	9	5
100	35	~5	26	23	18	14

# No Sulfur



# 20 lb S/acre



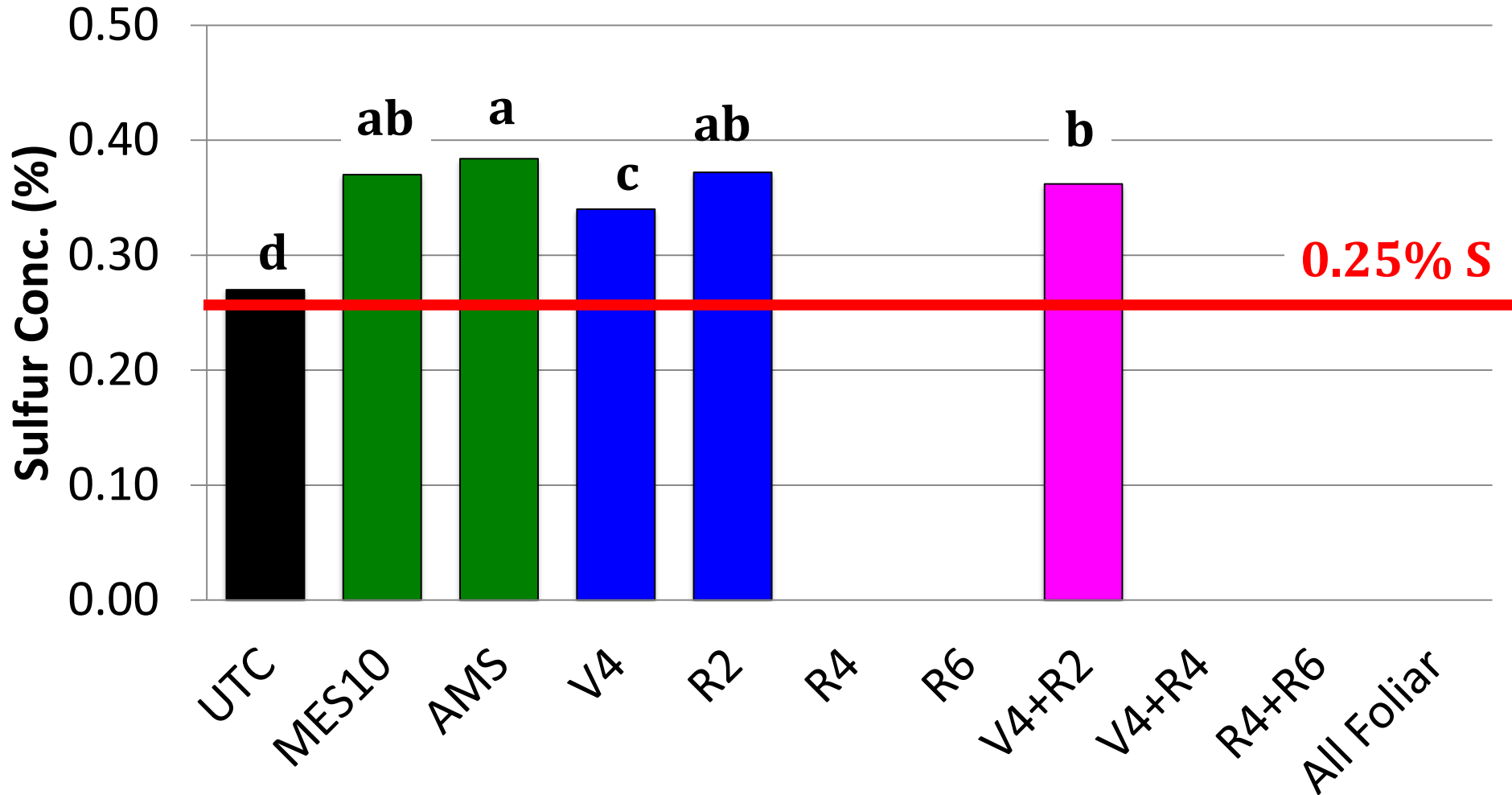
# Flowering (aka R2) Leaf Nutrient Sufficiency Ranges

N	P	K	Ca	Mg
3.25 to 5.0	0.30 to 0.60	1.5 to 2.25	0.8 to 1.4	0.25 to 0.70
S	Manganese	Zinc	Copper	Boron
<b>0.25 to 0.60</b>	17 to 100	21 to 80	4 to 30	20 to 60

# Sulfur Season Treatments

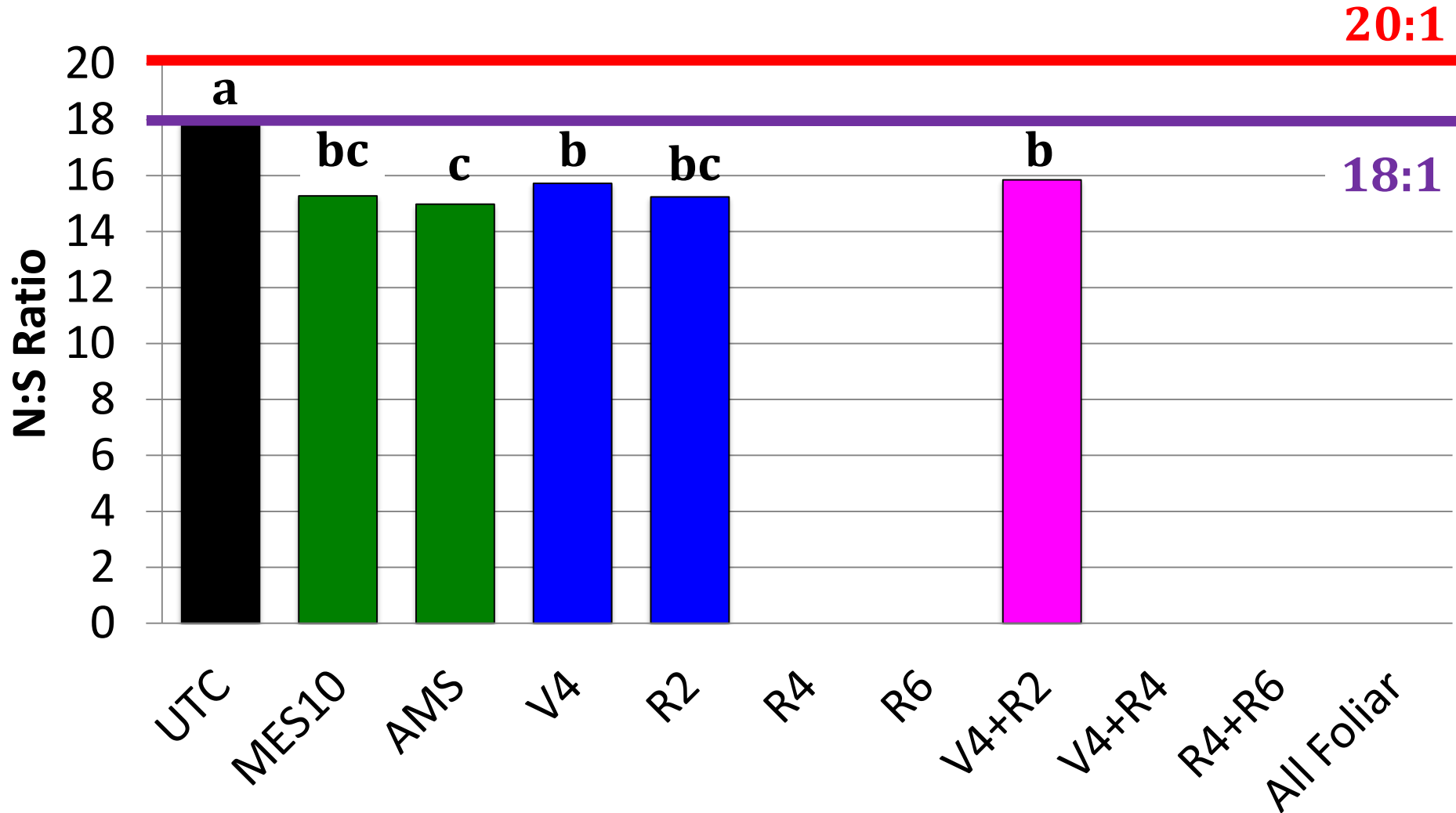
- **Untreated**
- **Broadcast @ 20 lb S/ac with MES10 or AMS** prior to emergence
- **Single foliar @ 5 lb S/ac with spraygrade AMS:**
  - V4, R2, R4, R6
- **Sequential foliar combos @ 5 lb S/ac per pass**
  - V4 + R2 → 5 + 5 = 10 lb S/ac
  - V4 + R4 → 5 + 5 = 10 lb S/ac
  - R4 + R6 → 5 + 5 = 10 lb S/ac
  - V4 + R2 + R4 + R6 → 5 + 5 + 5 + 5 = 20 lb S/ac

# 2016 Sulfur @ R3 (18 d after R2)



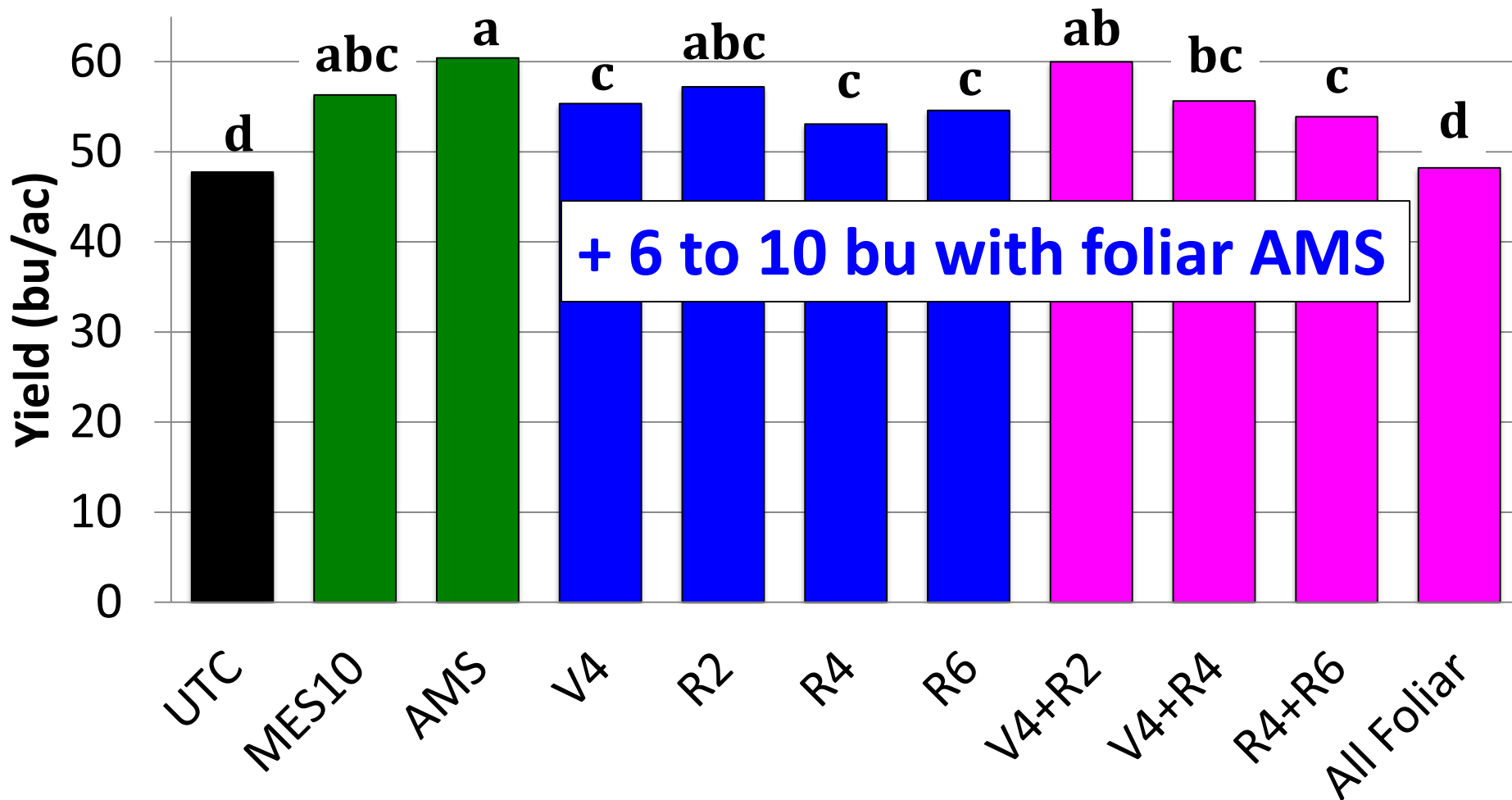


# 2016 N:S @ R3 (18 d after R2)



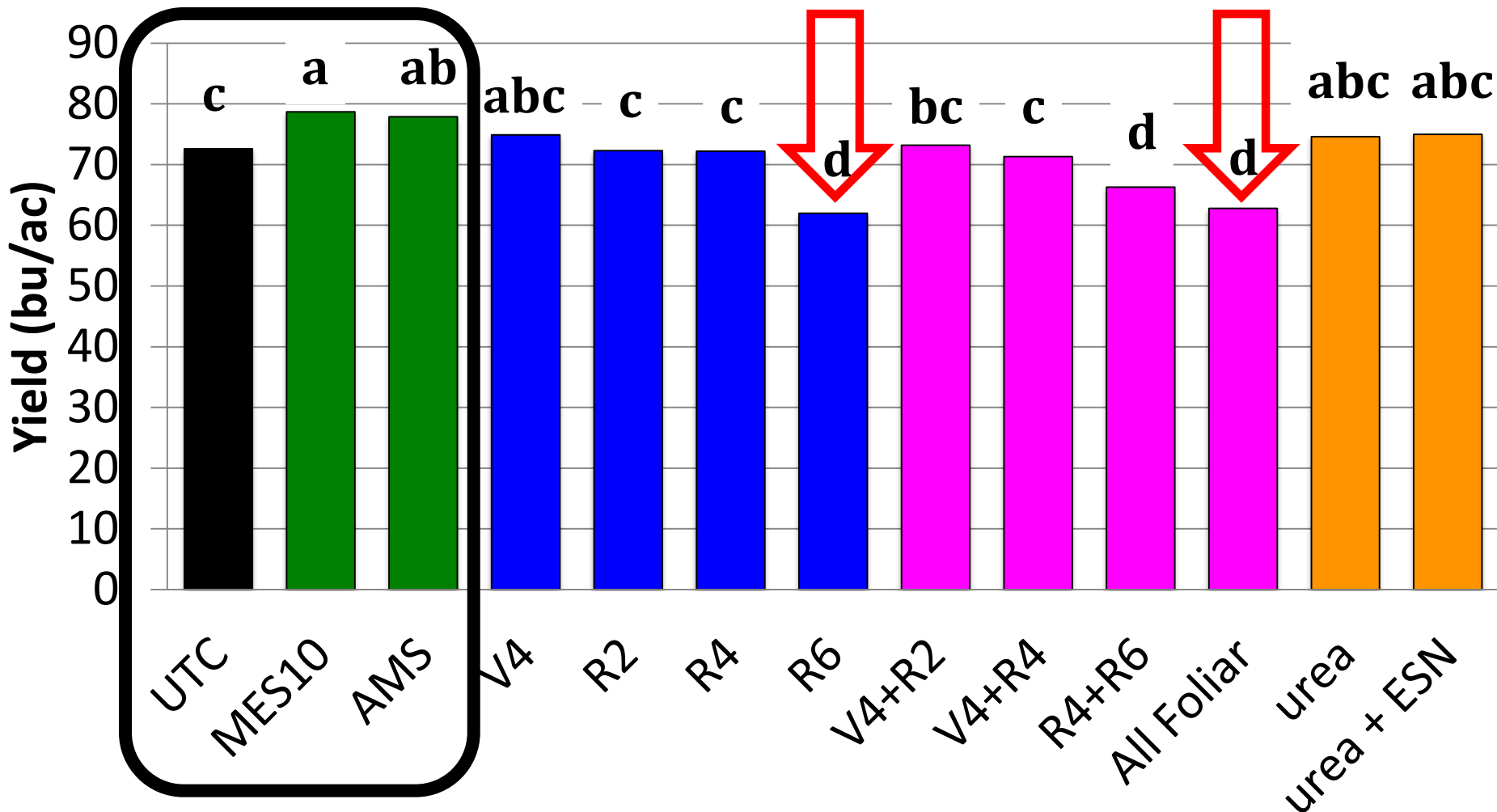
# 2016 Sulfur Season @ LaCrosse

+ 8.5 to 12.5 bu with broadcast



# 2016 Sulfur Season @ SWPAC

+ 6 bu with broadcast at V3



# 2017 Sulfur Response



# No Sulfur



# 20 lb S/acre





**AMS 20 lb S**

**AMS:ES**

**UTC**

**No Sulfur**



**20 lb S/acre**



## No Sulfur

**31 pods  
17 nodes  
1 branch**



## 20 lb S/acre

**45 pods  
18 nodes  
2 branches**





# 2017 Sulfur Responsiveness

- **Broadcast** @ 20 lb S/ac: + 13 bu
  - Similar to 2016
- **Single foliar** @ 5 lb S/ac: + 4 to 7 bu
  - Not as good as 2016
- **Sequential foliar combos**: + 5 to 7.5 bu
  - No response (i.e., crop phytotoxicity) with foliar applications at all four timings (V4, R2, R4, R6)
  - Not as good as 2016

# Doing the Math: Sulfur Needs (lb S/ac)

## (Rough Mass Balance)

### Soil Organic Matter

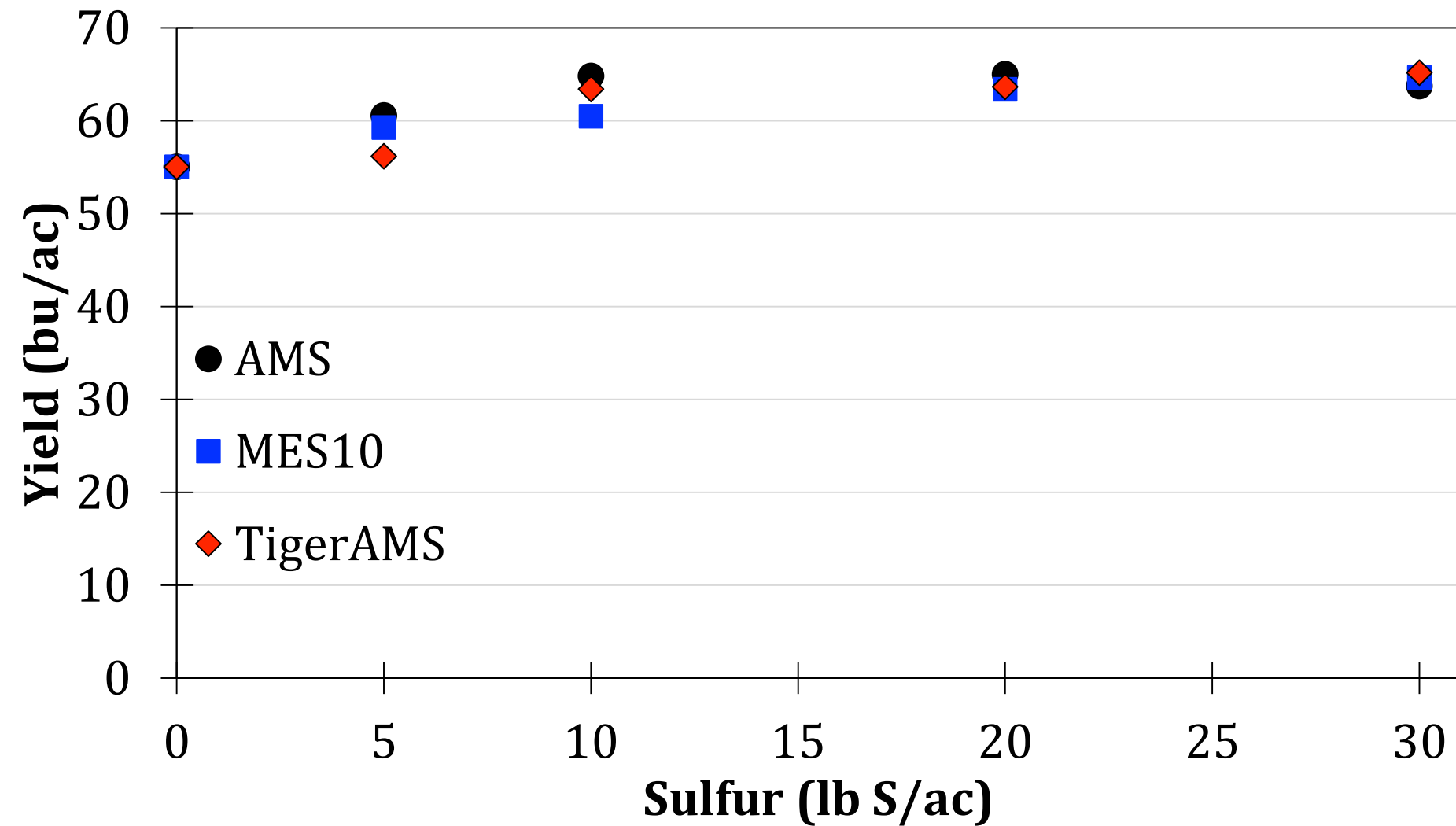
Yield	Need	Sky	1%	2%	3%	4%
bu	lb S/ac		~4	~8	~12	~16
50	18	~5				
75	26	~5				
100	35	~5				

What is the  
RIGHT RATE?

# Sulfur Rate x Source: 2016-17

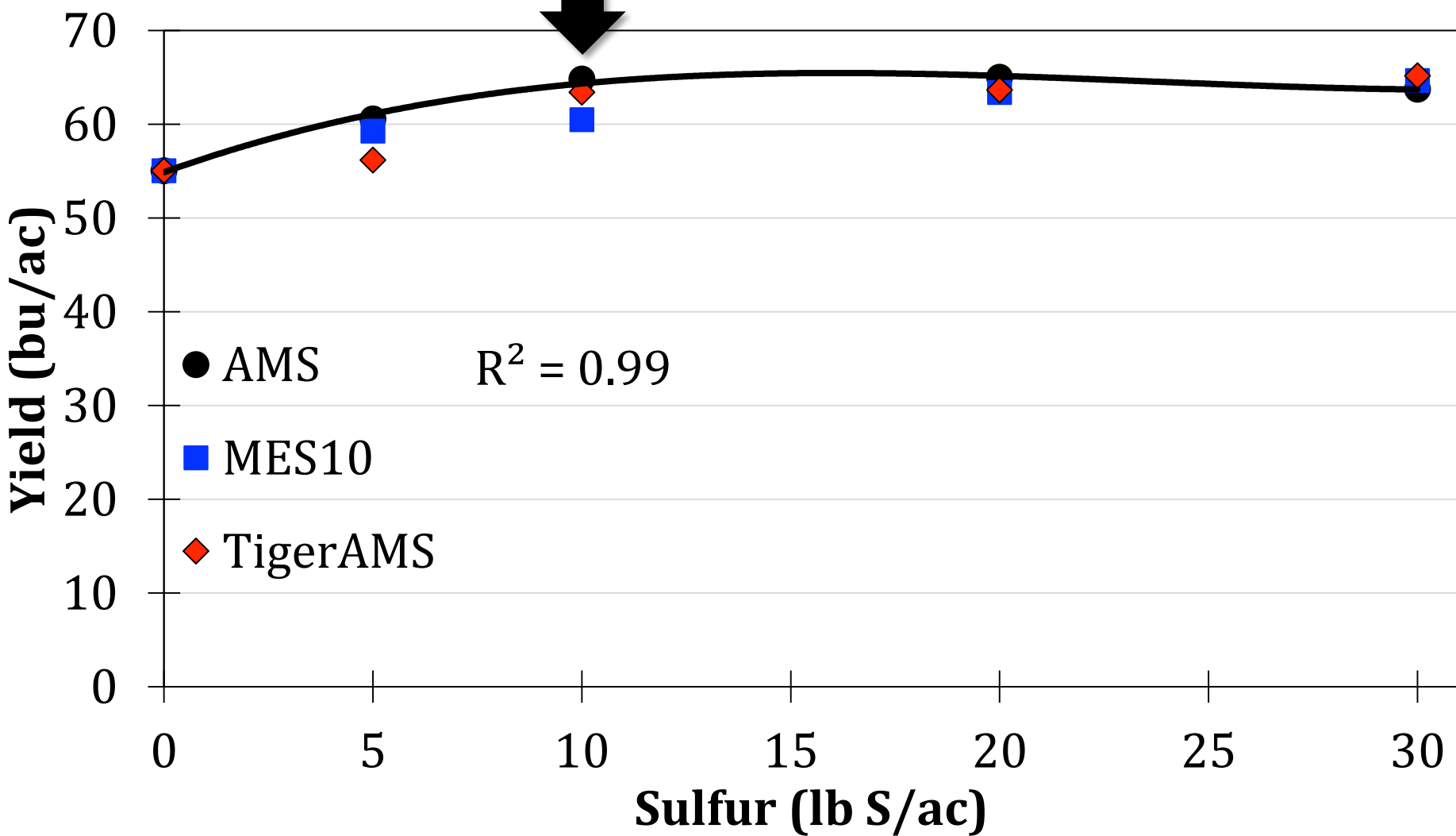
- **Untreated** control to be zero S rate
- **Sulfur Rates: 5, 10, 20, 30 lb S/ac**
- **Sources:**
  - **AMS** (21-0-0-24S), Ammonium Sulfate (Sulf-N®)
  - **MES10** (12-40-0-10S), MicroEssentials MES10S™
  - **TigerAMS** (50:50 blend of bentonite elemental sulfur and ammonium sulfate)
- Phosphorus was balanced for all fertilizer treatments with triple super phosphate (0-45-0)
- Broadcast applied to the soil surface within a few days of planting

# Sulfur Rate x Source: 2016-17



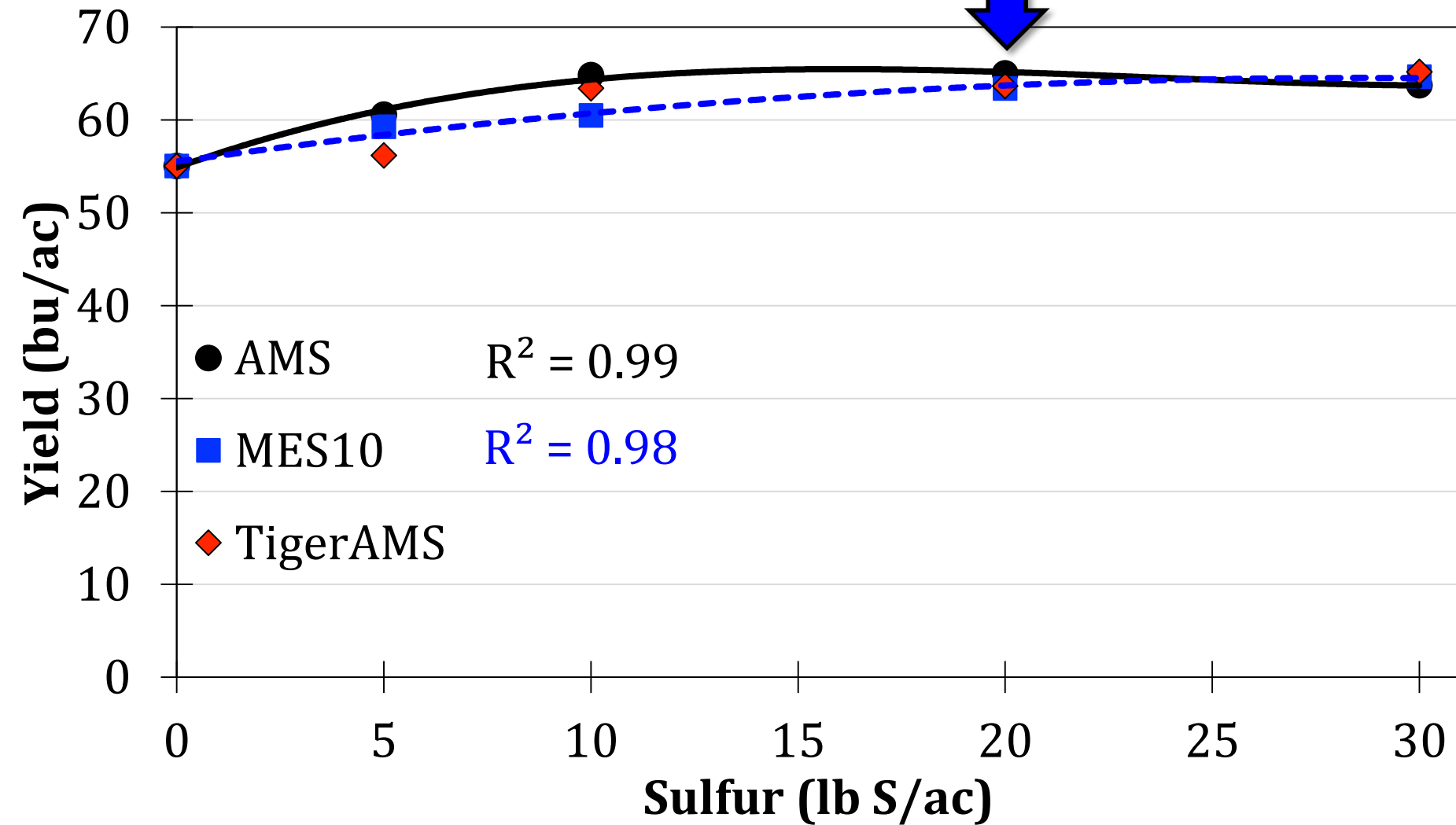
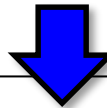
# Sulfur Rate x Source: 2016-17

AMS ~10 lb S/ac



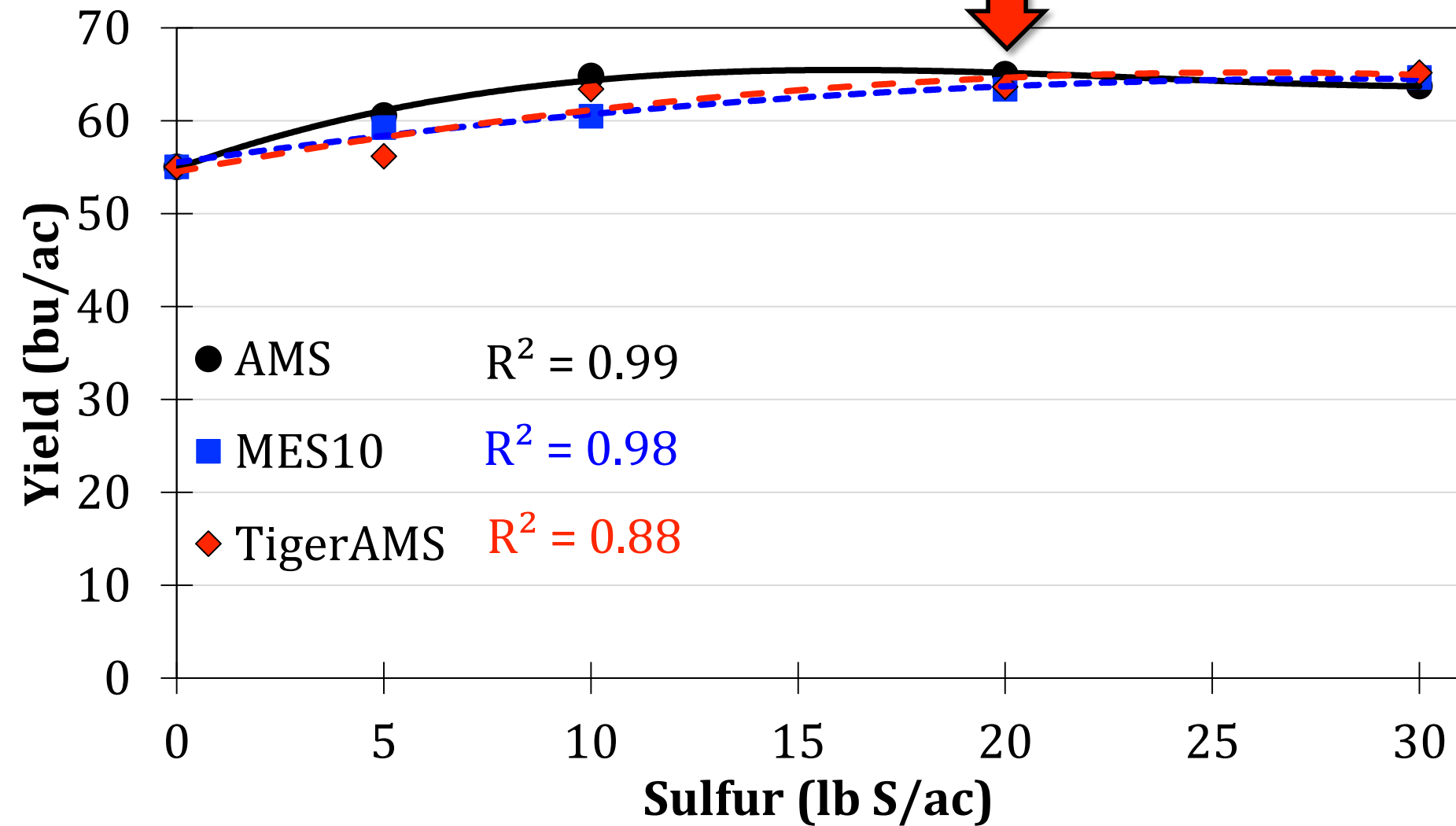
# Sulfur Rate x Source: 2016-17

MES10 ~20 lb S/ac

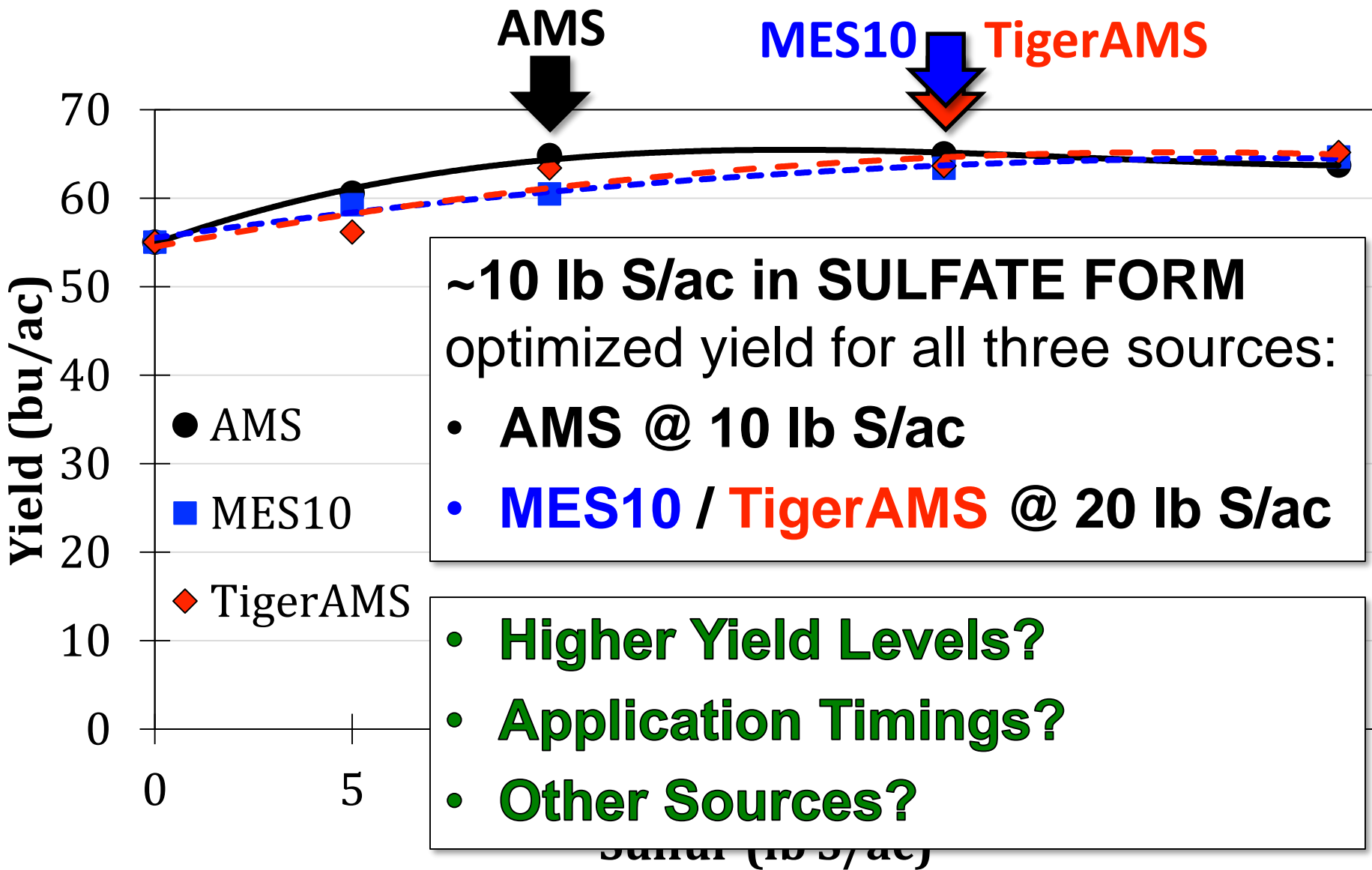


# Sulfur Rate x Source: 2016-17

TigerAMS ~20 lb S/ac



# Sulfur Rate x Source: 2016-17





# 18 New Sulfur Sources: Early R3



**UTC**

**AMS**

**MES10**

**Gyp**

**K-Mag**

**ATS**

# 18 Sulfur Sources: LaCrosse

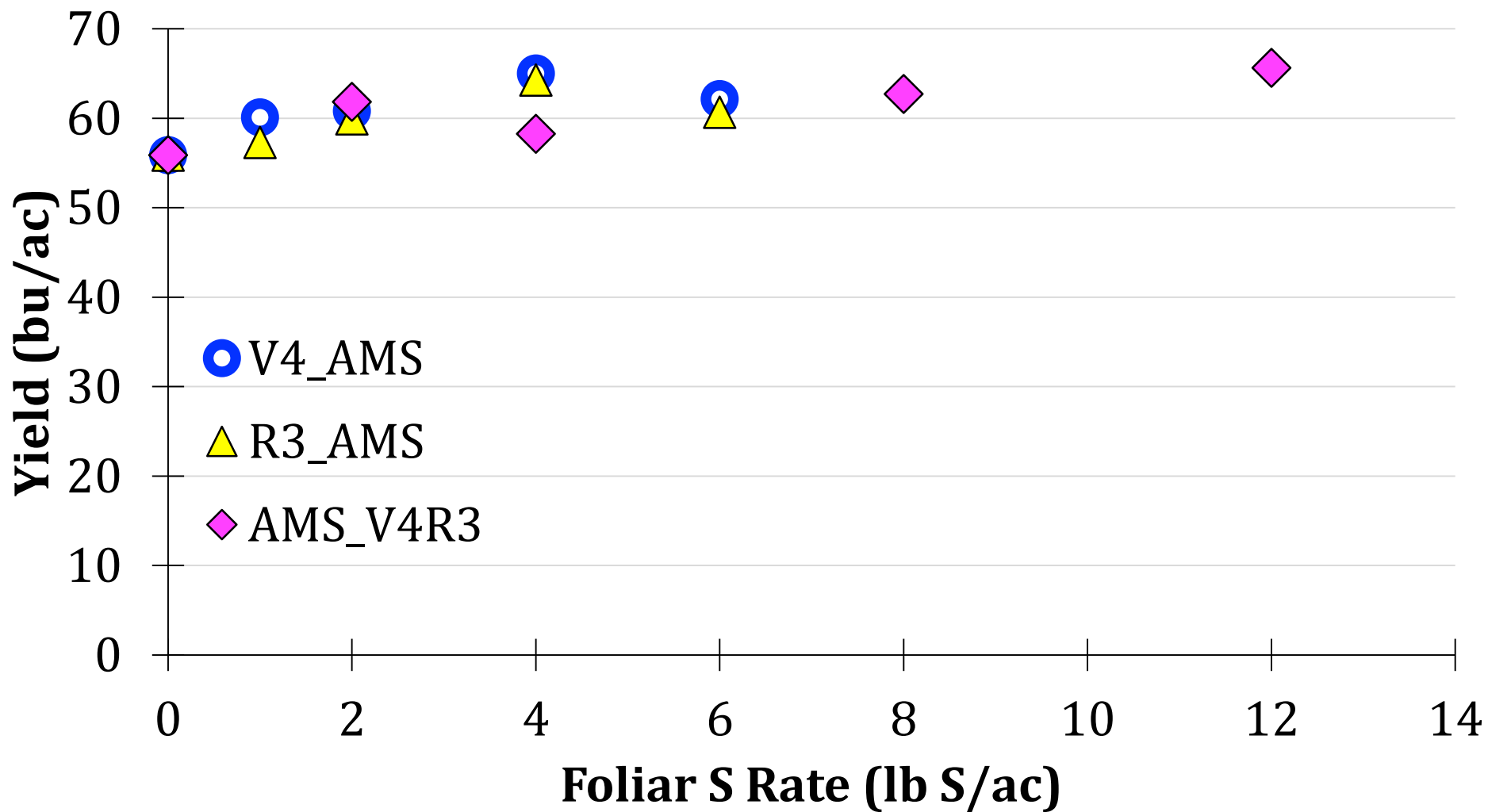
Source	Yield (bu/ac)
UTC	62.4
AMS	72.0
MES10	73.4
Gypsum	72.8
K-Mag	67.9
Tiger90CR	65.5
AMS:Tiger	68.8
spray.ATS	68.6
R3.Foliar.AMS	69.4

# 18 Foliar Sulfur Rate x Timing

- **Pre-AMS @ 20 lb S /ac**
- **Growth Stage Targets: V4, R3, V4 + R3**
- **Sulfur Rates: 0, 1, 2, 4, 6 lb S/ac**
- Spray grade AMS
- 15 GPA
- LaCrosse, IN

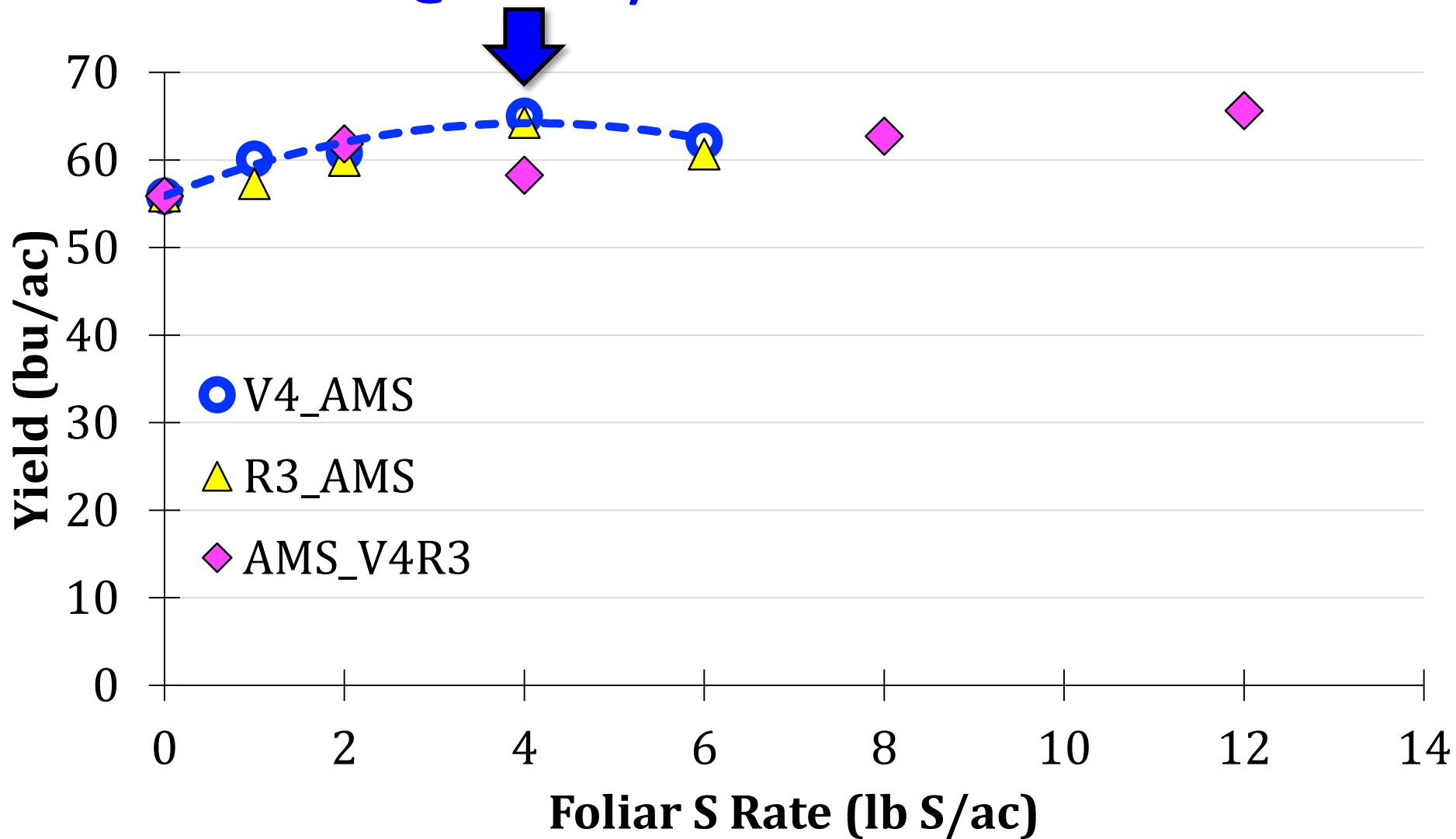


# 18 Foliar Sulfur Rate x Timing



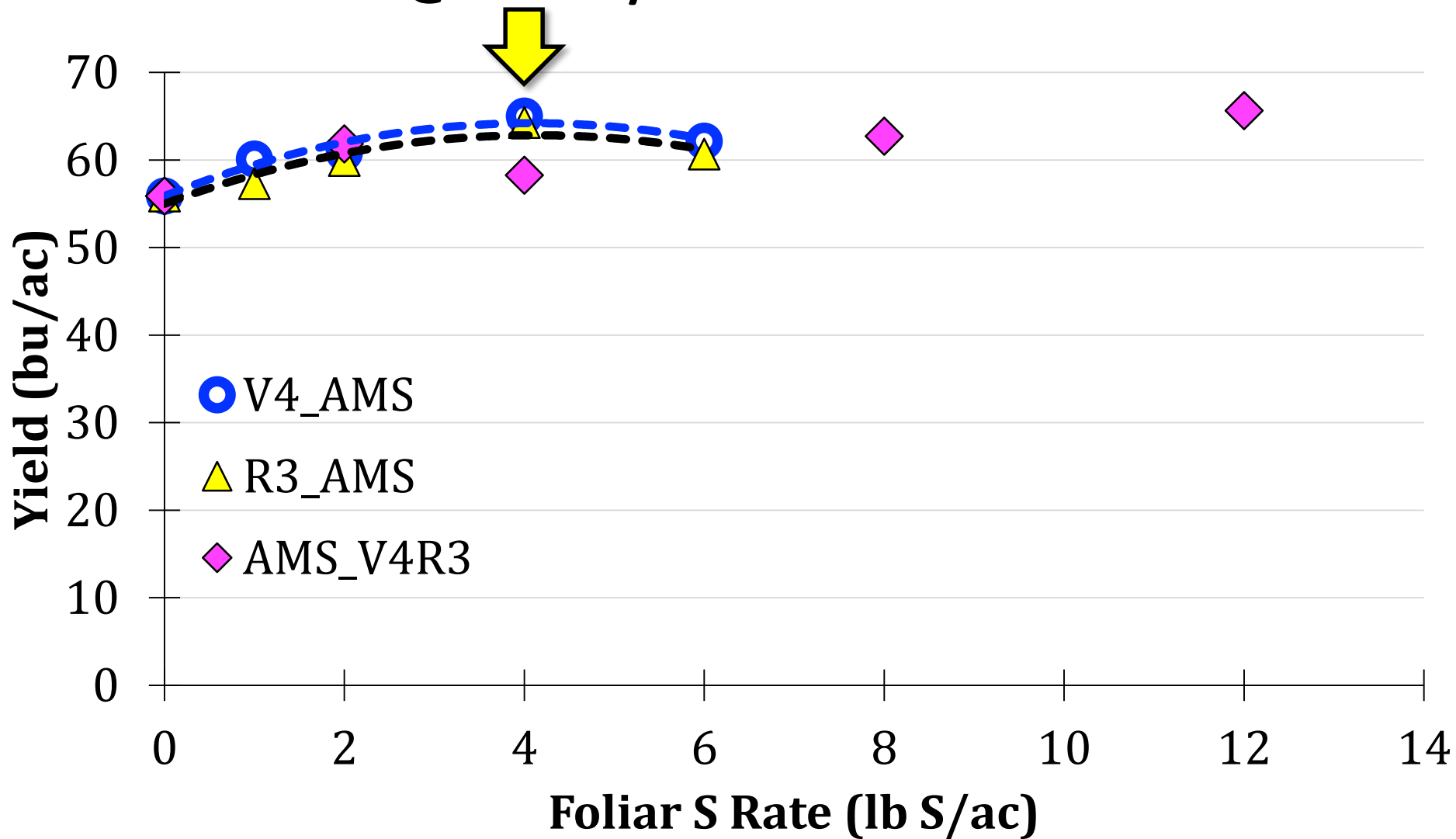
# 18 Foliar Sulfur Rate x Timing

V4 @ ~4 lb S/ac

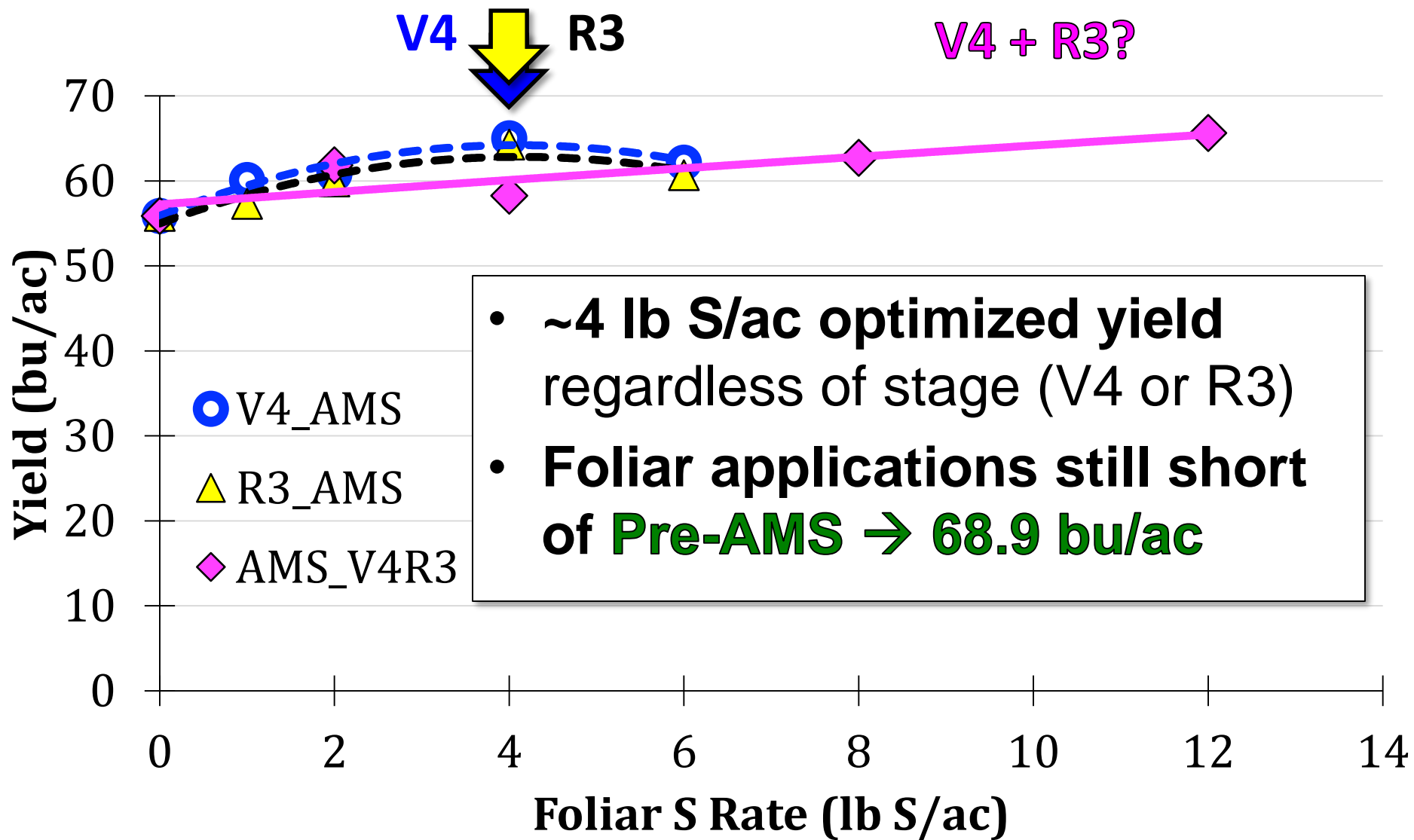


# 18 Foliar Sulfur Rate x Timing

R3 @ ~4 lb S/ac



# 18 Foliar Sulfur Rate x Timing



*Weather*

Variety

Selection

**Intentional  
Soybean  
Management**

Management

Weeds Early

*Soil*



# TIMELY PLANTING of Soybeans



# TIMELY PLANTING of Soybeans

- Best combination of **heat unit accumulation** and **light interception** to maximize:
  - Nodes
  - Pods
  - Reproductive branches
  - Canopy closure
  - Reproductive duration
- **Late April to Early May**: general sweet spot
- **Loss of yield potential 0.3 to 0.4 bu/ac/day after mid-May** (even early May occasionally)

# 18 Preliminary N+S Findings

- **N+S x Planting Date**
  - ACRE: **West Lafayette**
  - 2 x 10 Factorial arranged in RCBD with 5 reps
  - Variety: AG 34x6
  - 2 Planting Dates: **May 11<sup>th</sup>, June 5<sup>th</sup>**
  - 10 N-S Based Treatments

Treatment	Timing	Nitrogen lb N/ac	Sulfur lb S/ac	May 11 bu/ac	June 5 bu/ac
UTC	.	.	.	62.4	59.2
AMS	PRE-Emerge	17.5	20	69.5	60.7
ATS	PRE-Emerge	9.3	20	71.5	61.9

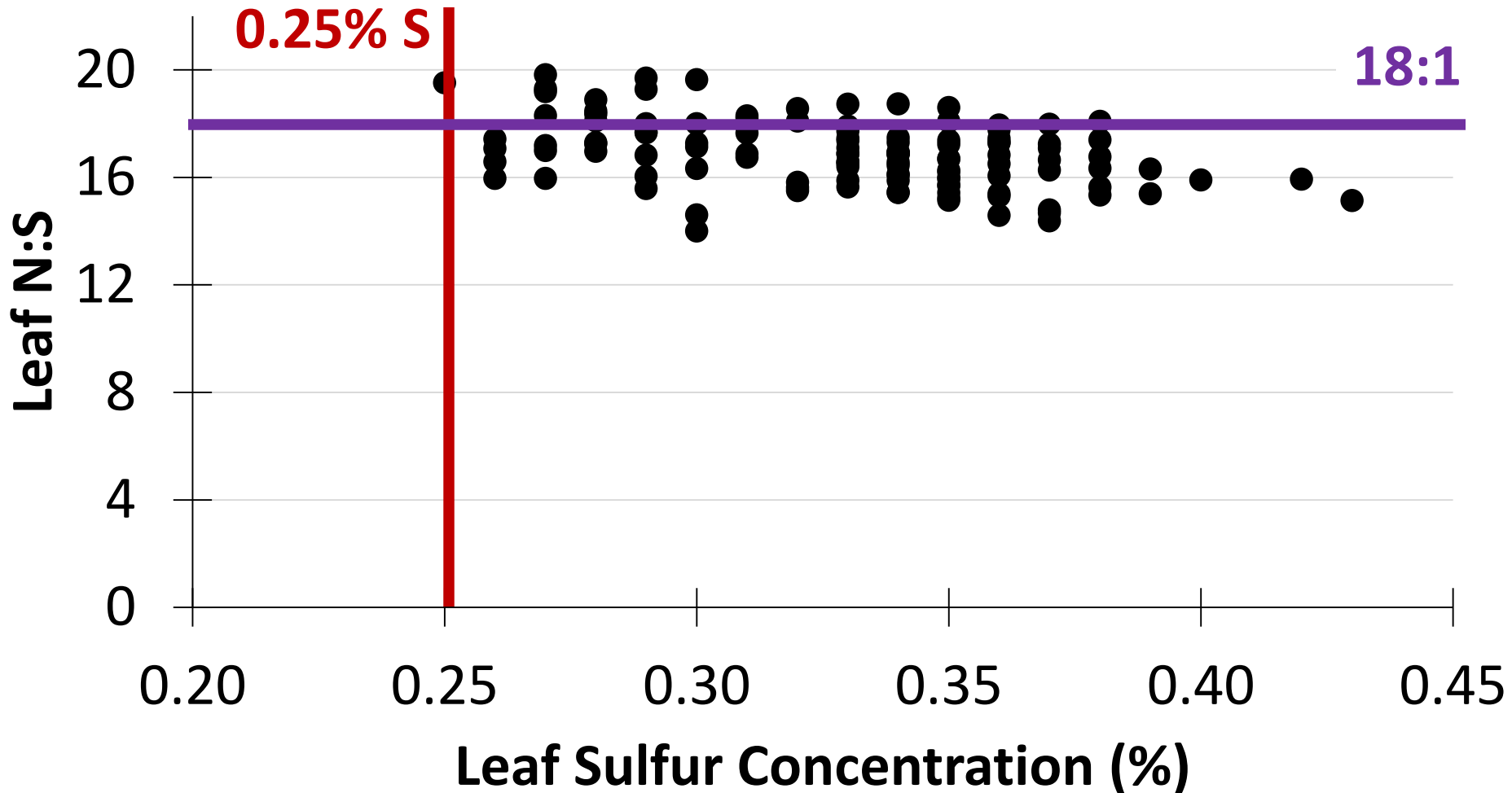
# 18 Preliminary N+S Findings

- **N+S x Variety**

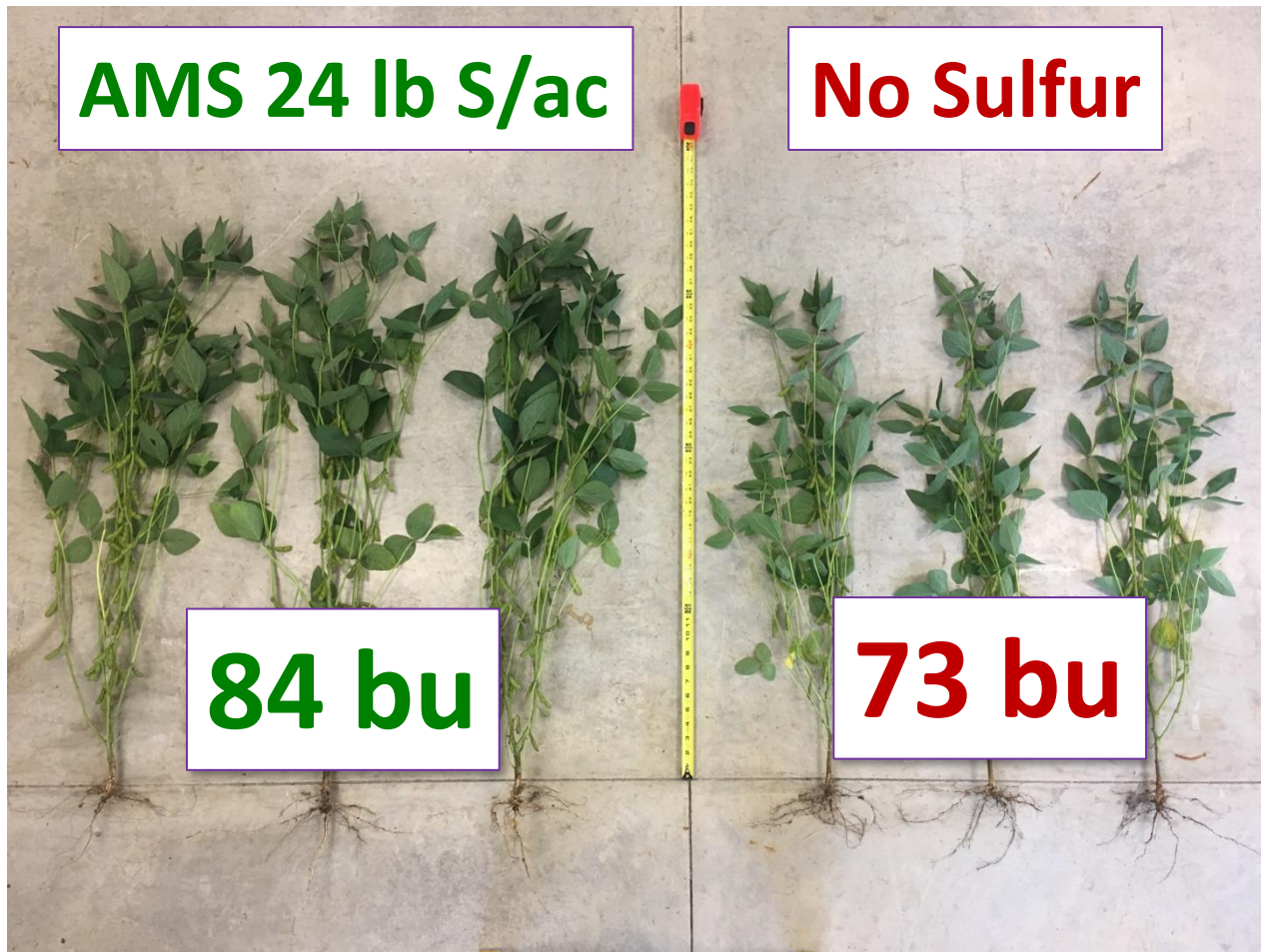
- Pinney PAC: **Wanatah, IN**
- 2 x 10 Factorial arranged in RCBD with 5 reps
- 2 Varieties: **AG24x7, AG34x6** planted **May 25<sup>th</sup>**
- 10 N-S Based Treatments

Treatment	Timing	Nitrogen lb N/ac	Sulfur lb S/ac	AG 24X7 bu/ac	AG 34X6 bu/ac
UTC	.	.	.	65.3	66.0
AMS	PRE-Emerge	17.5	20	69.3	65.4
ATS	PRE-Emerge	9.3	20	60.2	67.0

# 18 INField Advantage: Untreated Leaf Samples



# 18 INFA Tipton



66 pods/plant  
18.4 nodes

44 pods/plant  
16.6 nodes

# Concluding Thoughts on Sulfur

- **Soil test?** Not Really.
- **Soybean is the integrator**
  - **Late Spring Broadcast of ~20 lb S/ac** with soluble source (e.g., AMS, MES10, Gypsum, ATS)
  - **Leaf Nutritional Snapshots then Apply Sulfur**
    - “Close” to **critical S levels (0.25%)**
    - **N:S ~18:1 or higher**
  - **Foliar S → ~4 lb S/ac**
- **Management x Fertility Considerations?**
  - Field conditions that affect sulfur availability and nodulation + N fixation (e.g., soil temp, planting, residue)

# Thanks for the support!



**INDIANA  
SOYBEAN  
ALLIANCE**





QUESTIONS?



**Shaun Casteel, [scasteel@purdue.edu](mailto:scasteel@purdue.edu)**

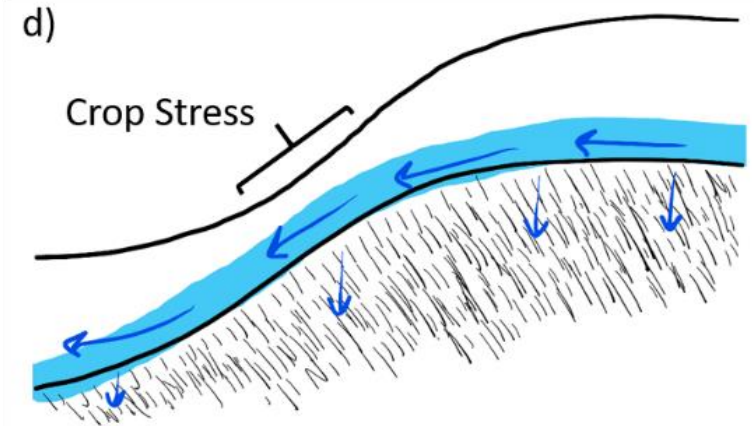
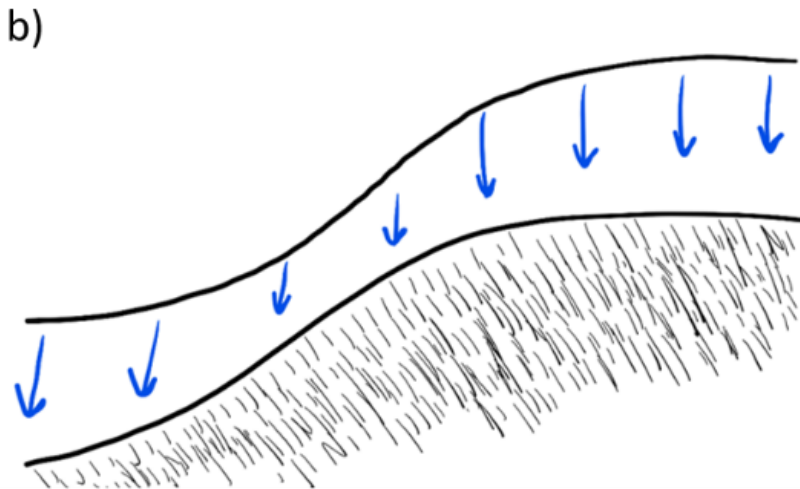
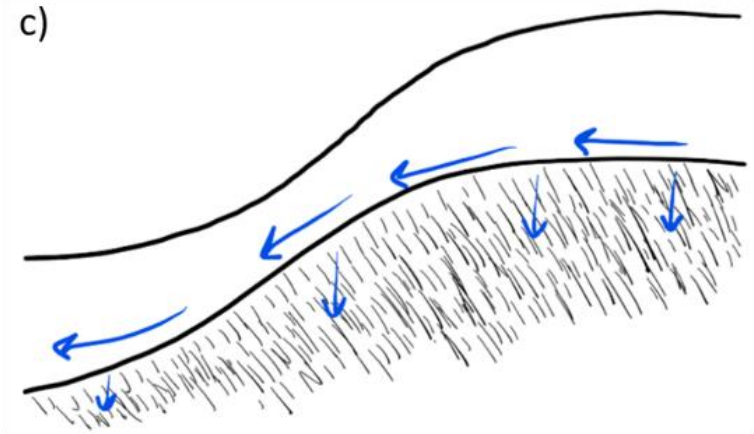
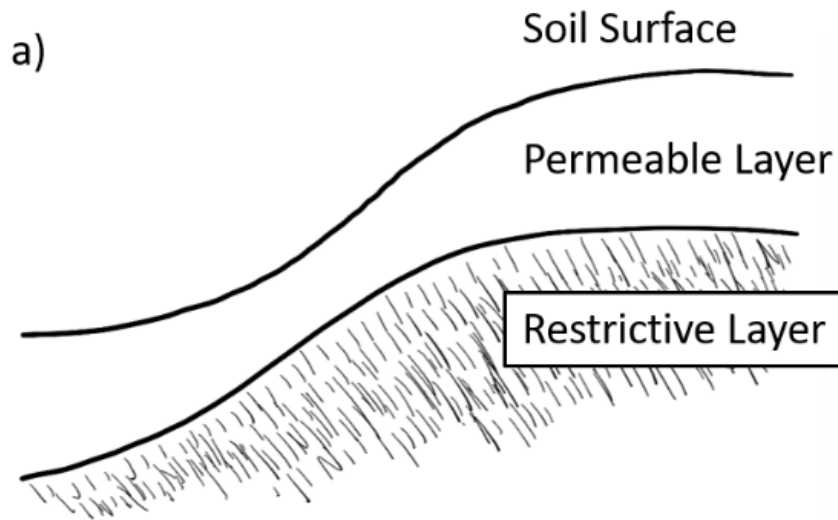
# Highlighter Green Soybeans

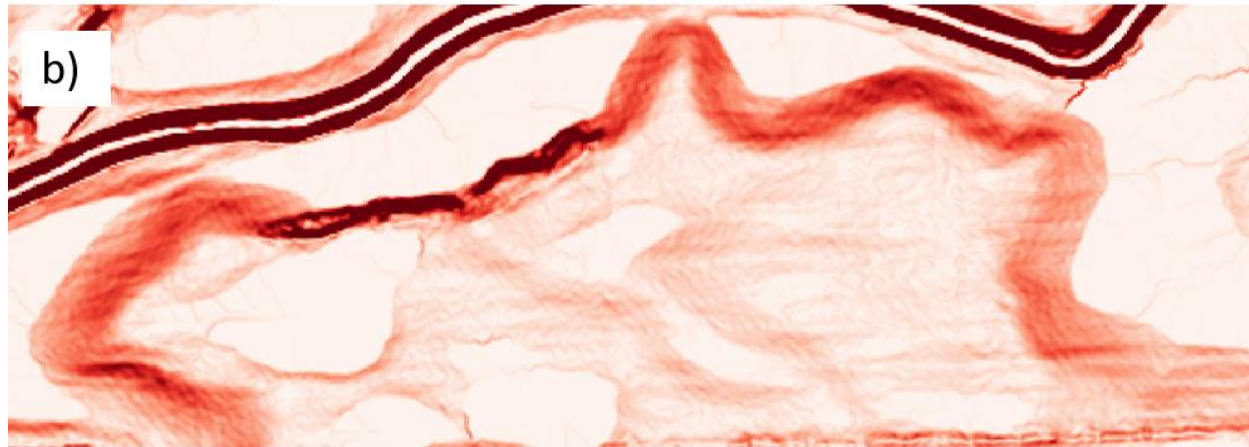






# Seep Hydrology





# A New Pest in 2018?



# Shelby County





# Shelby County



# Good

# Poor



**18.8 nodes**  
**43.1 pods**  
**~60 bu**

**16.7 nodes**  
**28.7 pods**  
**~40 bu**

# Good

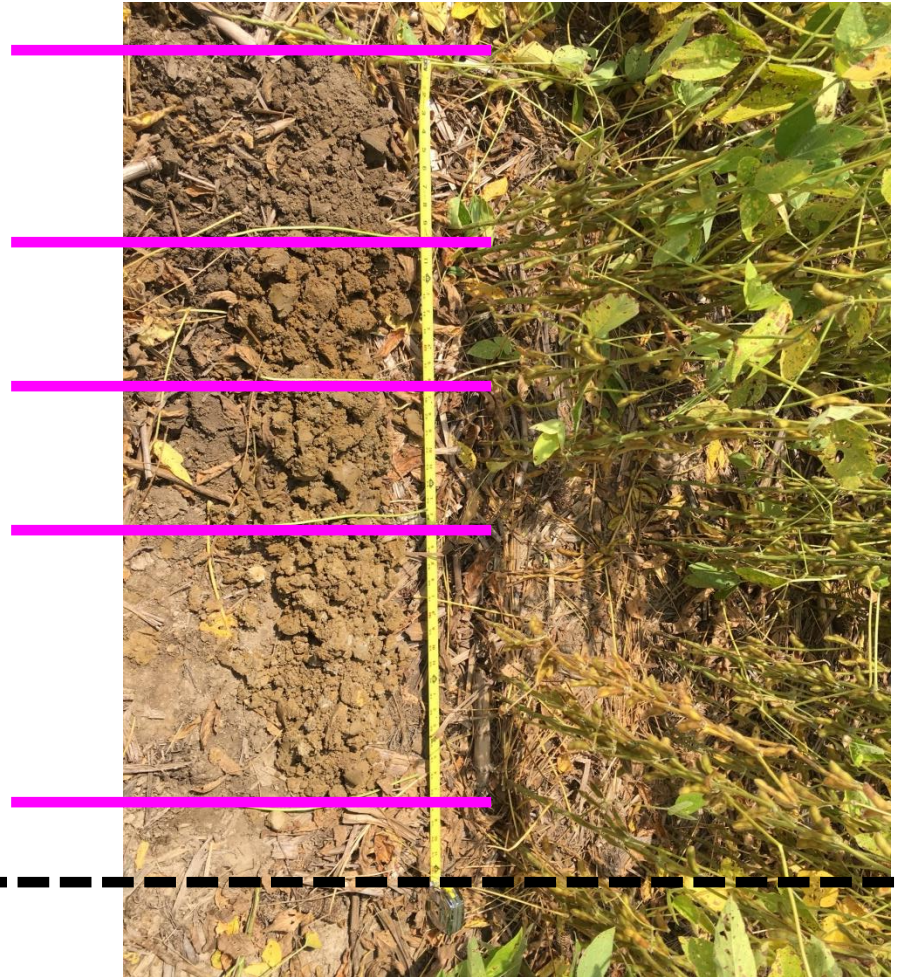
# Poor



# Good



# Poor



# Advancing the INField Advantage

## Soy + Sulfur Program

- Yield maps so data can be queried
- PDF yield maps are at the mercy of the legend's scale with no way of quantifying the yield response unless it is dramatic
  - How much of a yield response is break-even for 20 lb of S/ac via AMS? **~2 to 2.5 bu/ac**
  - Can you tell the difference between 2, 3, or 4 bu pixels on a yield map?

# Firm Foundations For Yield

- **Varieties** are taking up more N and S
- **Timely Planting** sets the stage
- **Fertility** for yield potential
- **Sulfur (and Nitrogen)**
  - Sulfur-Deficient Fields
  - Sulfur can be ***Situationally Deficient*** (and N?)
  - Sulfur → Nodulation, N Fixation, N Utilization

# Yield Map Legend Example

May 11	June 5
bu/ac	bu/ac
62.4	59.2
69.5	60.7
71.5	61.9
74.2	62.8
75.9	58.0
76.1	57.6
77.3	59.9
72.8	60.5
68.1	59.7
72.4	57.2

May 11	June 5
bu/ac	bu/ac
62.4	59.2
69.5	60.7
71.5	61.9
74.2	62.8
75.9	58.0
76.1	57.6
77.3	59.9
72.8	60.5
68.1	59.7
72.4	57.2

# Yield Map Legend Example

Treatment	Timing	Nitrogen lb N/ac	Sulfur lb S/ac	May 11 bu/ac	June 5 bu/ac
<b>UTC</b>	.	.	.	62.4	59.2
<b>AMS</b>	PRE-Emerge	17.5	20	69.5	60.7
<b>ATS</b>	PRE-Emerge	9.3	20	71.5	61.9
<b>AMS + Urea</b>	PRE-Emerge	40	10	74.2	62.8
<b>AMS + Urea</b>	V4	40	10	75.9	58.0
<b>V4 + R3</b>	V4 + R3 Direct	80	20	76.1	57.6
<b>AMS + UAN</b>	R3 Direct	40	10	77.3	59.9
<b>UAN</b>	R3 Direct	40	.	72.8	60.5
<b>AMS</b>	R3 Direct	8.75	10	68.1	59.7
<b>R3 + Feed</b>	R3 + R5, 5.5, 6, 6.5	80	20	72.4	57.2



# Yield Map Legend Example

Treatment	Timing	Nitrogen lb N/ac	Sulfur lb S/ac	May 11 bu/ac	June 5 bu/ac
UTC	.	.	.	62.4	59.2
AMS	PRE-Emerge	17.5	20	69.5	60.7
ATS	PRE-Emerge	9.3	20	71.5	61.9
AMS + Urea	PRE-Emerge	40	10	74.2	62.8
AMS + Urea	V4	40	10	75.9	58.0
V4 + R3	V4 + R3 Direct	80	20	76.1	57.6
AMS + UAN	R3 Direct	40	10	77.3	59.9
UAN	R3 Direct	40	.	72.8	60.5
AMS	R3 Direct	8.75	10	68.1	59.7
R3 + Feed	R3 + R5, 5.5, 6, 6.5	80	20	72.4	57.2

# Shelby County







# Good

# Poor



**18.8 nodes**  
**43.1 pods**  
**~60 bu**

**16.7 nodes**  
**28.7 pods**  
**~40 bu**

# Good

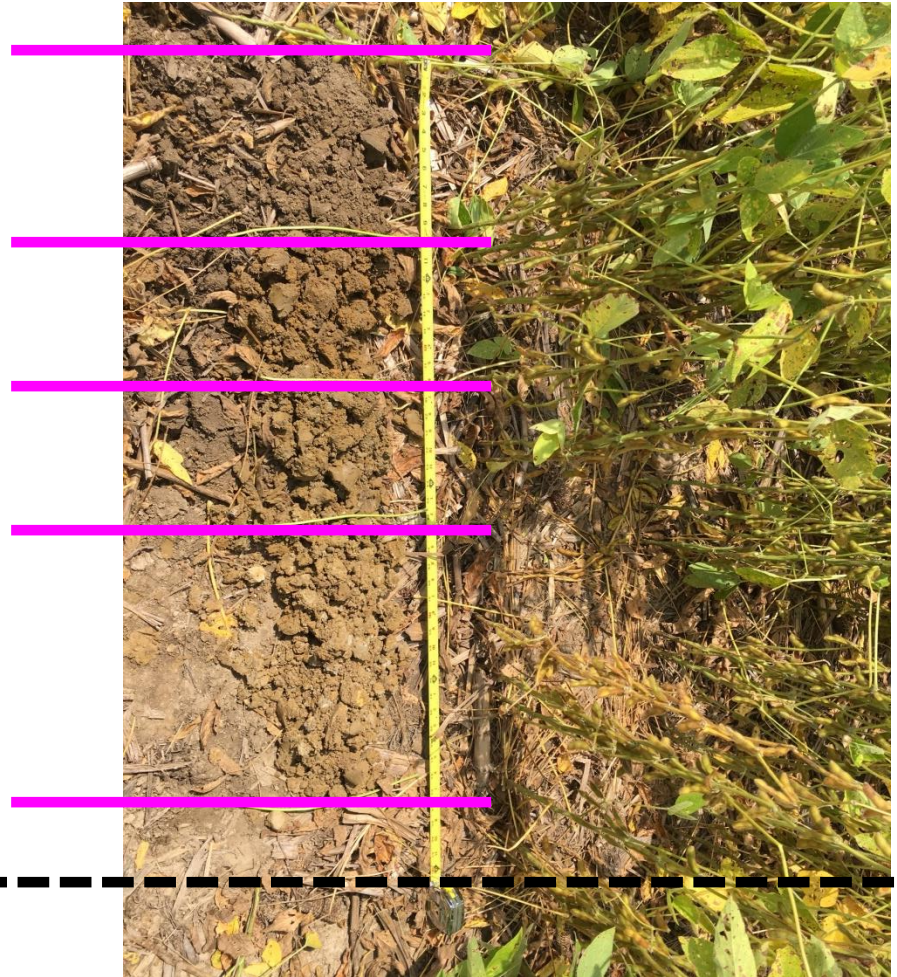
# Poor



# Good



# Poor



# 18 Preliminary N+S Findings

## N+S x Planting at West Lafayette, IN

Treatment	Timing	Nitrogen lb N/ac	Sulfur lb S/ac	May 11 bu/ac	June 5 bu/ac
UTC	.	.	.	62.4	59.2
AMS	PRE-Emerge	17.5	20	69.5	60.7
ATS	PRE-Emerge	9.3	20	71.5	61.9

## N+S x Variety at Wanatah, IN: May 25<sup>th</sup> Planting

Treatment	Timing	Nitrogen lb N/ac	Sulfur lb S/ac	AG 24X7 bu/ac	AG 34X6 bu/ac
UTC	.	.	.	65.3	66.0
AMS	PRE-Emerge	17.5	20	69.3	65.4
ATS	PRE-Emerge	9.3	20	60.2	67.0



# Future: Planting Date x Source

- Planting Date: 5 small, but 2 to 3 at PACs?
- Sources:
  - ATS Burndown
  - ATS in Starter 0x2
  - AMS Broadcast
  - Other Soluble Sources

# Future: Field Residue x Source

- Field Residue:
  - Corn Stalks
  - Corn Residue levels
  - Cover Crop: C. Rye, Others
- Sources:
  - ATS Burndown
  - ATS in Starter 0x2
  - AMS Broadcast
  - Other Soluble Sources

# Future: Incubation Studies

- 2 Soils
- Residues
  - C. Rye
  - Corn Stover
  - Corn Stover + C. Rye
- C:N Ratios
- C:S Ratios
- Fertilizer additions?

# Future: App Timing x Source

- Application: 5 to 6 timings
  - Fall
  - Feb-March (~60 d prior to planting)
  - March-April (~30 d prior to planting)
  - Planting (within 1 week)
  - V2 (~30 d after planting)
  - V6/R1 (~60 d after planting)
- Sources: 4 to 6?
  - AMS Broadcast
  - Gypsum
  - MES10
  - Elemental S
  - ATS?
  - Any Blends?
- Rates?
  - 12 lb, 24 lb S/ac
- Untreated