Is Sulfur is the "S" in Soybean?

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SOYBEAN STATION
DELIVERING FIRST CLASS SOYBEAN INFORMATION

Weather
Variety
Weeds Early
Intentional
Soybean
Management
Soil

1923

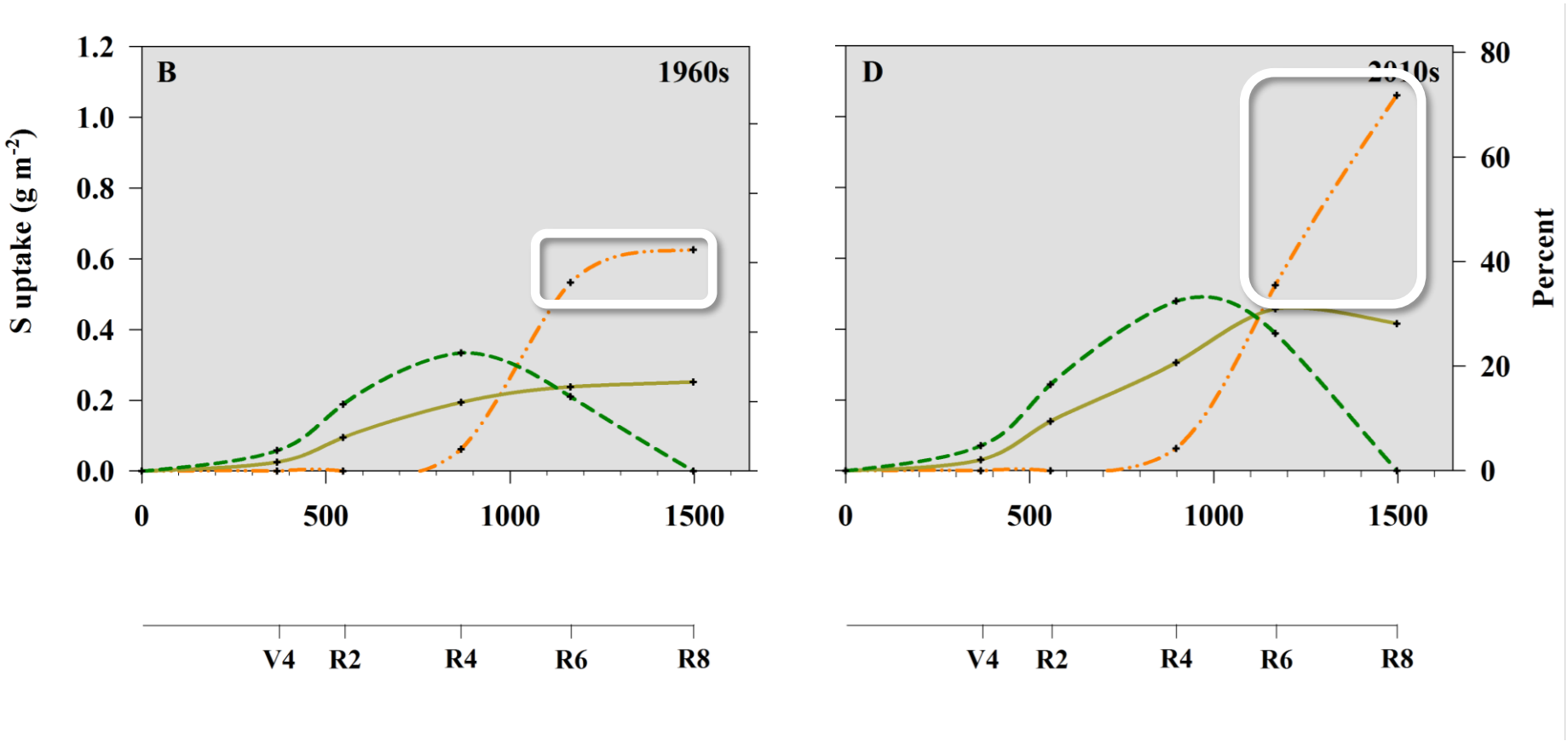
1943

1964

2011

Maturity Group 2

S Accumulation: 1960s vs. 2010s



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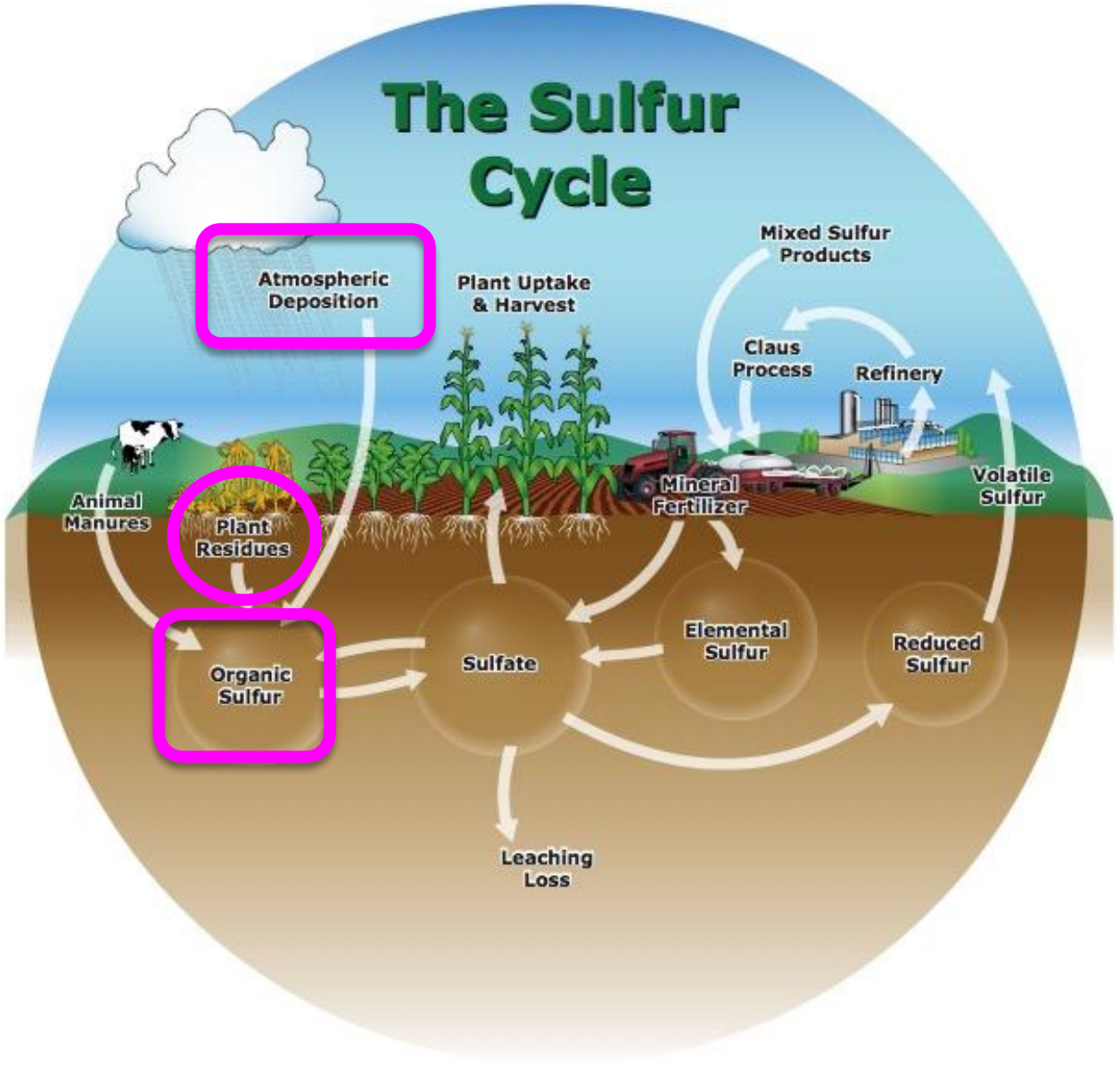
- Atmospheric Deposition
- Organic S
- Plant Residue



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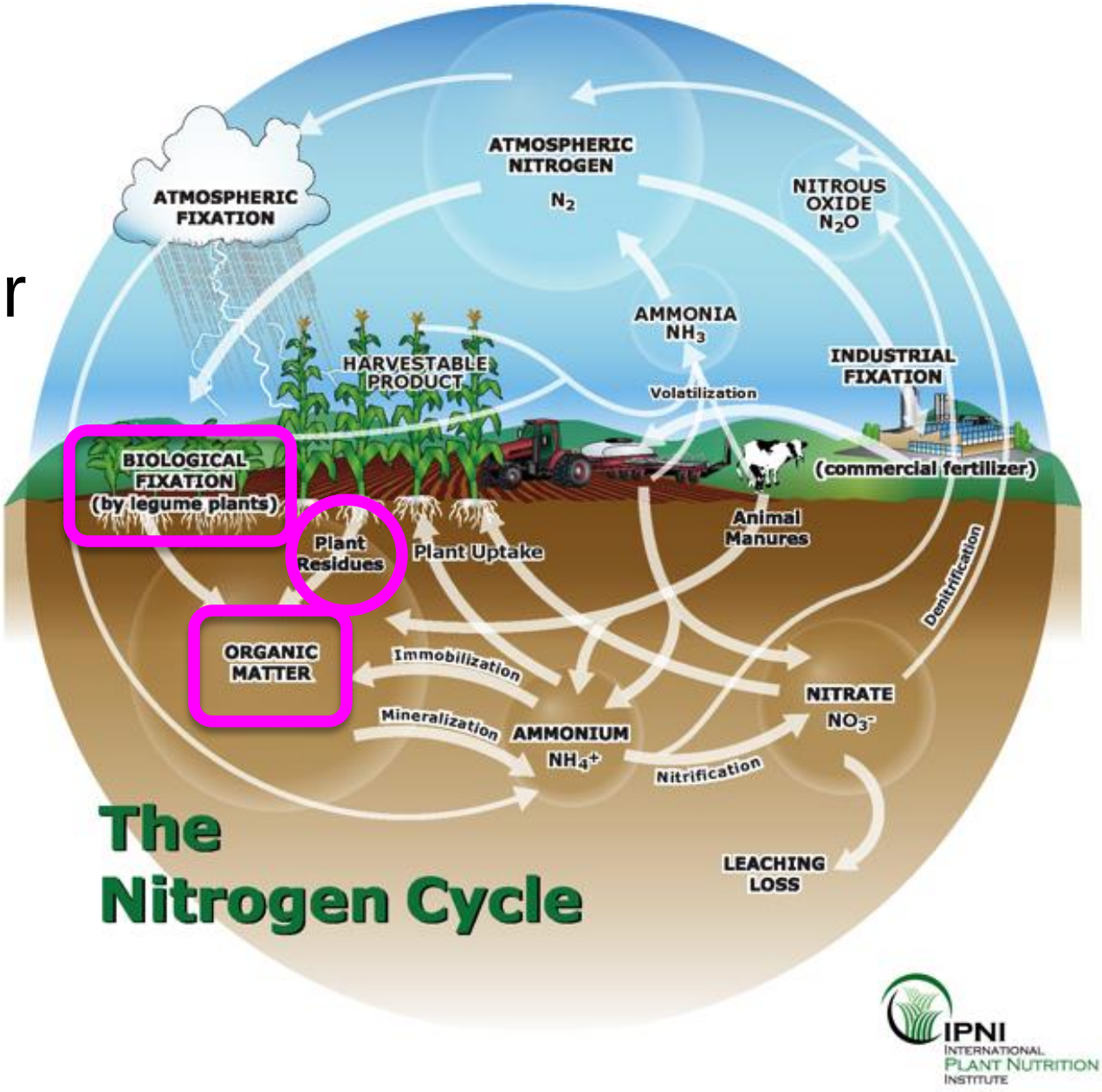
- Organic Matter
- Plant Residue
- N Fixation



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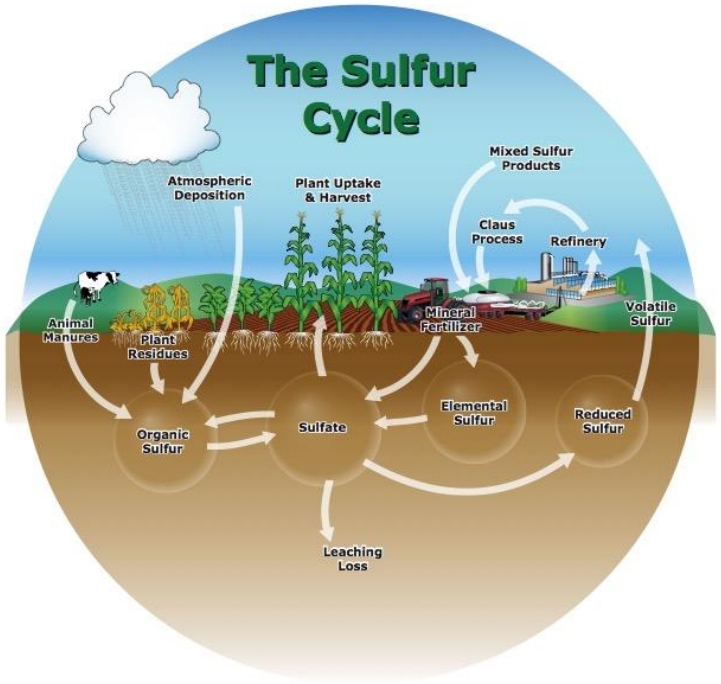

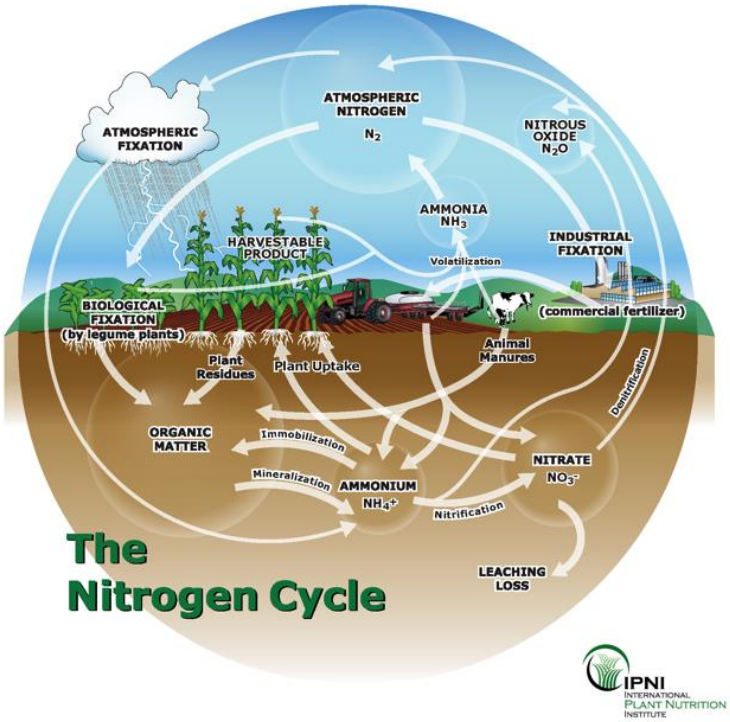

High Yielding Soybeans!

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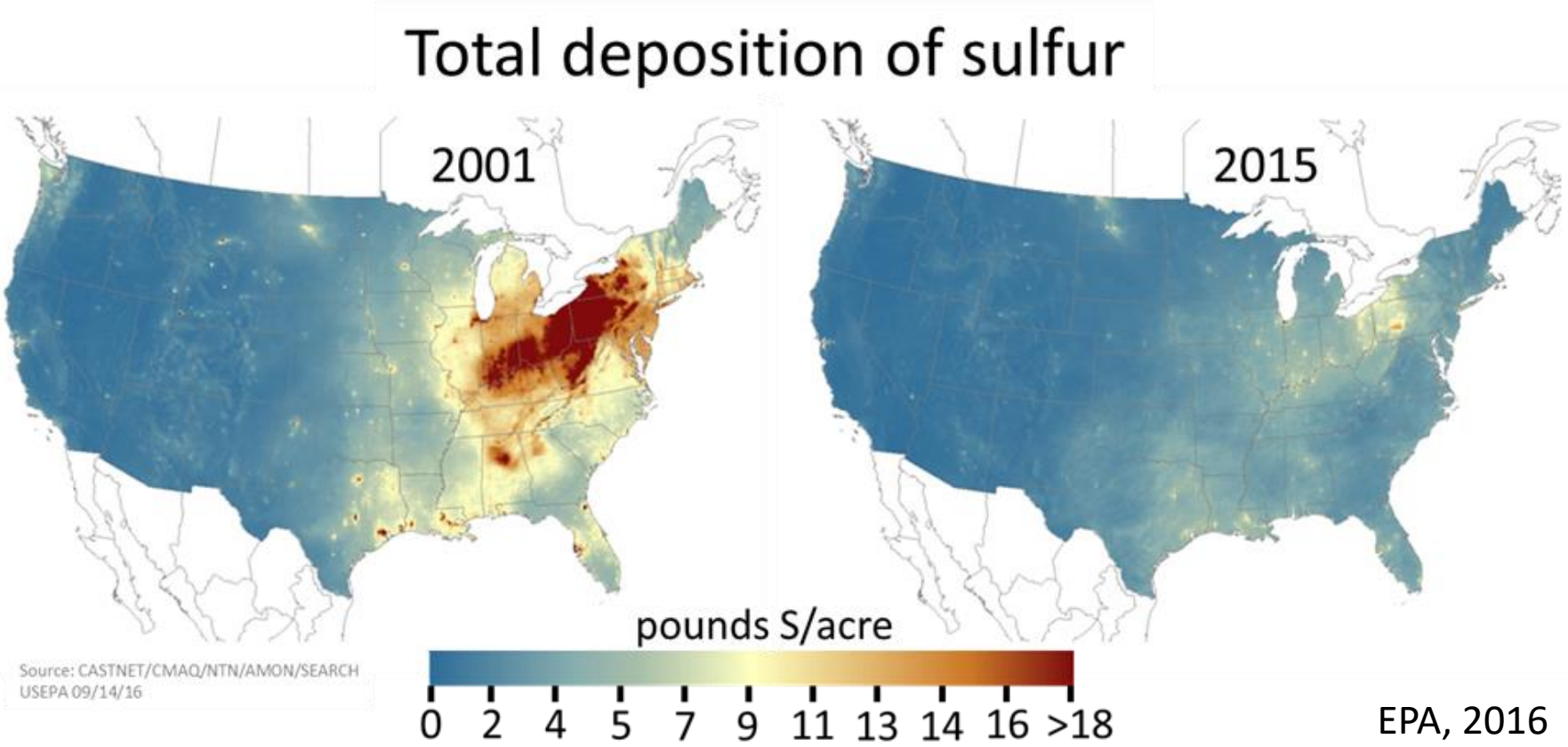
Sulfur: Who Needs It…Maybe You?



EPA, 2016

Which Crops Should Be the Most Responsive to Sulfur?

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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_4-S**
  - **C:S Ratio > 400:1 → IMMOBILIZED SO_4-S**
  - Corn Stover ~350:1
  - Soybean Stover ~125:1
  - Wheat Straw ~300:1
  - Cover Crop? Other Factors?

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How Much S Does CORN Remove?

Grain	lb/bu	180 bu	220 bu	260 bu
Nitrogen	0.67	121	147	174
P_2O_5	0.35	63	77	91
K_2O	0.25	45	55	65
Sulfur	**0.08**	**14**	**18**	**21**
Total S	0.15	27	33	39

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How Much S Does Soybean Need?

Grain	lb/bu	50 bu	75 bu	100 bu
Nitrogen	3.30	165	248	330
P_2O_5	0.73	37	55	73
K_2O	1.20	60	90	120
Sulfur	**0.18**	**9**	**14**	**18**
Total S	**0.35**	**18**	**26**	**35**

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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

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No Sulfur

20 lb S/acre

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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**
0.25 to 0.60	17 to 100	21 to 80	4 to 30	20 to 60

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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

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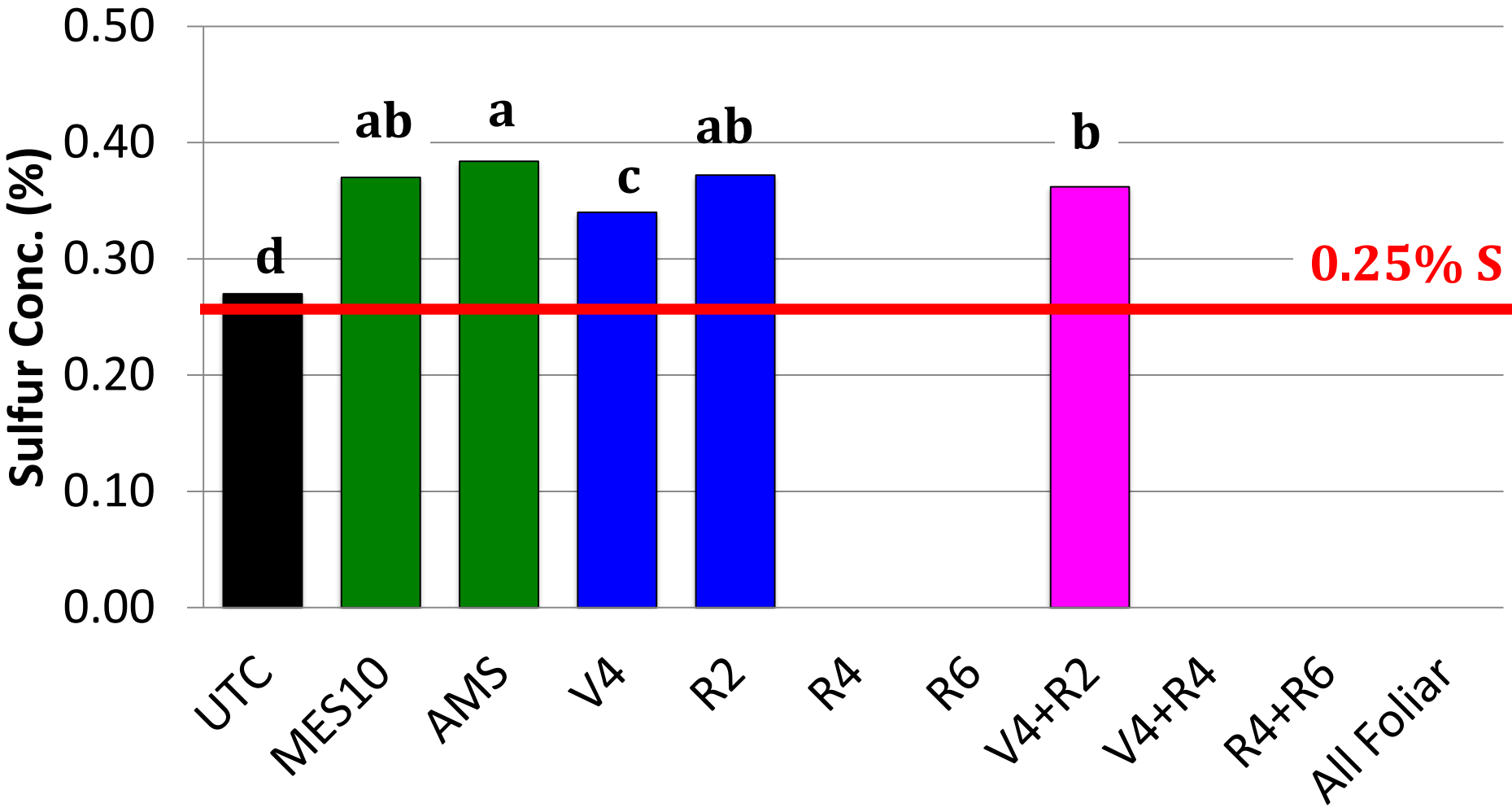
2016 Sulfur @ R3 (18 d after R2)



Fisher's Protected $LSD_{0.05}$

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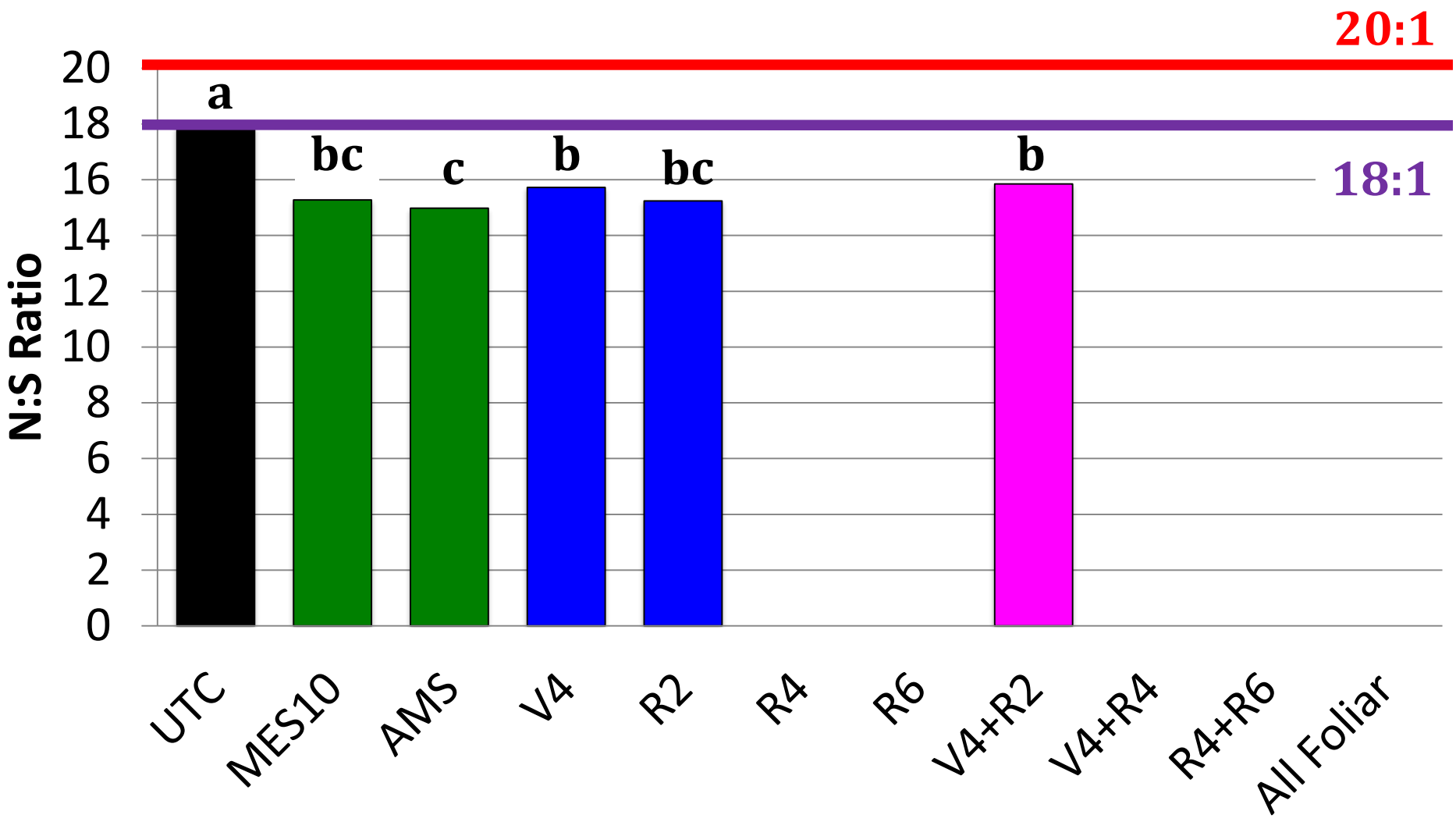
2016 N:S @ R3 (18 d after R2)



Fisher's Protected $LSD_{0.05}$

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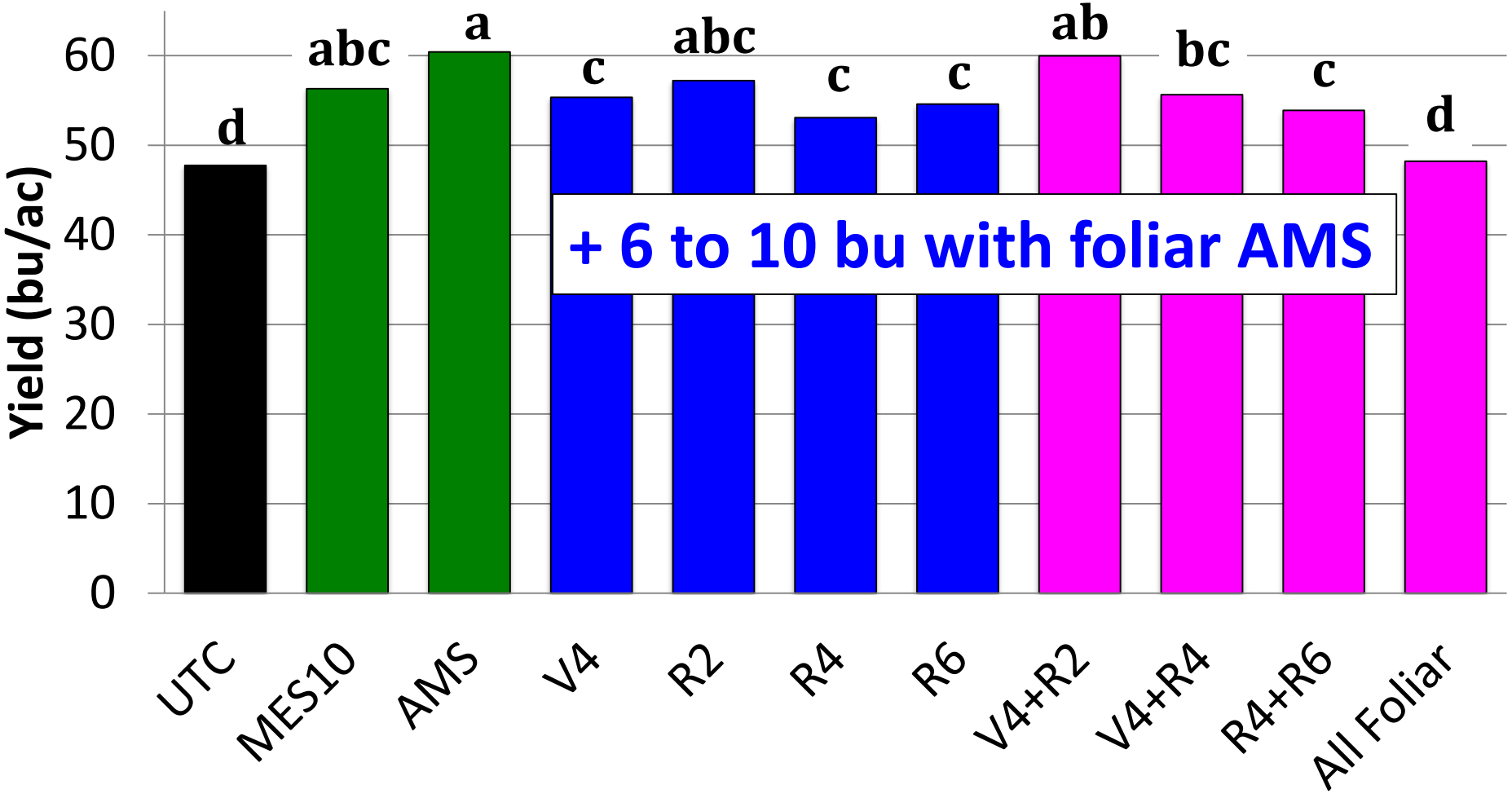
2016 Sulfur Season @ LaCrosse

+ 8.5 to 12.5 bu with broadcast



Fisher's Protected $LSD_{0.05}$

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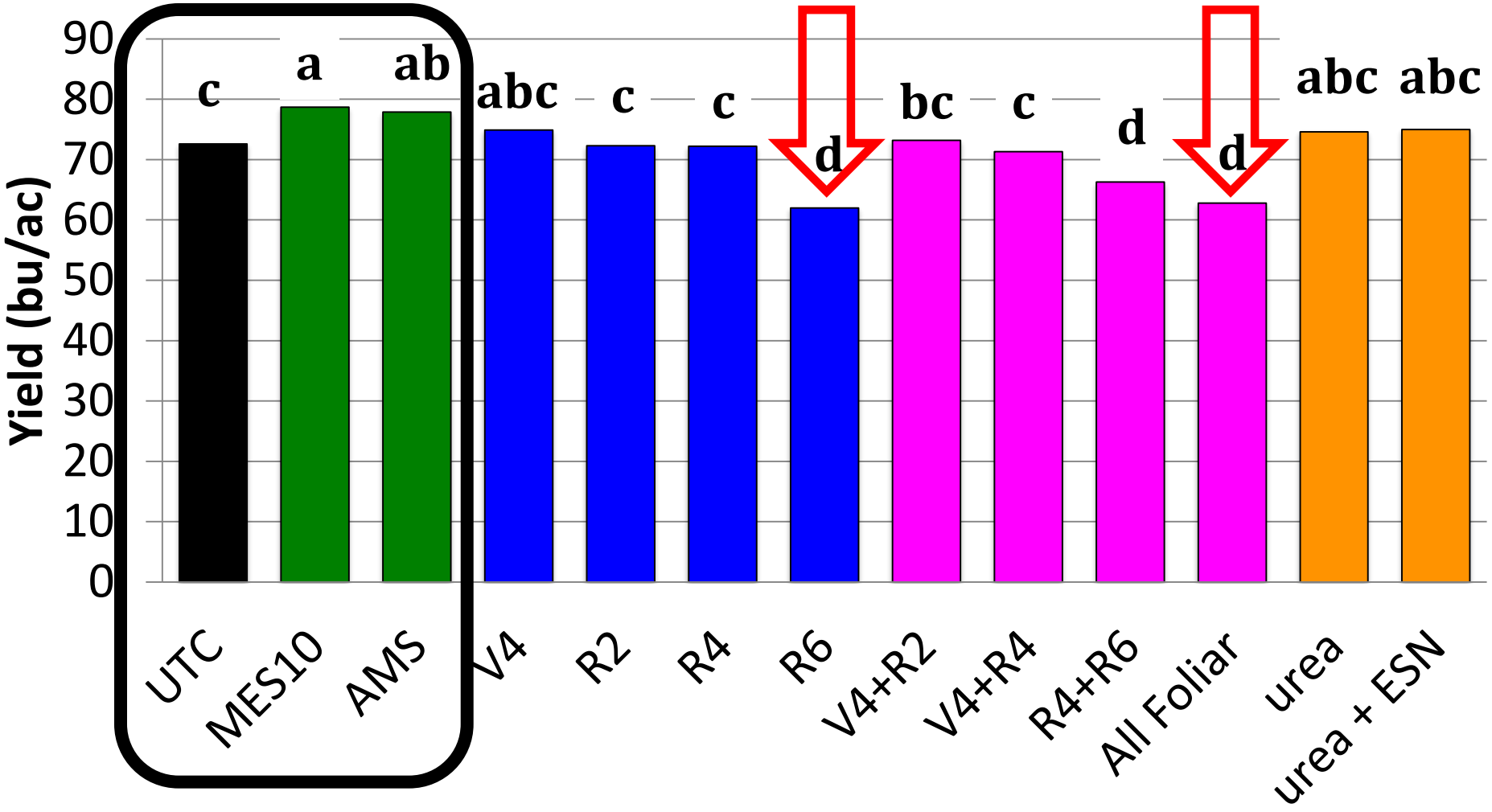
2016 Sulfur Season @ SWPAC

+ 6 bu with broadcast at V3



Fisher's Protected $LSD_{0.10}$

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2017 Sulfur Response

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No Sulfur

20 lb S/acre

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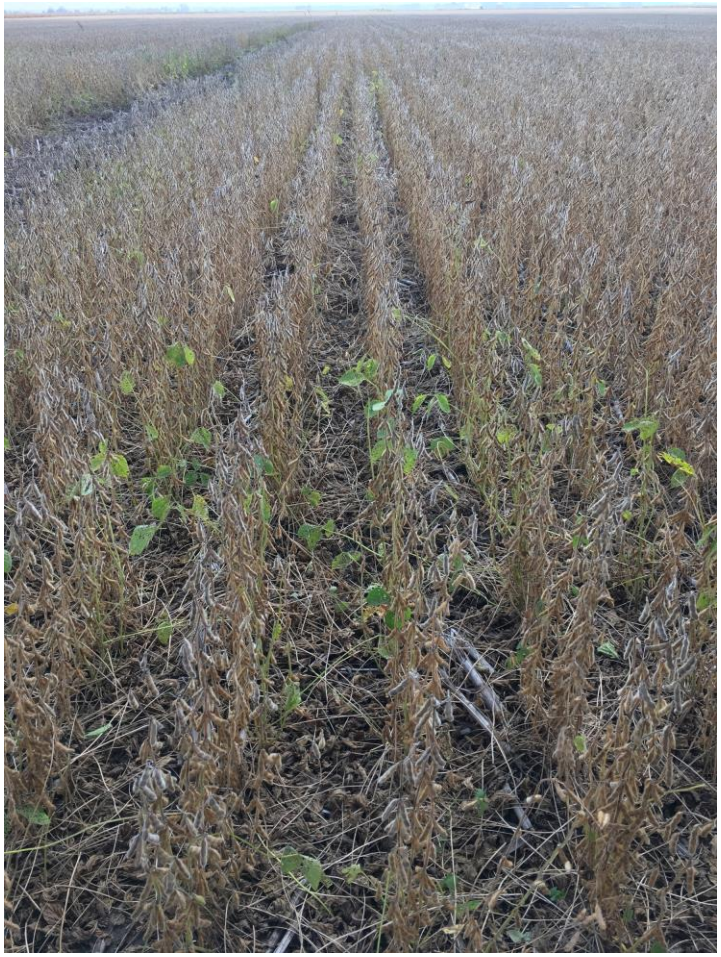
AMS 20 lb S
AMS:ES
UTC
LaCrosse, IN - 2017

No Sulfur



20 lb S/acre

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No Sulfur

31 pods
17 nodes
1 branch

20 lb S/acre

45 pods
18 nodes
2 branches

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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

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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

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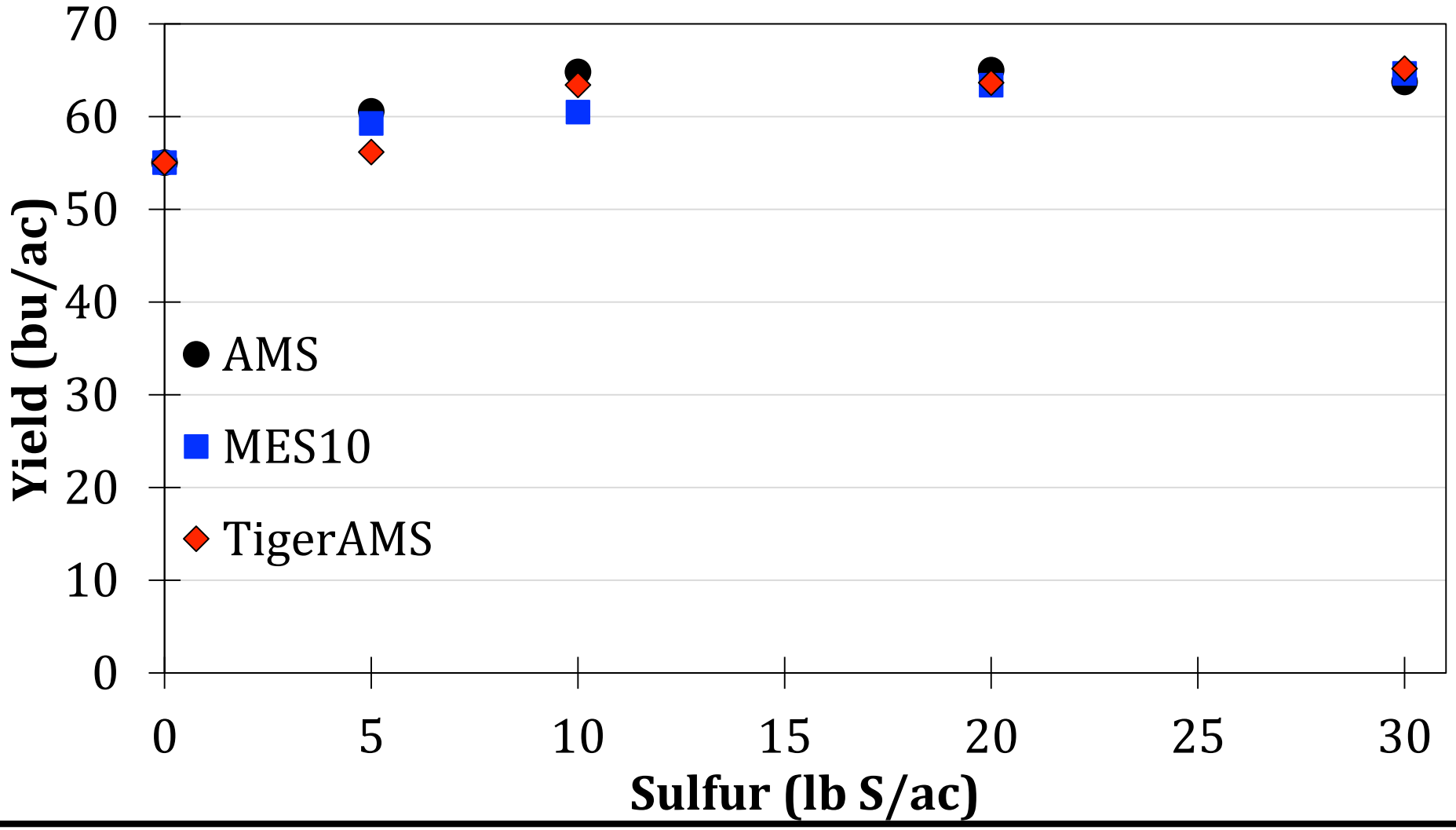
Sulfur Rate x Source: 2016-17



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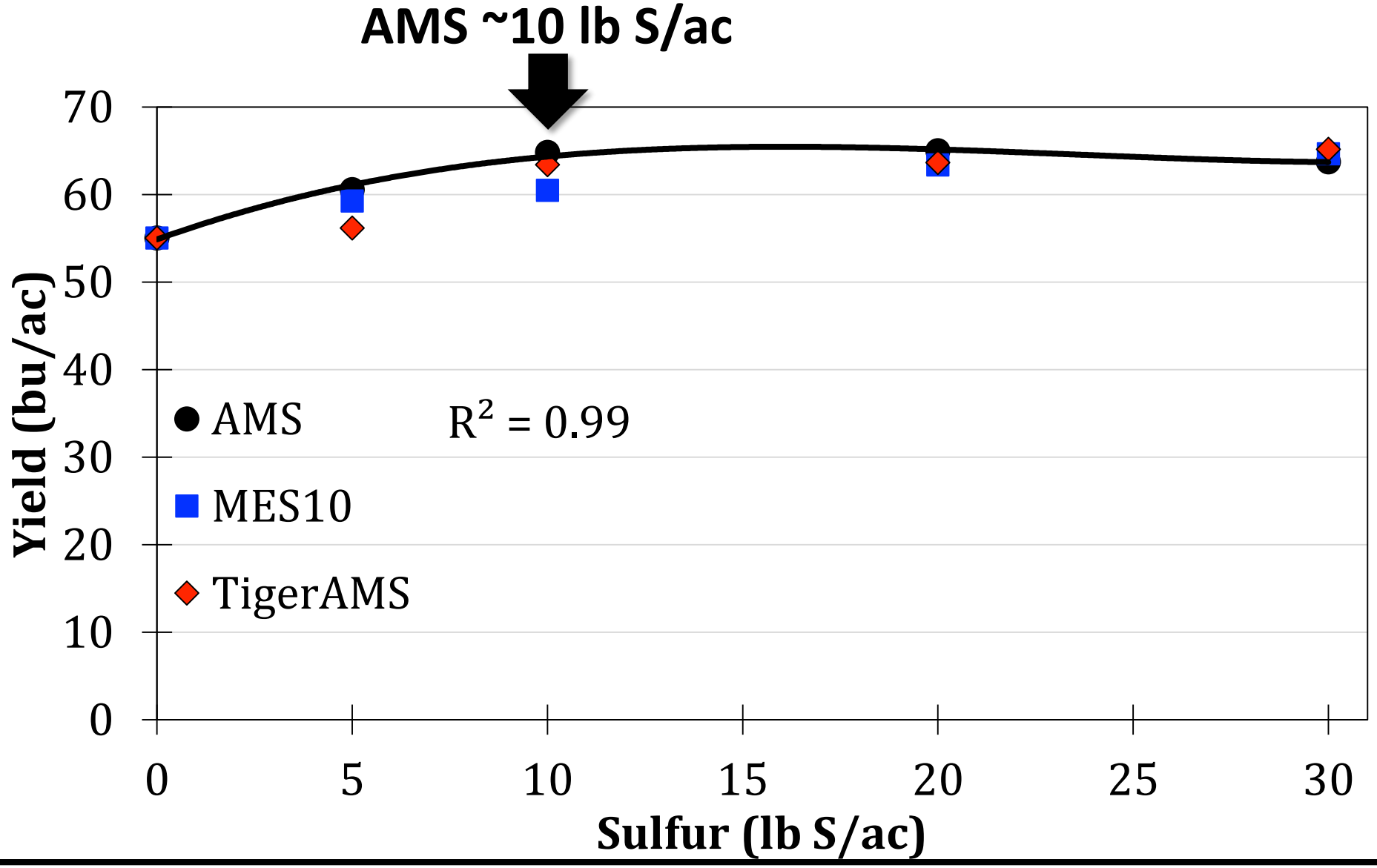
Sulfur Rate x Source: 2016-17



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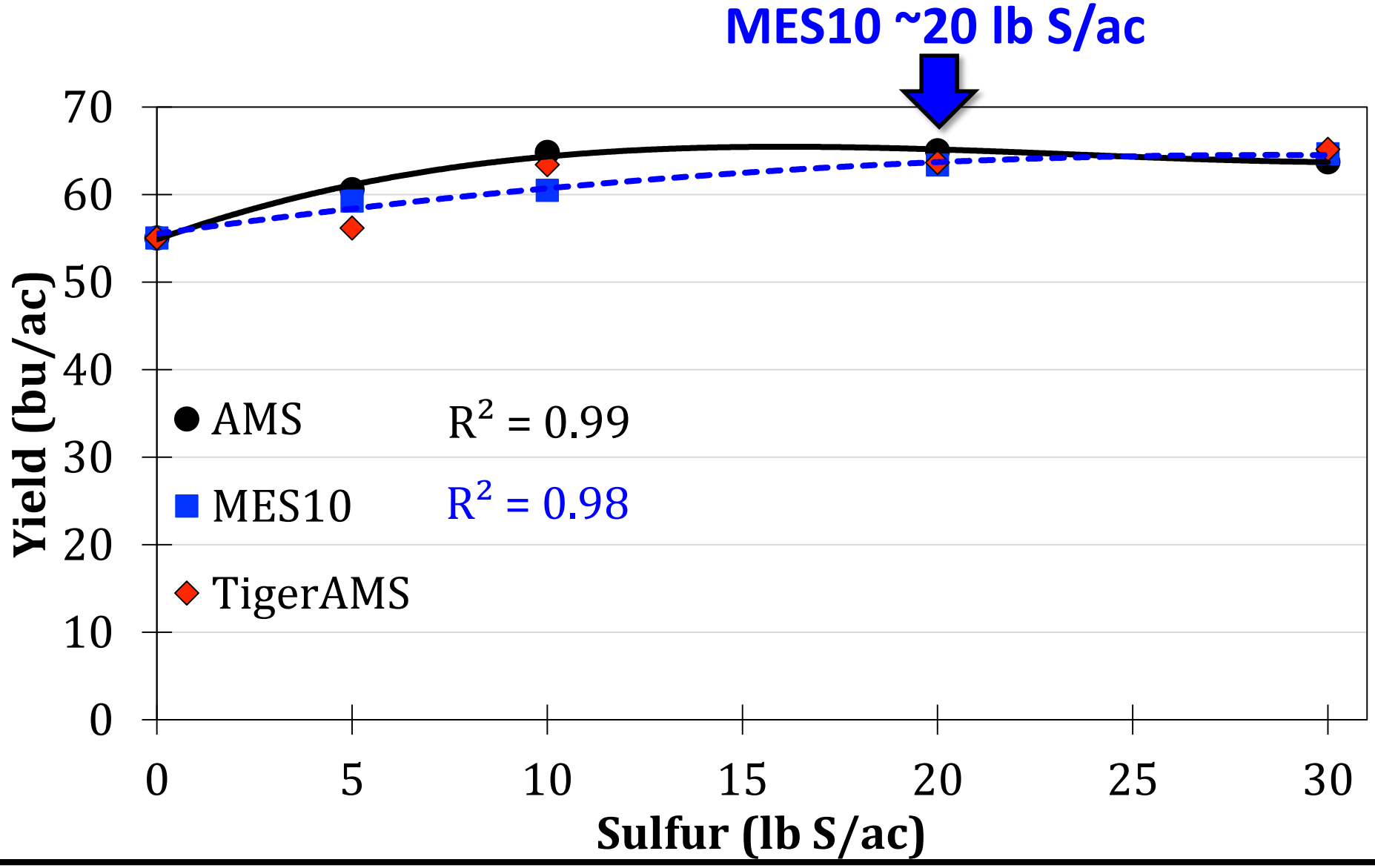
Sulfur Rate x Source: 2016-17



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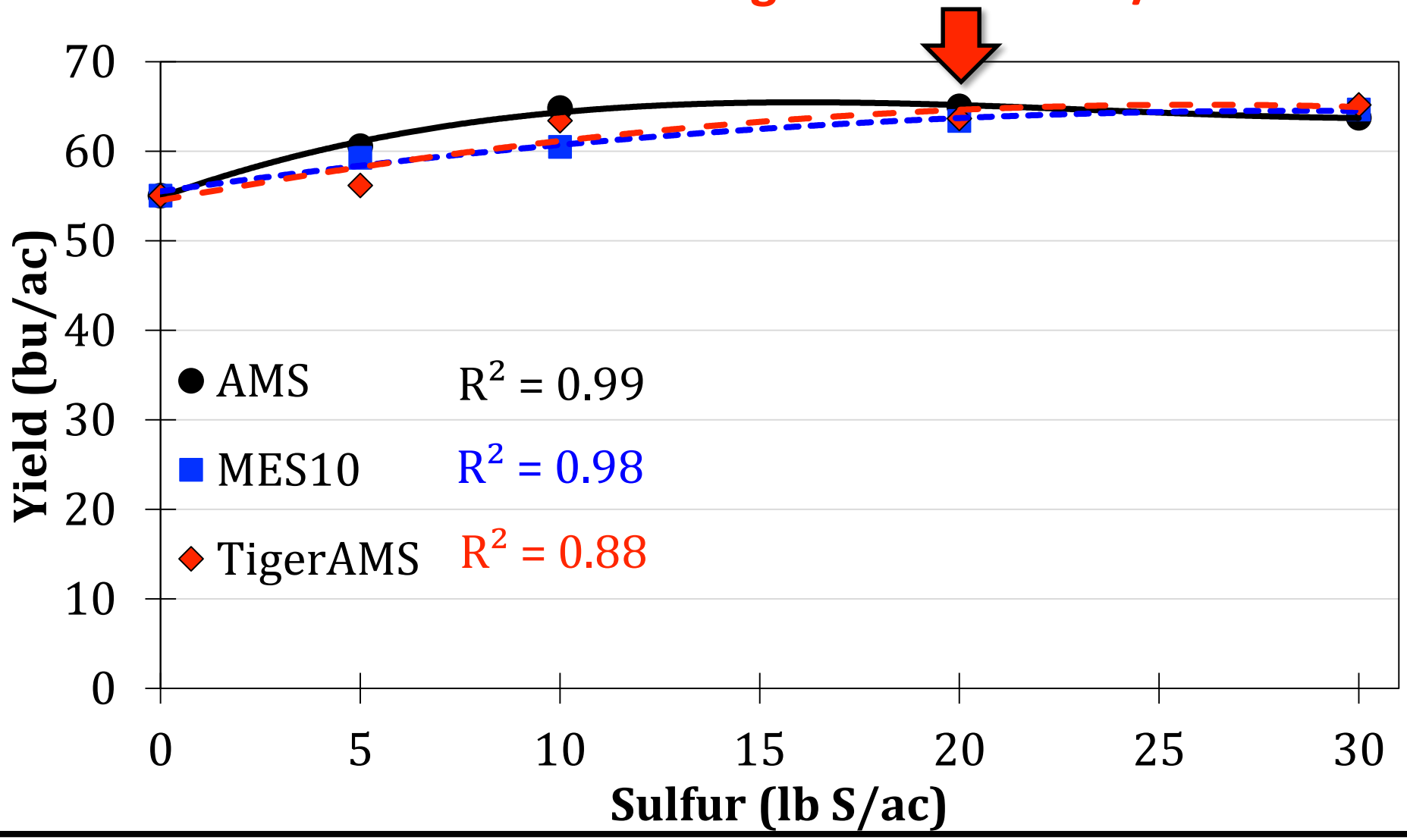
Sulfur Rate x Source: 2016-17



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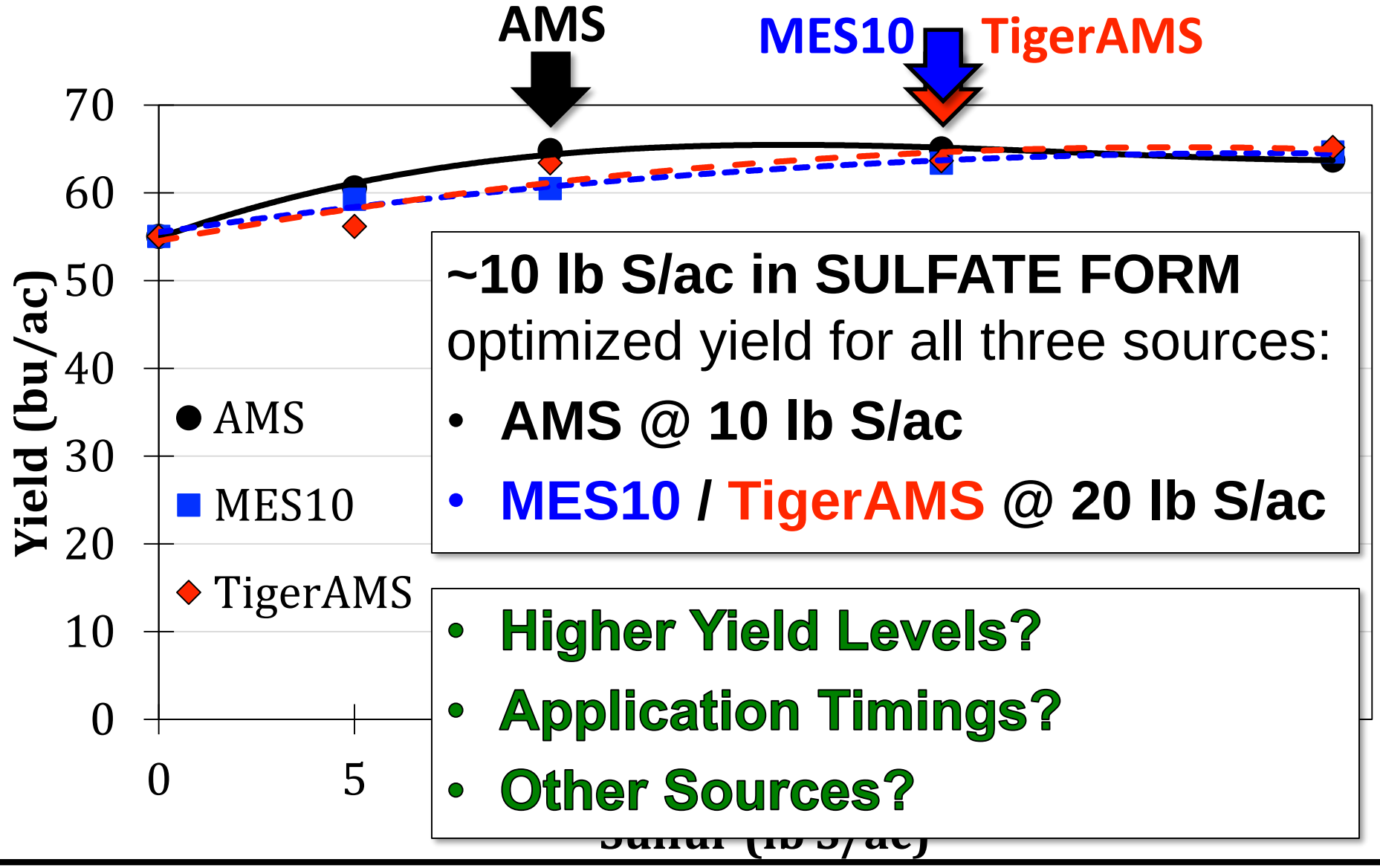
Sulfur Rate x Source: 2016-17



~10 lb S/ac in SULFATE FORM
optimized yield for all three sources:

- **AMS @ 10 lb S/ac**
- **MES10 / TigerAMS @ 20 lb S/ac**

- **Higher Yield Levels?**
- **Application Timings?**
- **Other Sources?**

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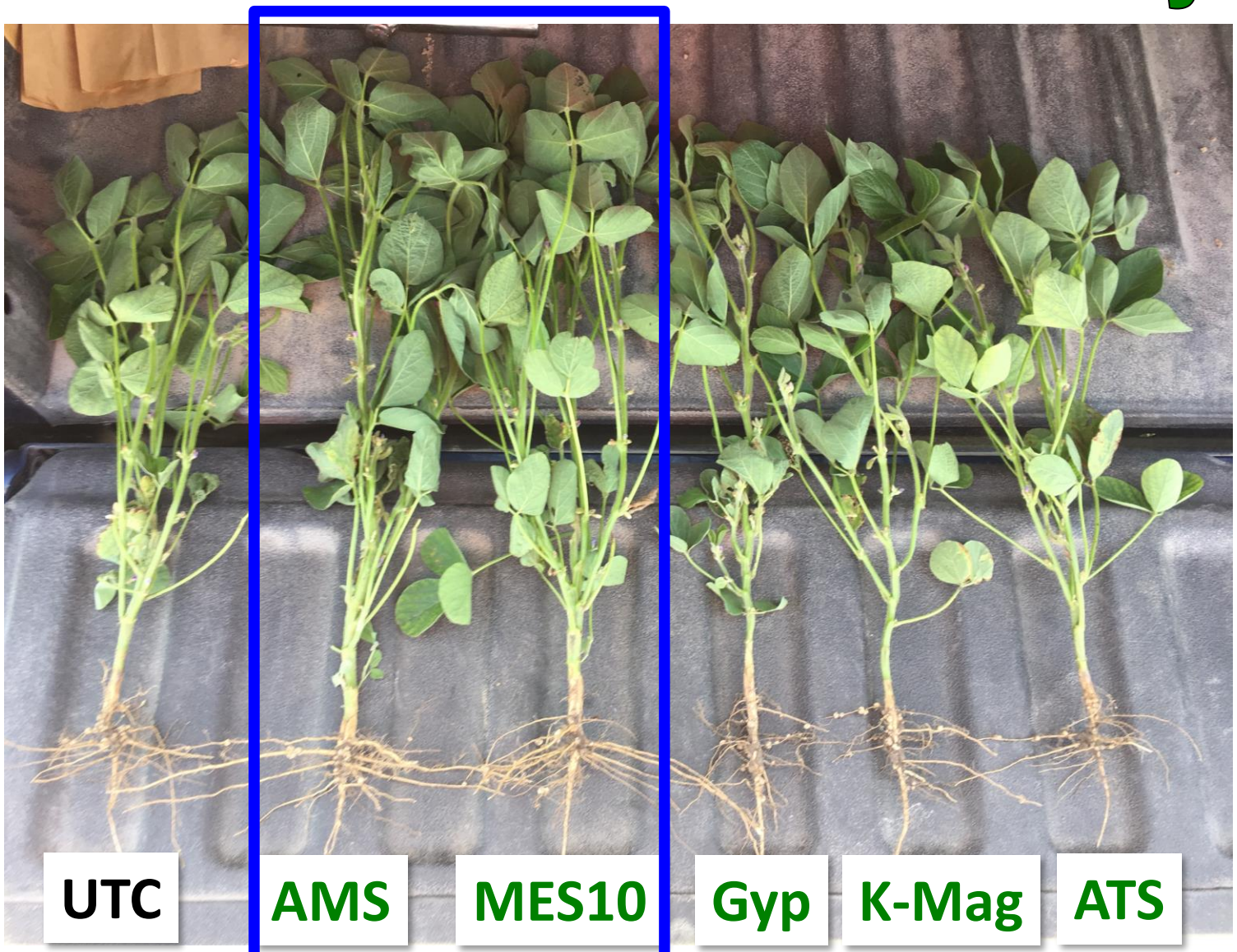
18 New Sulfur Sources: Early R3



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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

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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

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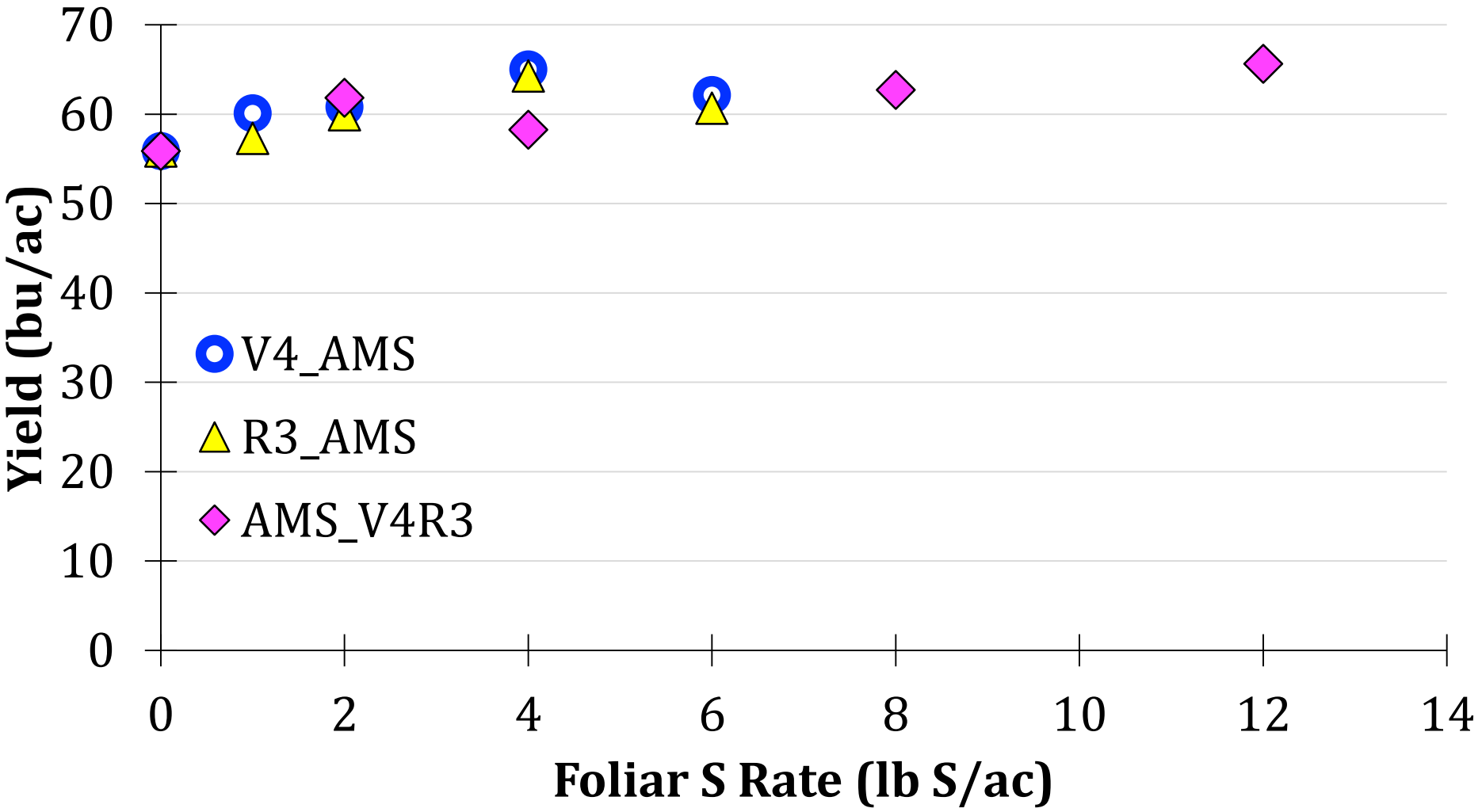
18 Foliar Sulfur Rate x Timing



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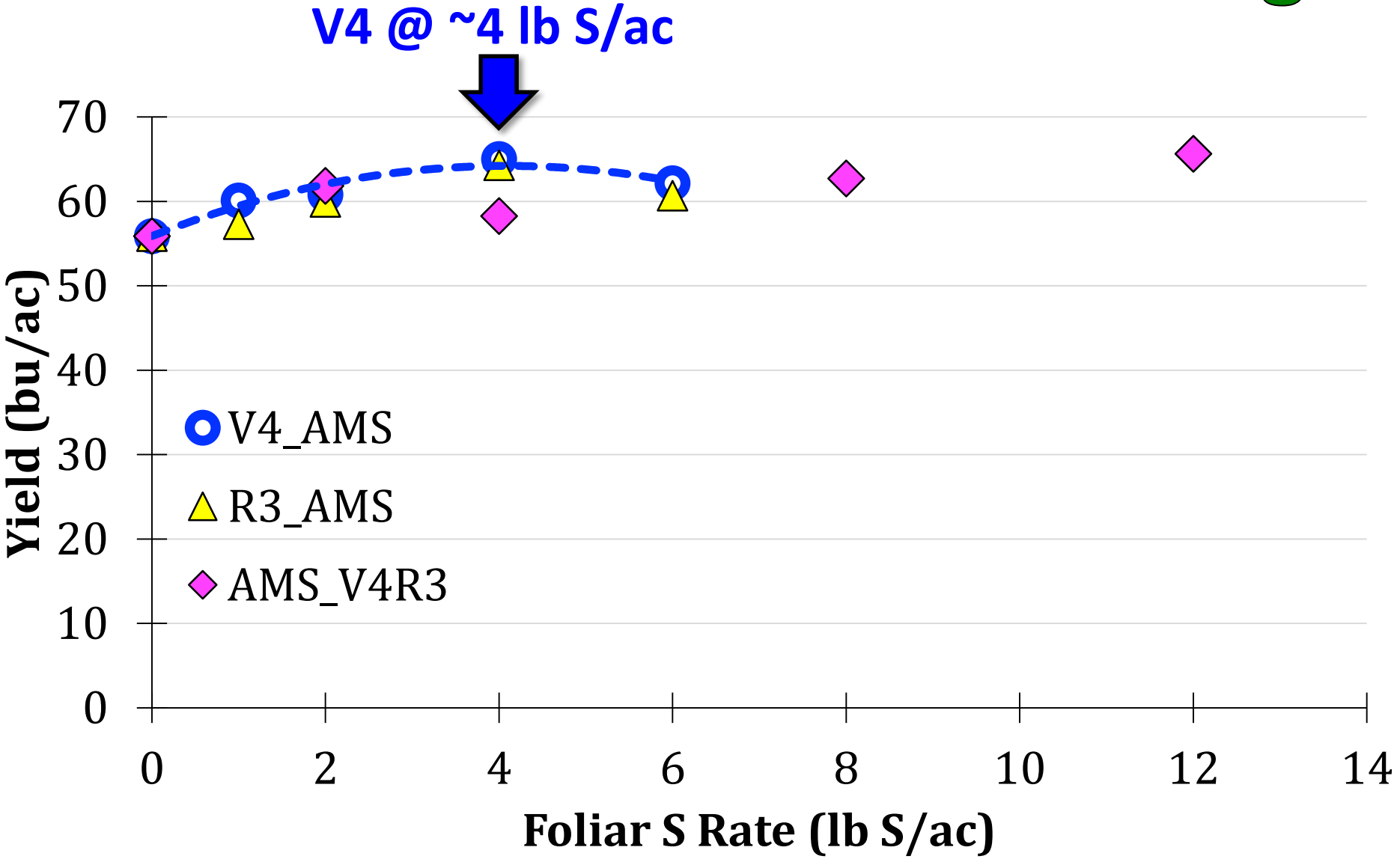
18 Foliar Sulfur Rate x Timing



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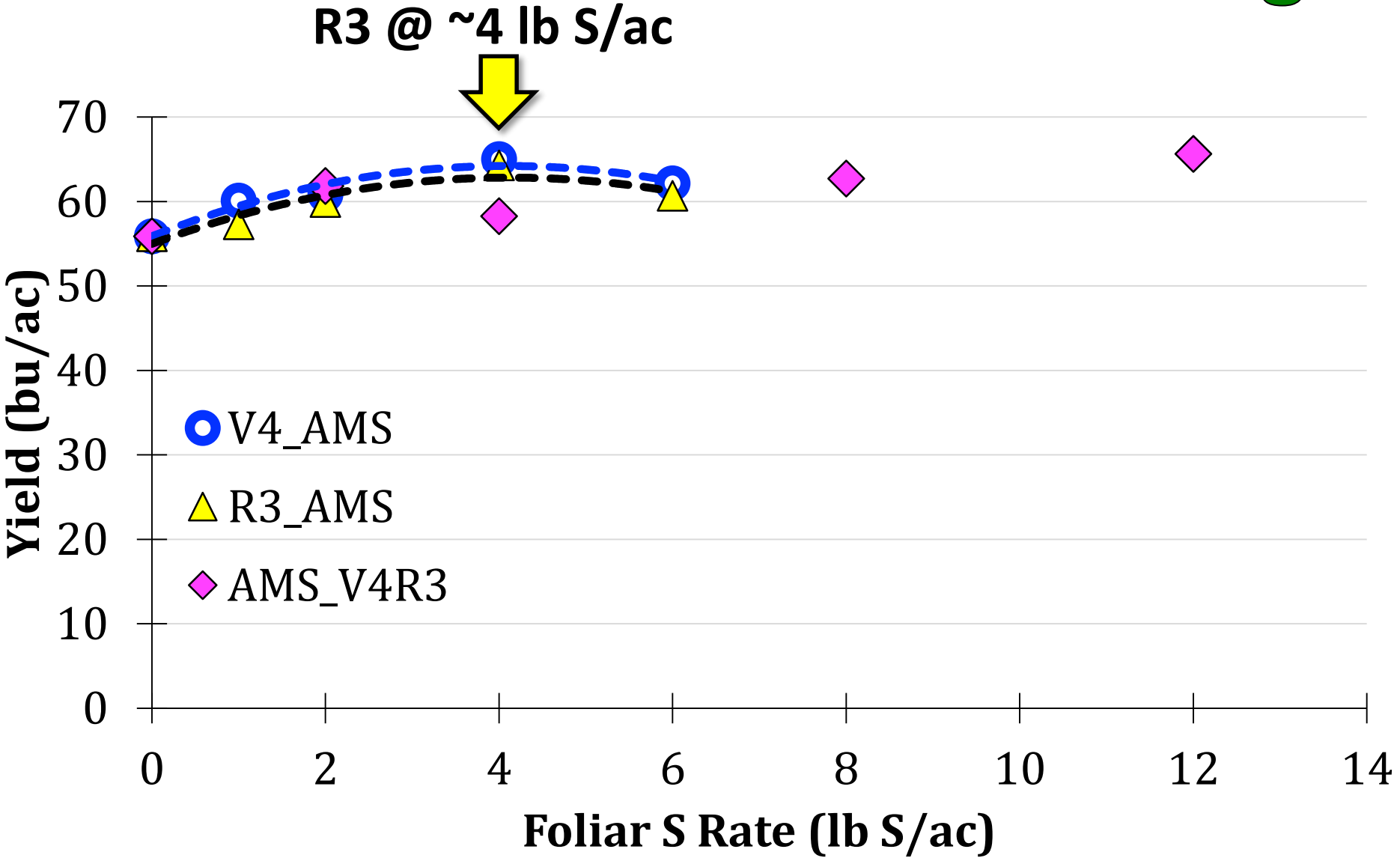
18 Foliar Sulfur Rate x Timing



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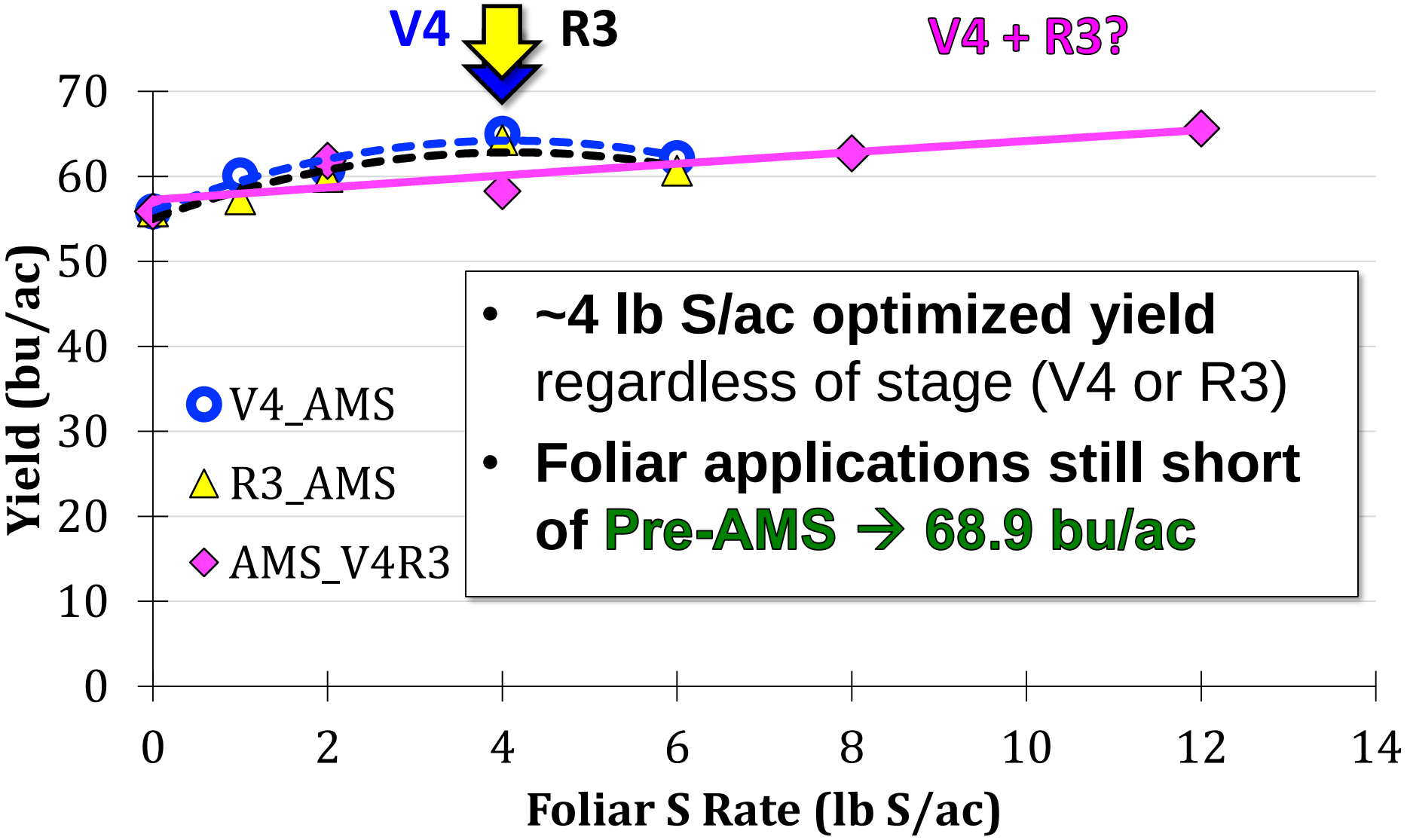
18 Foliar Sulfur Rate x Timing



- **~4 lb S/ac optimized yield** regardless of stage (V4 or R3)
- **Foliar applications still short of Pre-AMS → 68.9 bu/ac**

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Weather
Variety
Weeds Early
Intentional
Soybean
Management
Soil

TIMELY PLANTING of Soybeans

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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)

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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 11th, June 5th**
  - 10 N-S Based Treatments

Treatment	Timing	Nitrogen	Sulfur	May 11	June 5
		lb N/ac	lb S/ac	bu/ac	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

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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 25th**
  - 10 N-S Based Treatments

Treatment	Timing	Nitrogen	Sulfur	AG 24X7	AG 34X6
		lb N/ac	lb S/ac	bu/ac	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

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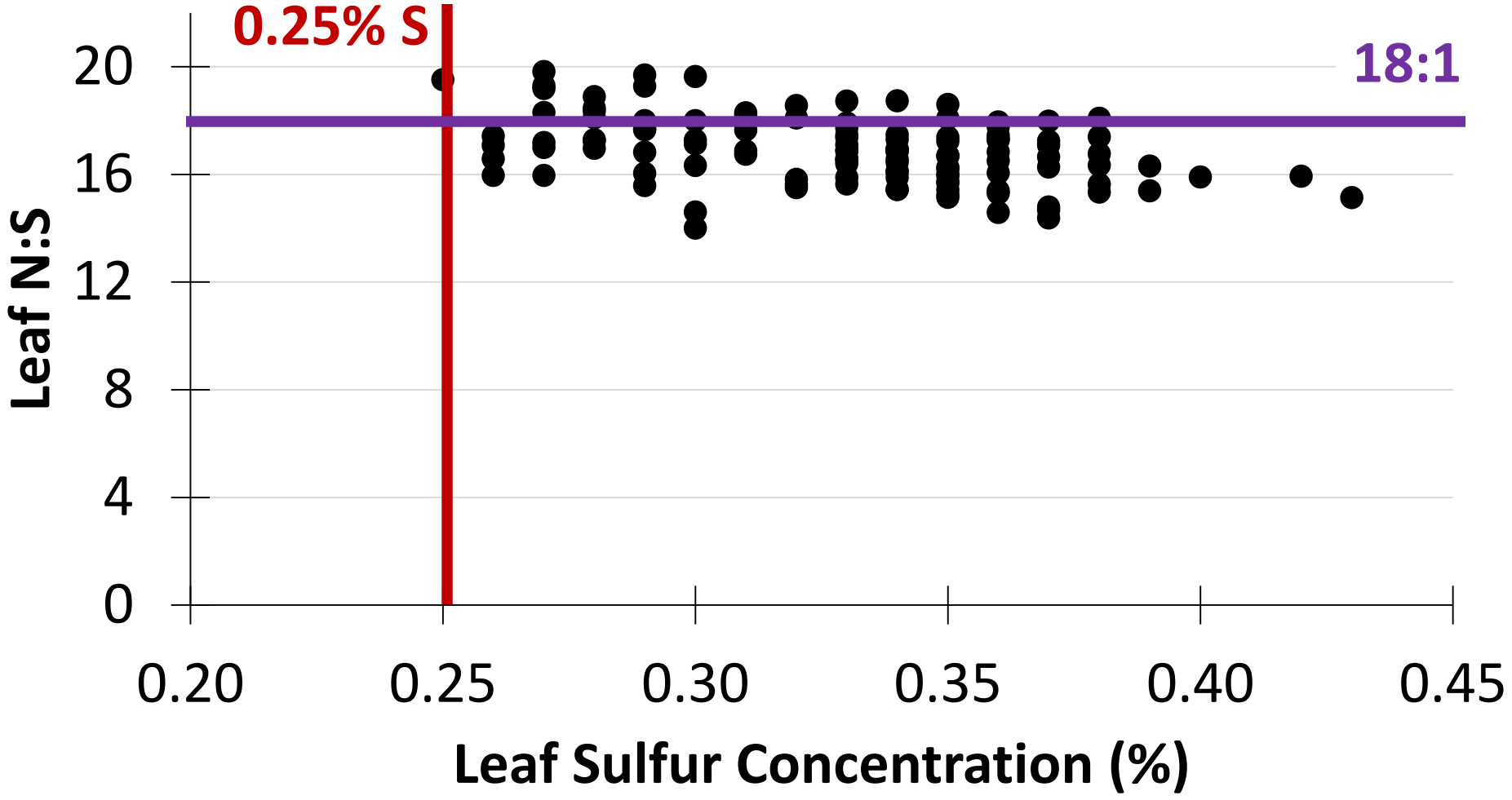
18 INField Advantage: Untreated Leaf Samples



2018 INFA > 100 fields

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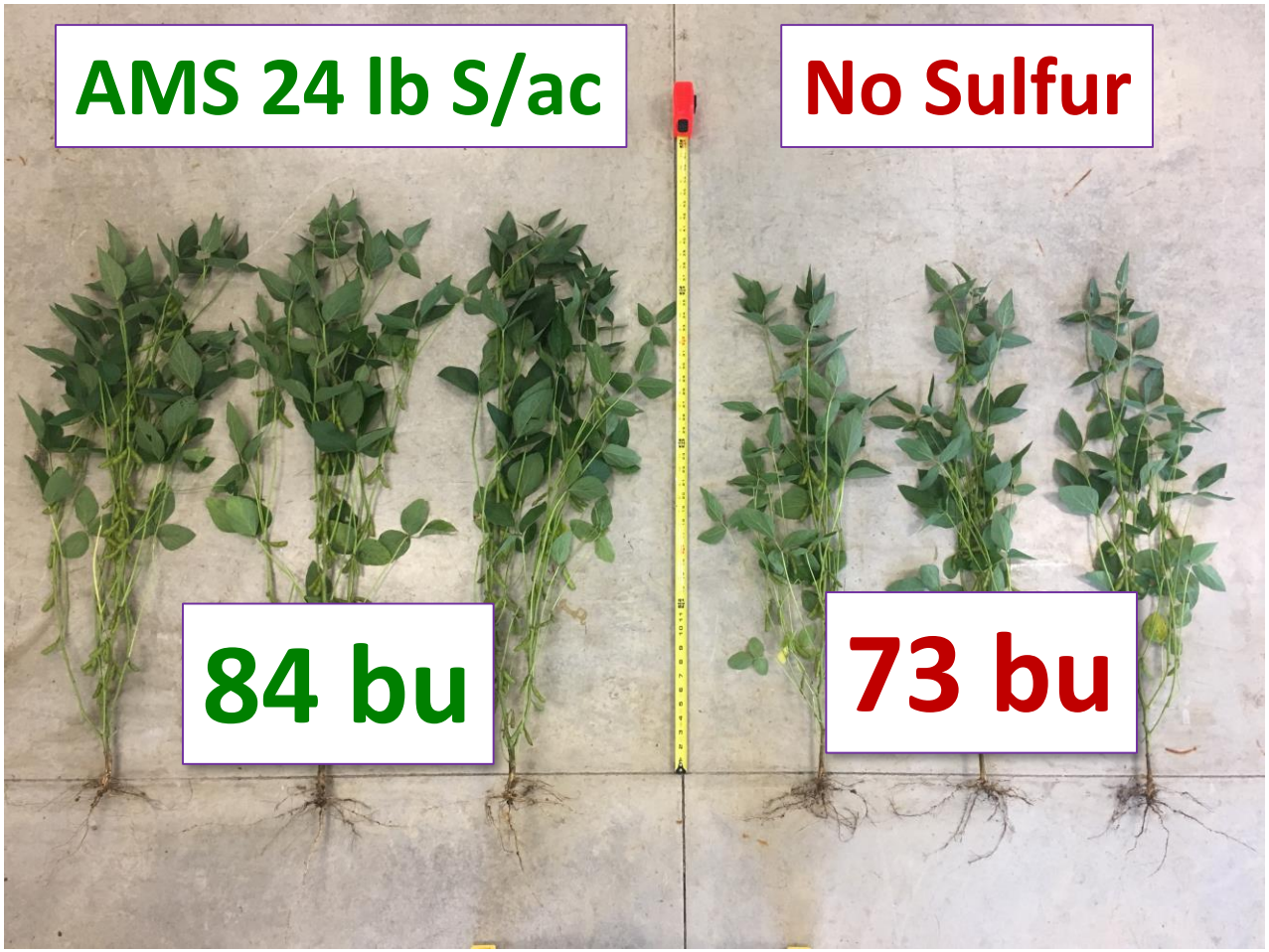
18 INFA Tipton



66 pods/plant
18.4 nodes

44 pods/plant
16.6 nodes

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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)

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Thanks for the support!

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QUESTIONS?

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