POLYHALITE FERTILIZATION IN CORN AND SOYBEAN

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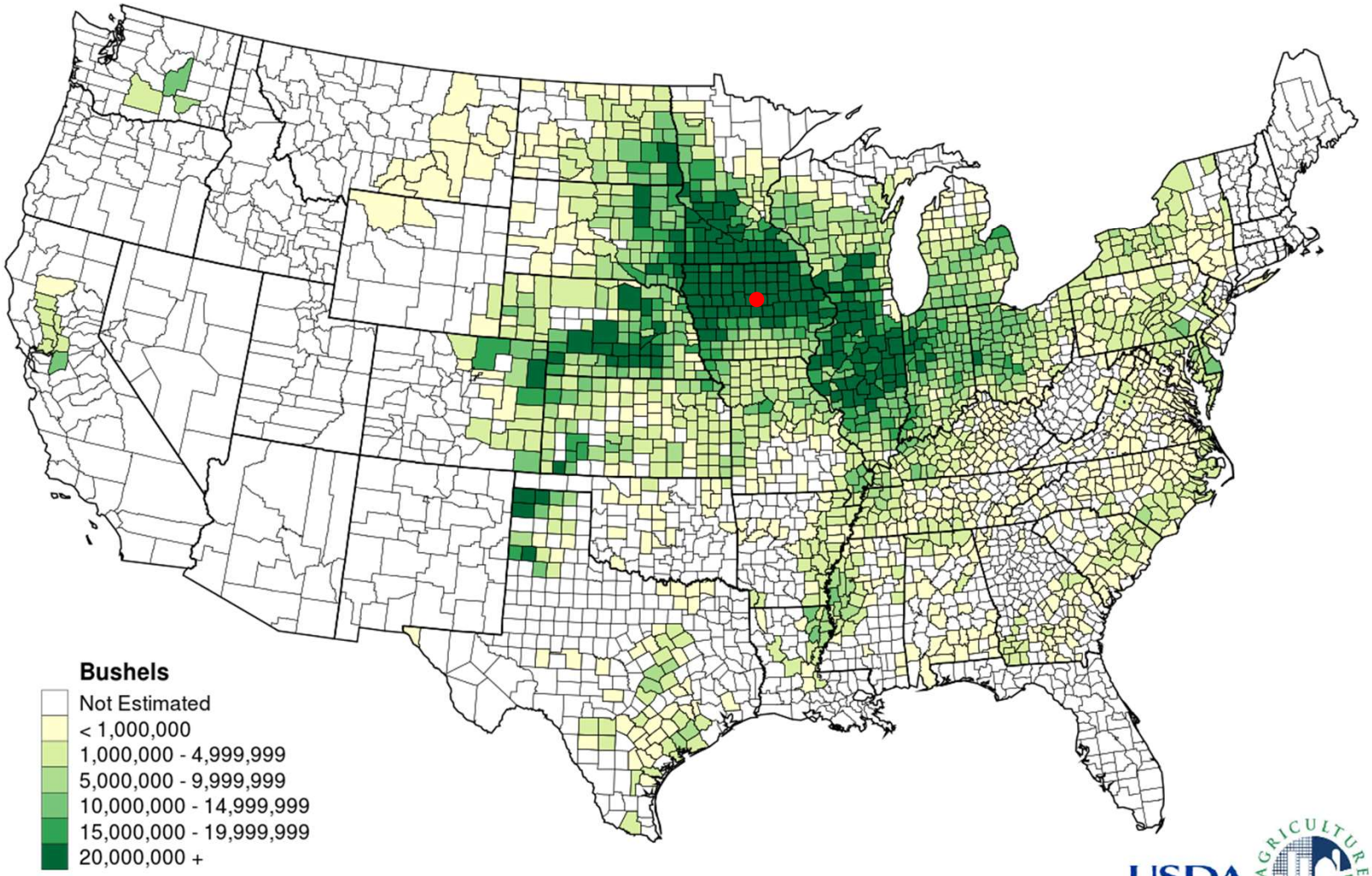
Corn for Grain 2010
Production by County
for Selected States



U.S. Department of Agriculture, National Agricultural Statistics Service

SULFUR FERTILIZER IN U.S. CORN BELT:

- Historically, farmers did not apply S fertilizer.

SULFUR FERTILIZER IN U.S. CORN BELT:

Sulfur fertilizer rate trials

- Prior to 2005:
  - 3/200 (1.5%) had positive yield response

SULFUR FERTILIZER IN U.S. CORN BELT:

Sulfur fertilizer rate trials

- Prior to 2005:
  - 3/200 (1.5%) had positive yield response
- **After 2005:**
  - **40% of corn trials had positive yield response**
  - **15% of soybean trials had positive yield response**

SULFUR FERTILIZER IN U.S. CORN BELT:

- Now almost all farmers apply S fertilizer.

SULFUR FERTILIZER IN U.S. CORN BELT:

- Two questions:
- **Why more response?**
- **Why variable response?**

SULFUR FERTILIZER IN U.S. CORN BELT:

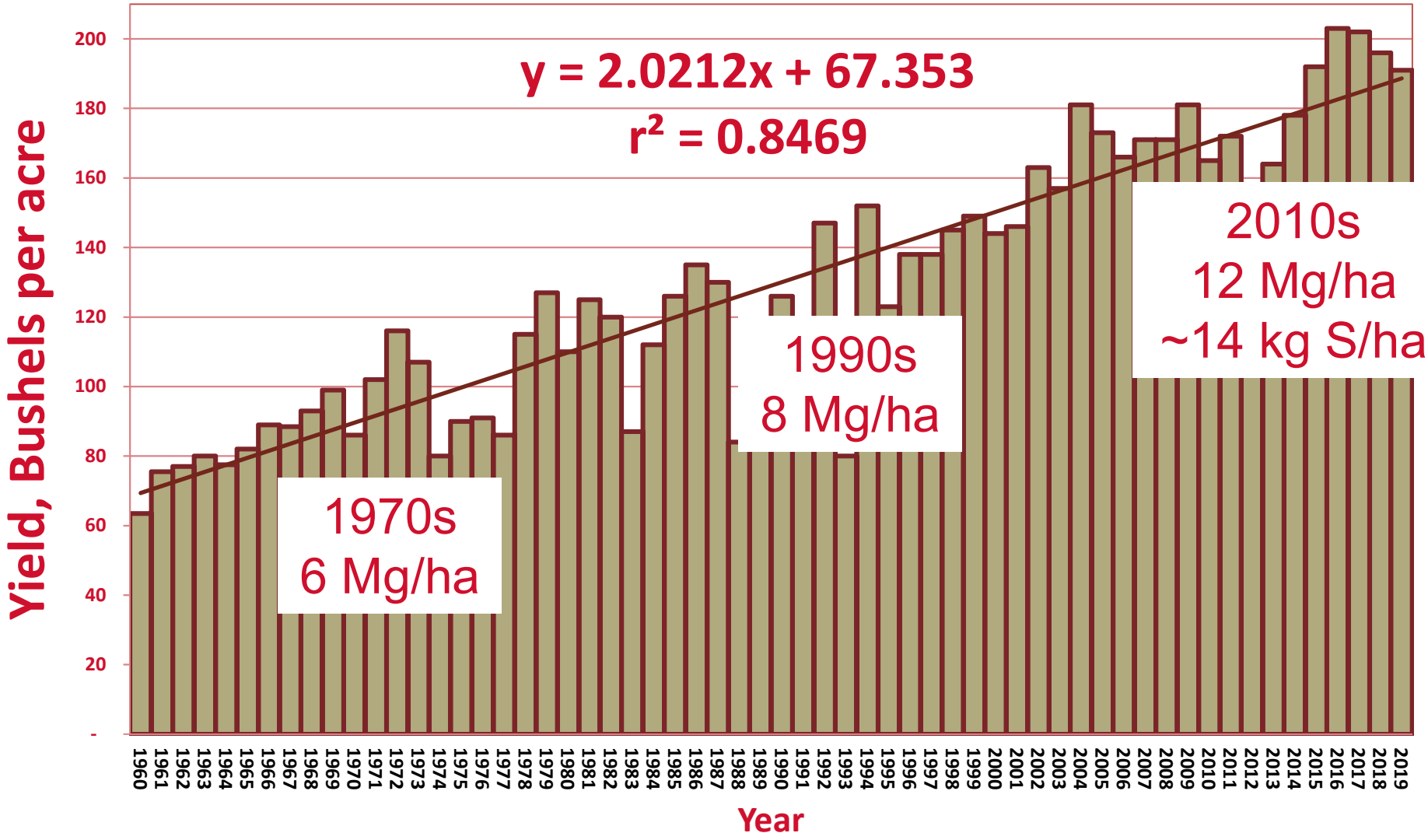
Why more response?

SULFUR FERTILIZER IN U.S. CORN BELT:

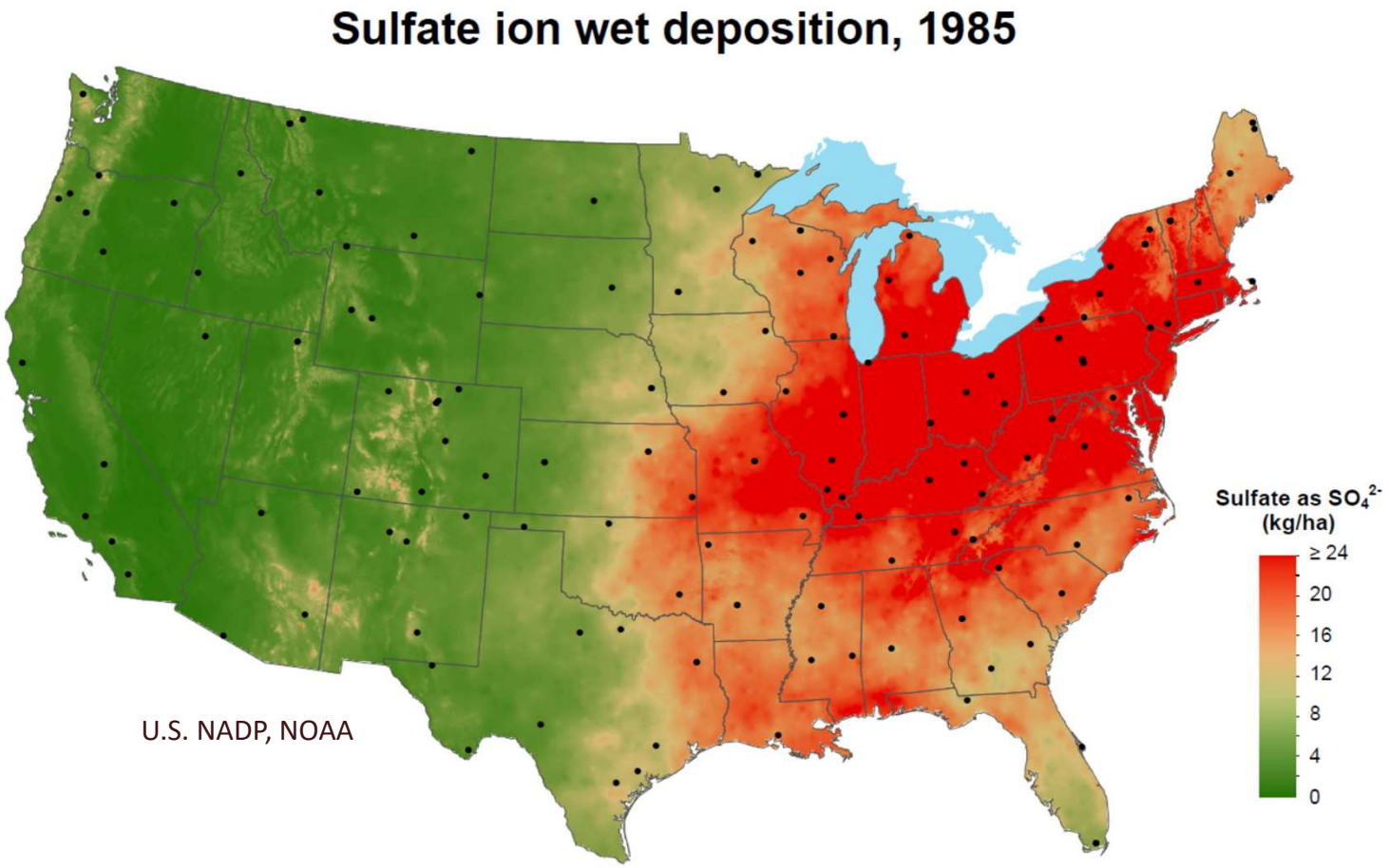
Why more response?

3 reasons

1. MORE SULFUR IS HARVESTED:



2. LESS SULFUR IN ATMOSPHERIC DEPOSITION:

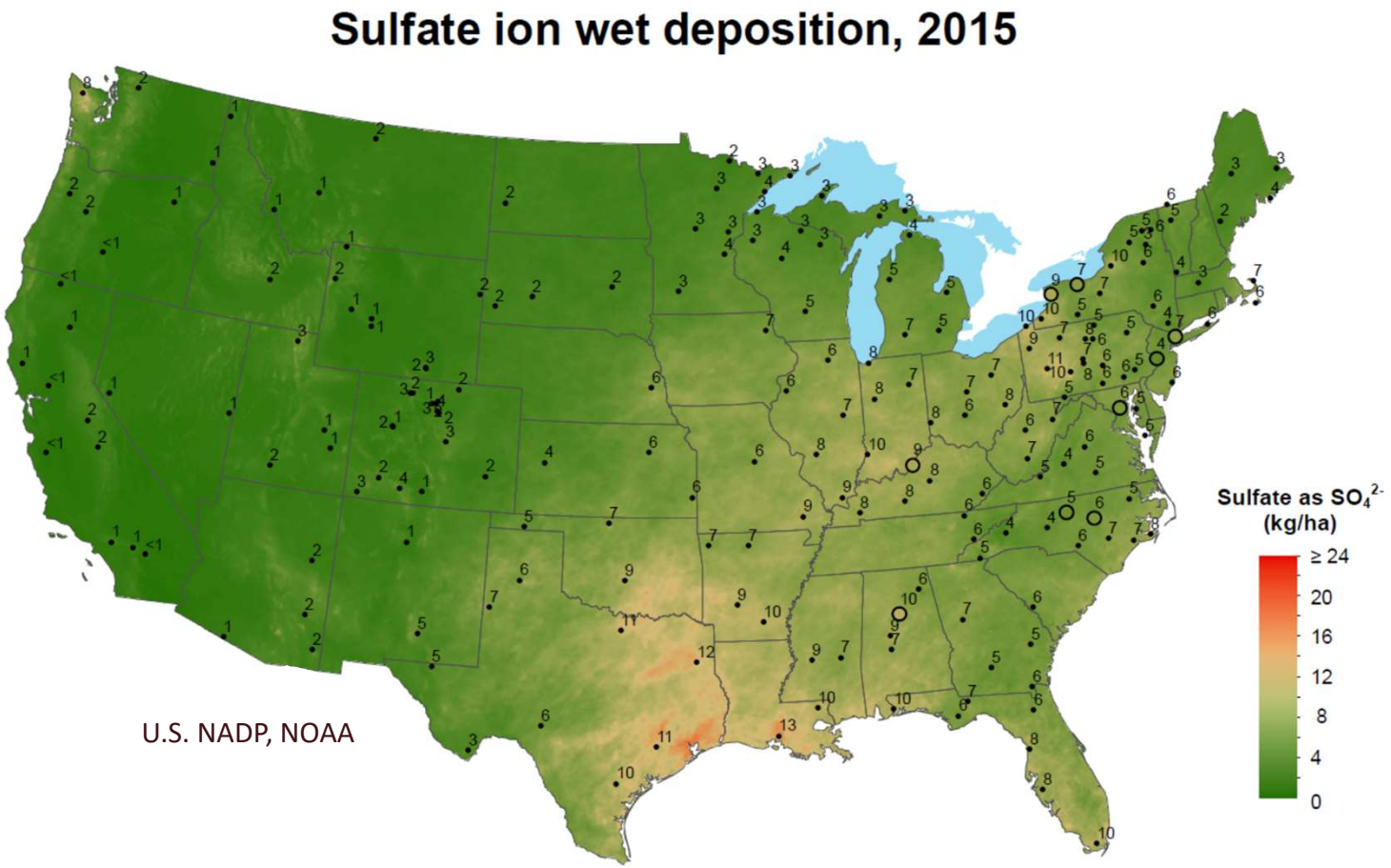


>5 kg S ha^{-1}

Corn grain = 0.12% S

Soybean = 0.33% S

2. LESS SULFUR IN ATMOSPHERIC DEPOSITION:



< 2 kg S ha^{-1}

Corn grain = 0.12% S

Soybean = 0.33% S

3. LESS CROPLAND RECEIVES MANURE

SUMMARY:
WHY WE REQUIRE MORE SULFUR:

- **Outputs** are higher:
  - Greater crop yield.
- **Inputs** are lower:
  - Less atmospheric deposition.
  - Less cropland receiving manure.

SULFUR FERTILIZER IN U.S. CORN BELT:

Why the variable response?

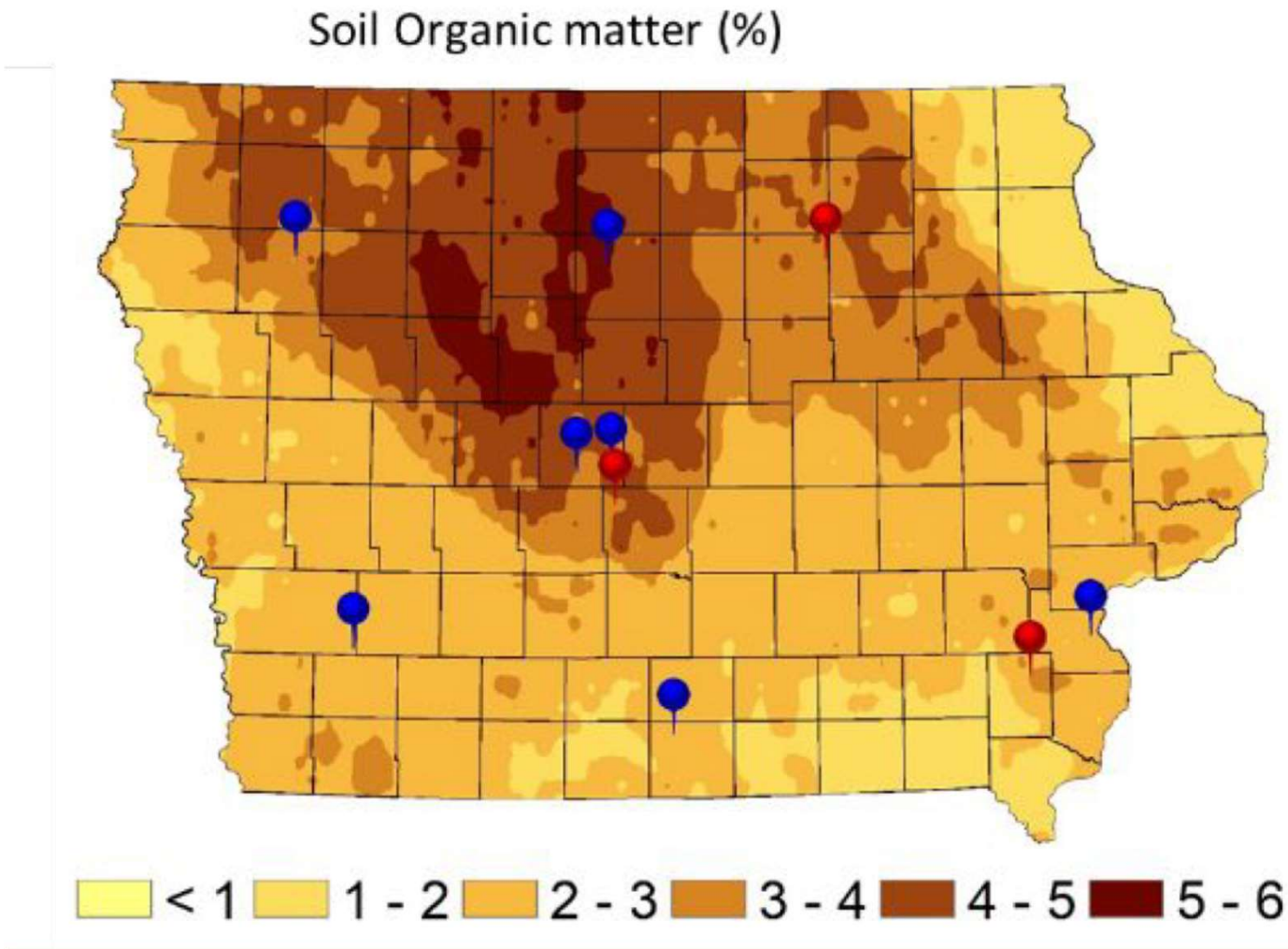
SULFUR FERTILIZER IN U.S. CORN BELT:

Why the variable response?

2 reasons

(subject of this research)

1. VARIABILITY IN SOIL SULFUR SUPPLY: ORGANIC MATTER MINERALIZATION



2. VARIABILITY IN SOIL SULFUR FERTILIZER SOURCE: DISSOLUTION/ MINERALIZATION

- Ammonium Sulfate $(NH_4)_2SO_4$
- Gypsum $(CaSO_4)$
- Polyhalite $K_2Ca_2Mg(SO_4)_4$
- Elemental S (requires microbial oxidation)

SUMMARY:
WHY CROP RESPONSE IS VARIABLE:

Focus of this research

1. **Soil organic matter:** more than enough S for crop, but, in many places or years, S mineralization is too low to meet crop demand.
2. **Sulfur fertilizer source*:*** different sources have dissolution/mineralization kinetics

METHODS

- >20 site-years (2017 + 2018)
- Two crops (maize + soybean)
- Two soils (high OM + low OM)
- Four S sources + zero-S control
  - $(NH_4)_2SO_4$;
  - $CaSO_4$,
  - Polyhalite,
  - Elemental

METHODS (CONTINUED)

- Low rate of S application to maximize potential to observe fertilizer source effect
  - Low OM, sandy soils = 15 kg S ha^{-1}
  - High OM, loamy soils = 10 kg S ha^{-1}
- Other nutrients in fertilizers were equalized to control for S-response
- Lab experiment to measure dissolution/ mineralization kinetics

METHODS

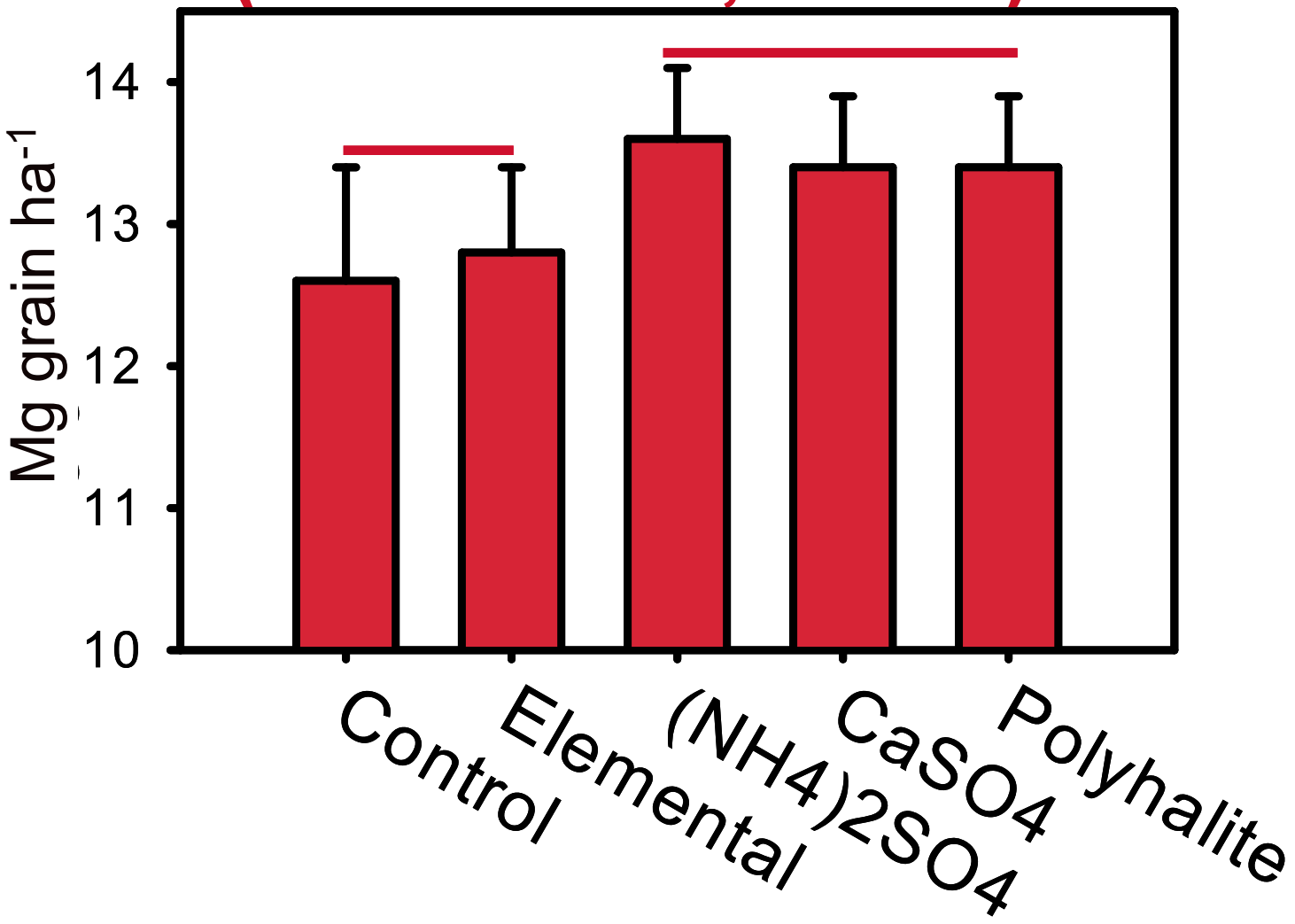
Responses:

- **New sites**: S applied before crop planting
  - ~1 month before planting
- '**Residual sites**': S applied to the previous crop
  - 18 months and one full crop cycle (i.e. harvest) before we measured the effect of S on 2nd crop since S application

RESULTS HIGHLIGHTS

- New Sites: significant positive effect of *sulfate-based* S fertilizers on maize yield.

NEW MAIZE SITES (2017 & 2018; N = 12):



NEW MAIZE SITES (2017 & 2018; N = 12):

- Sulfate-based fertilizers:
  - +0.88 Mg ha^{-1} vs. control
  - +0.74 Mg ha^{-1} vs. elemental
- Elemental no different than control
- No difference across SO_4-based fertilizers

RESULTS HIGHLIGHTS

- Soybean generally did not respond to S source.

RESULTS HIGHLIGHTS

- No consistent effect of soil-type

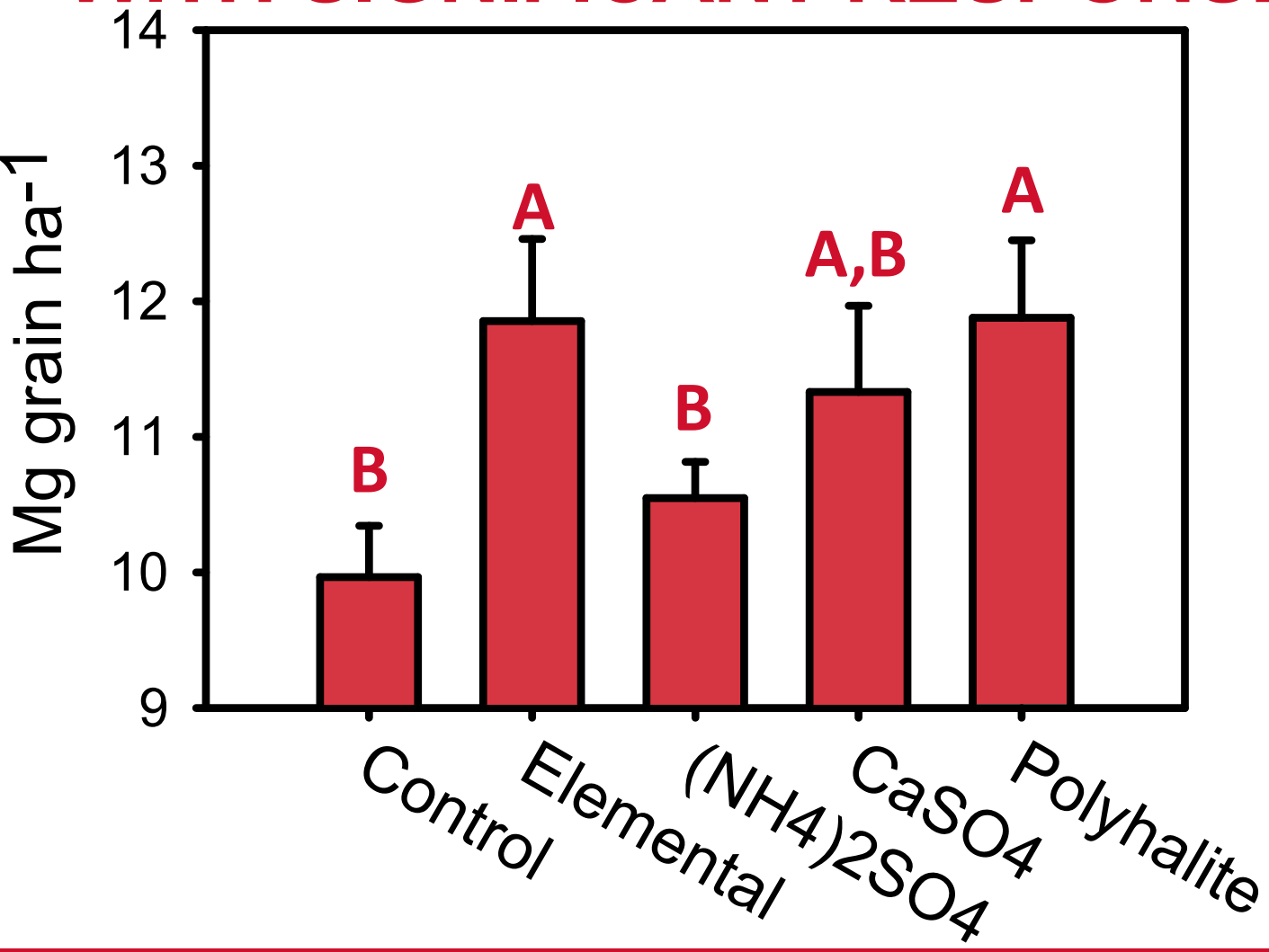
RESULTS HIGHLIGHTS

- Residual Sites:
  - 1/6 with a *significant* response to sulfur fertilizer
  - *but, remember we used a very low S rate*

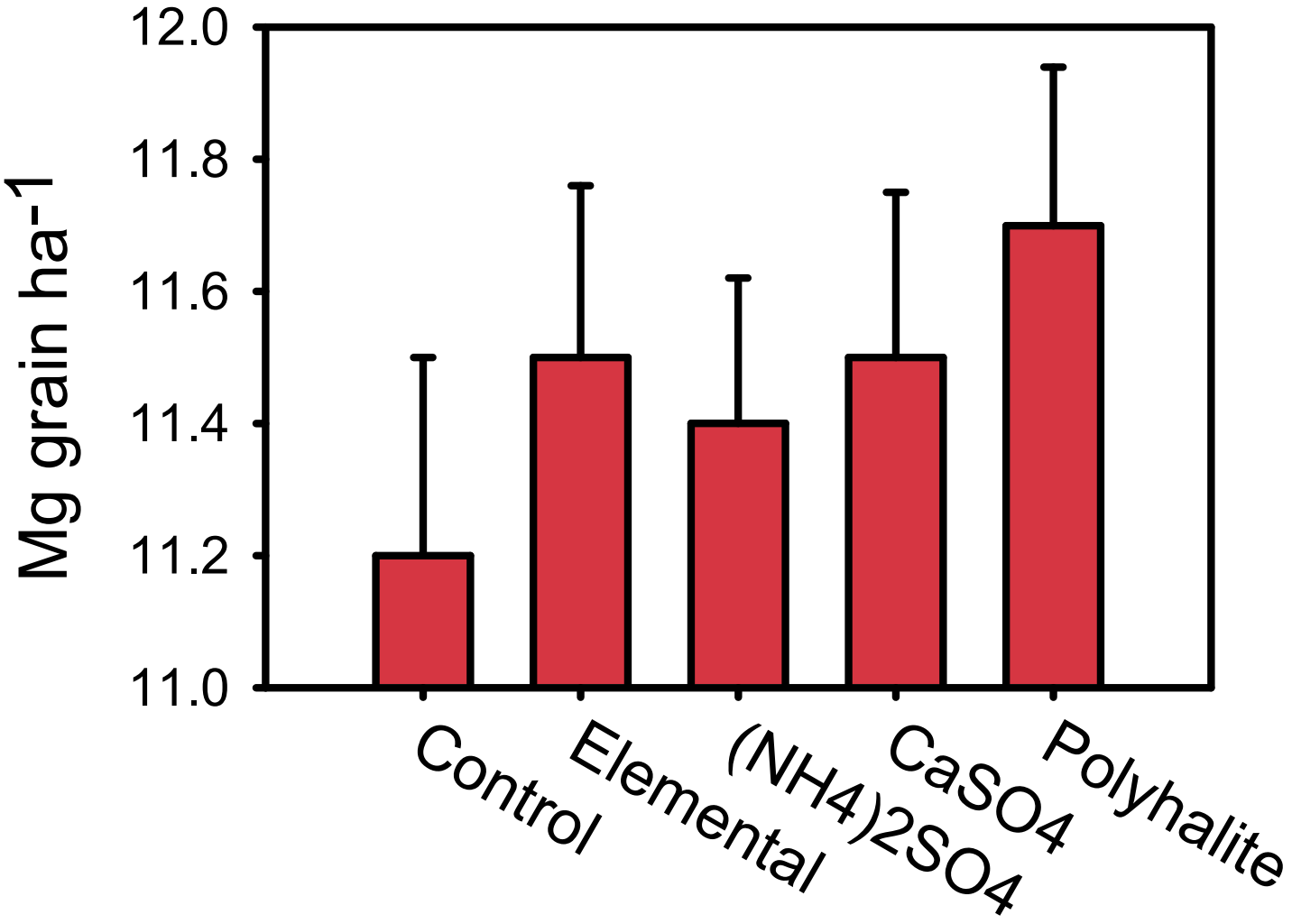
Yield:

- Polyhalite, $CaSO_4$ and Elemental > $(NH_4)_2SO_4$ and Zero-S

RESIDUAL MAIZE SITE WITH SIGNIFICANT RESPONSE

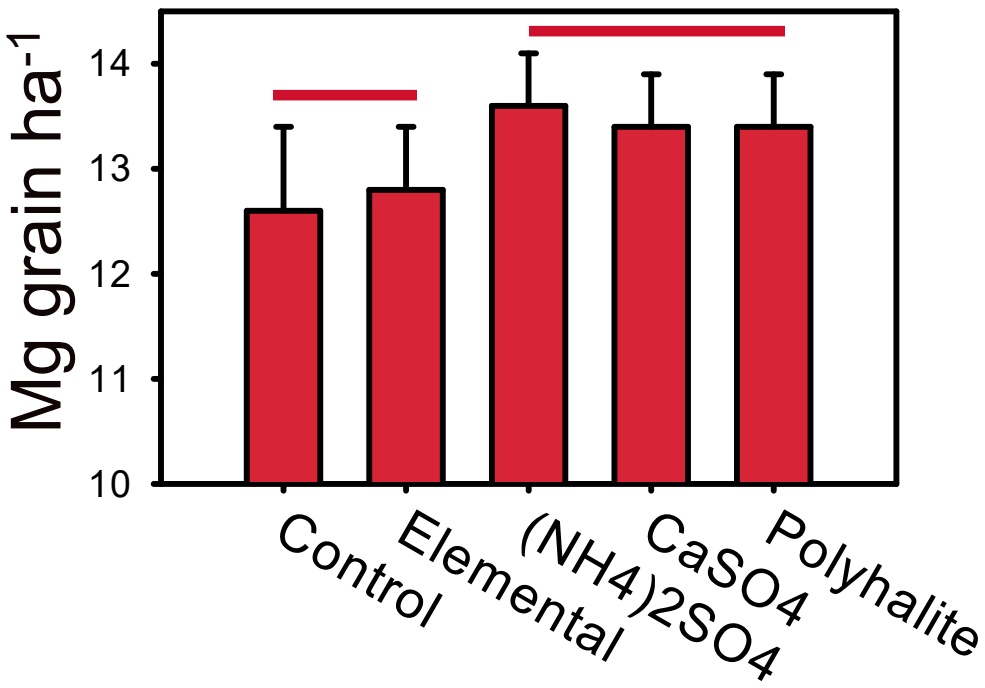


ALL RESIDUAL MAIZE SITES (N = 6)

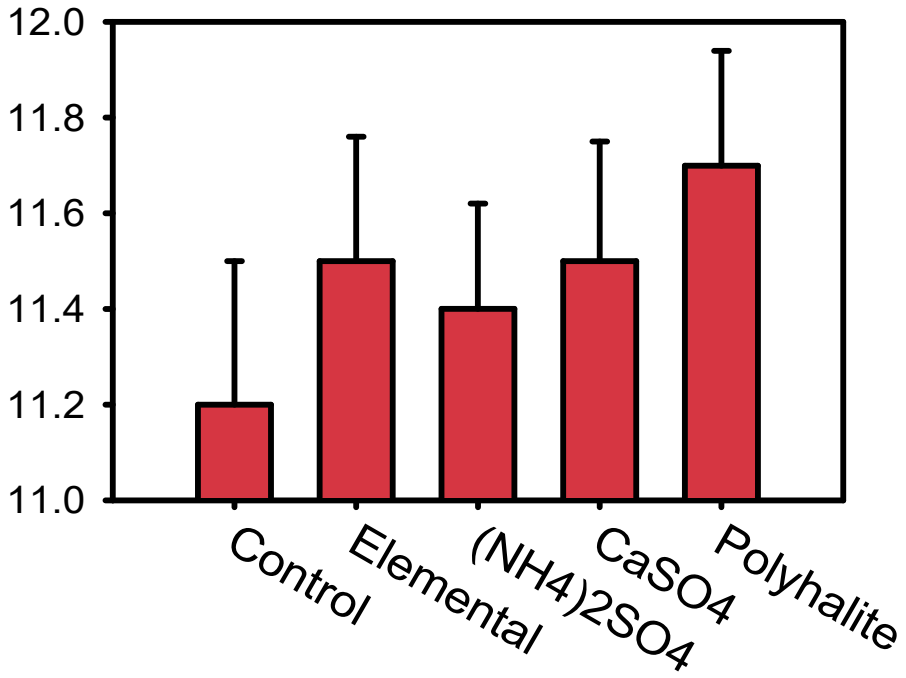


FIRST VS. RESIDUAL YEAR:

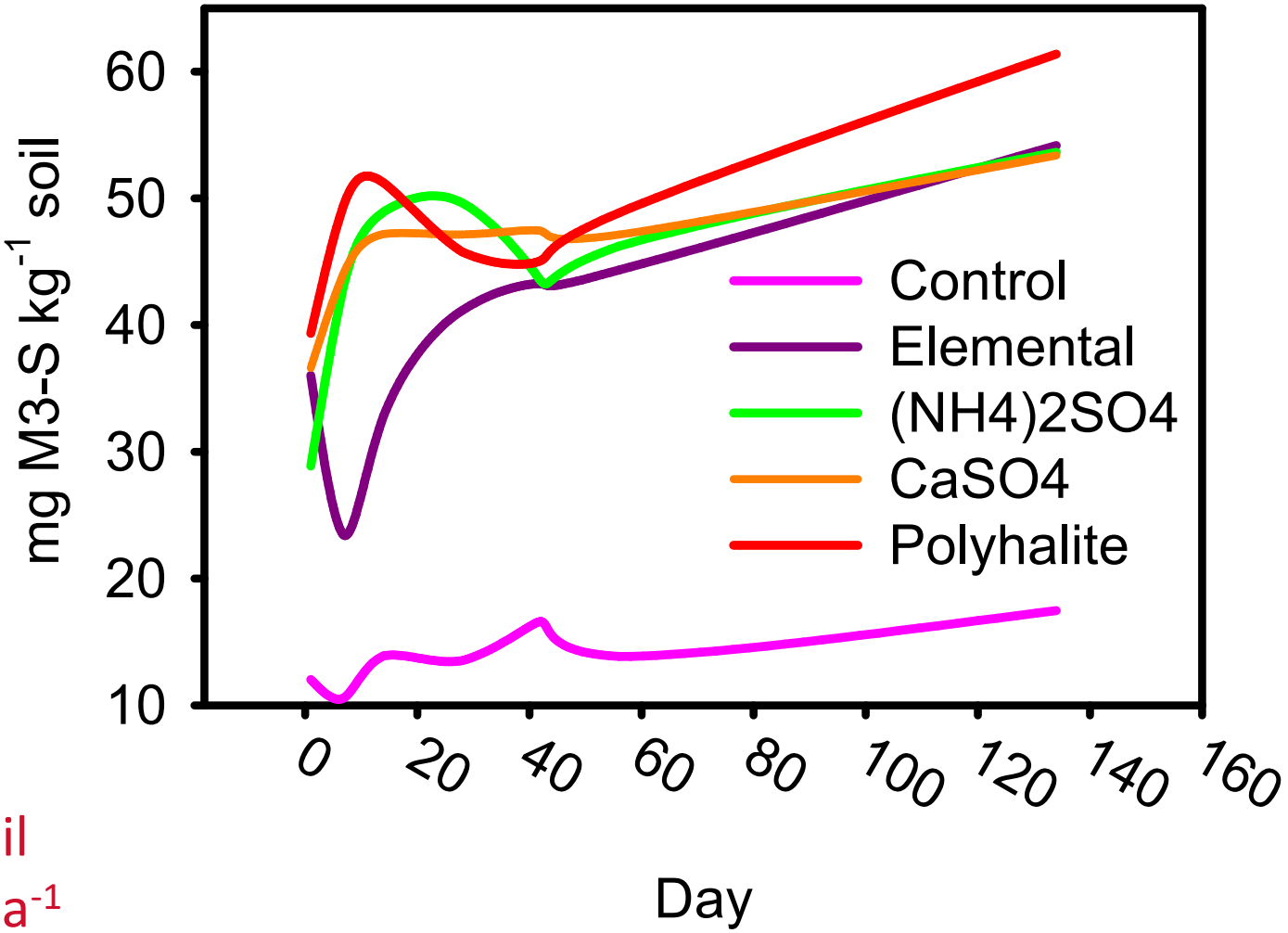
First-Year



Residual-Year



SULFUR FERTILIZER AVAILABILITY KINETICS IN LAB INCUBATIONS:



Sandy soil

30 kg S ha^{-1}

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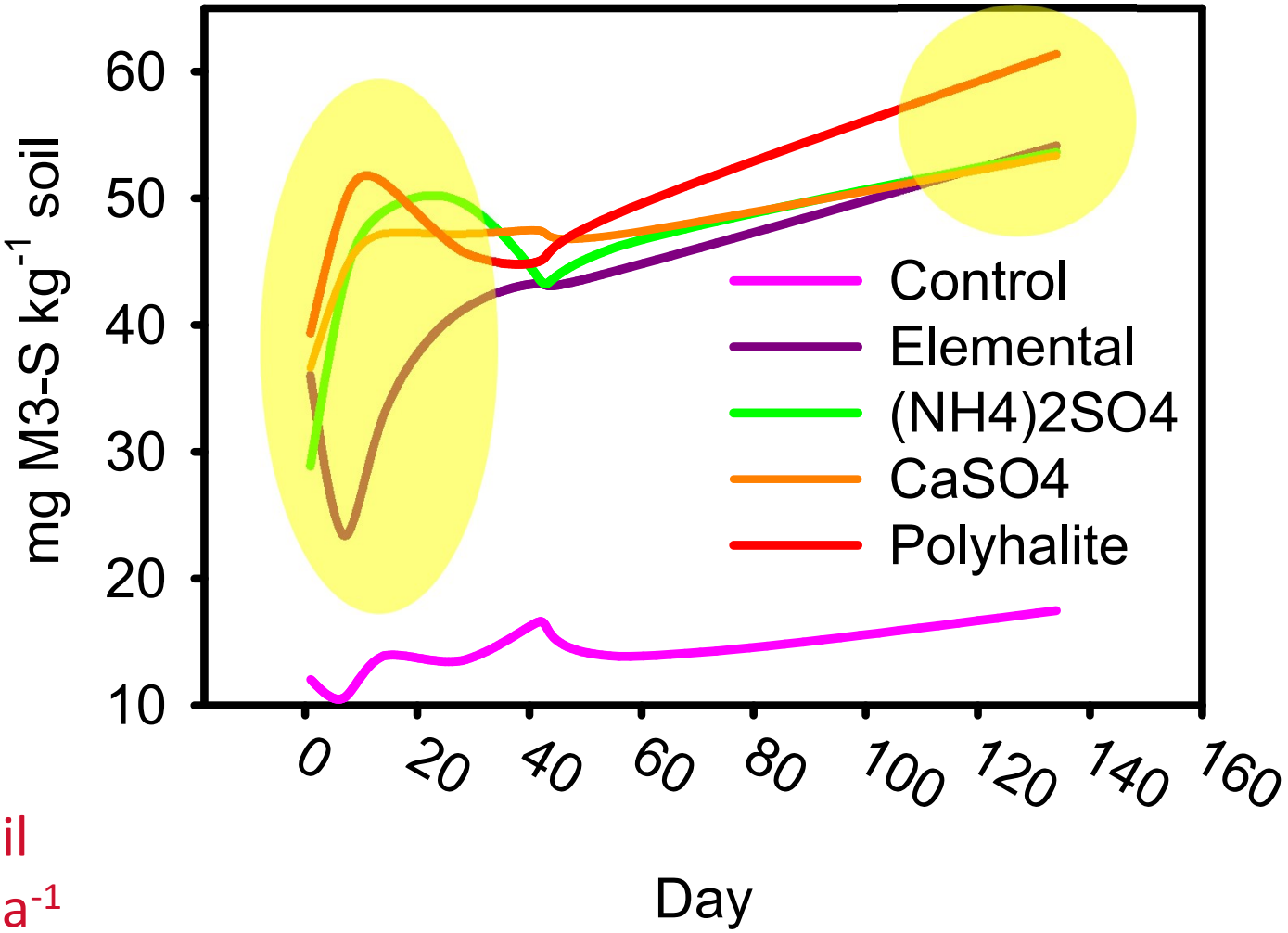

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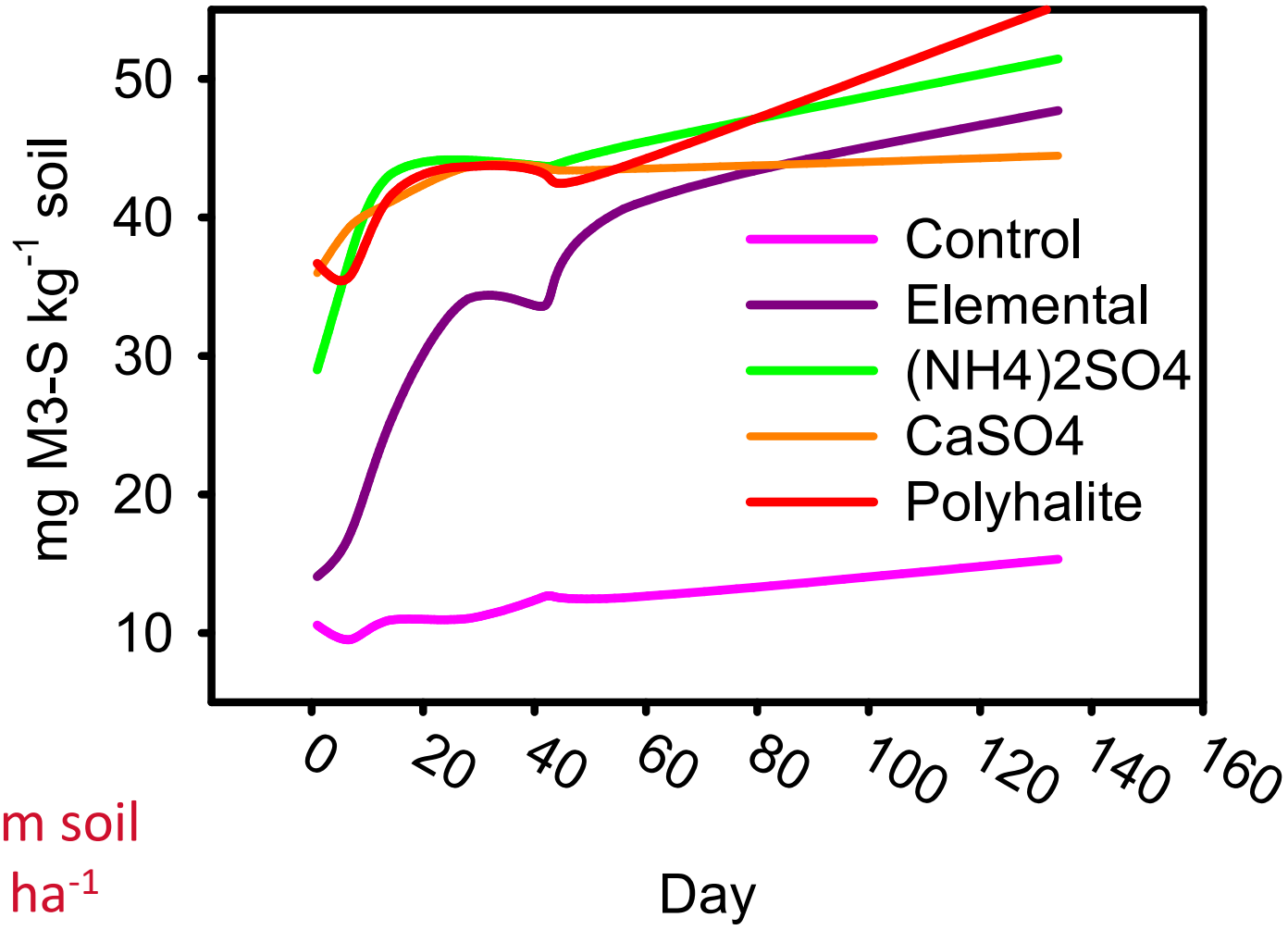

Silt Loam soil

30 kg S ha^{-1}

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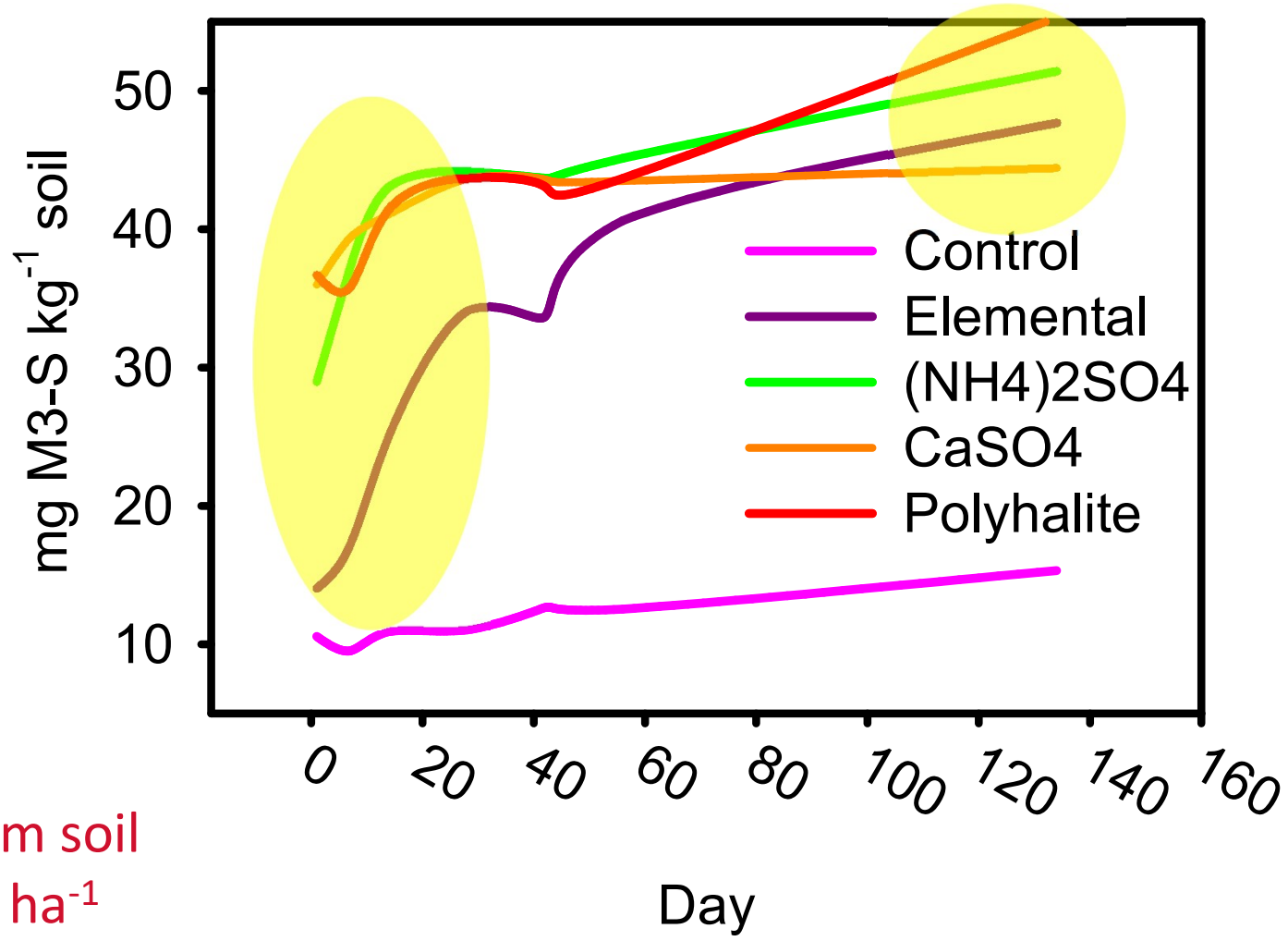


Silt Loam soil

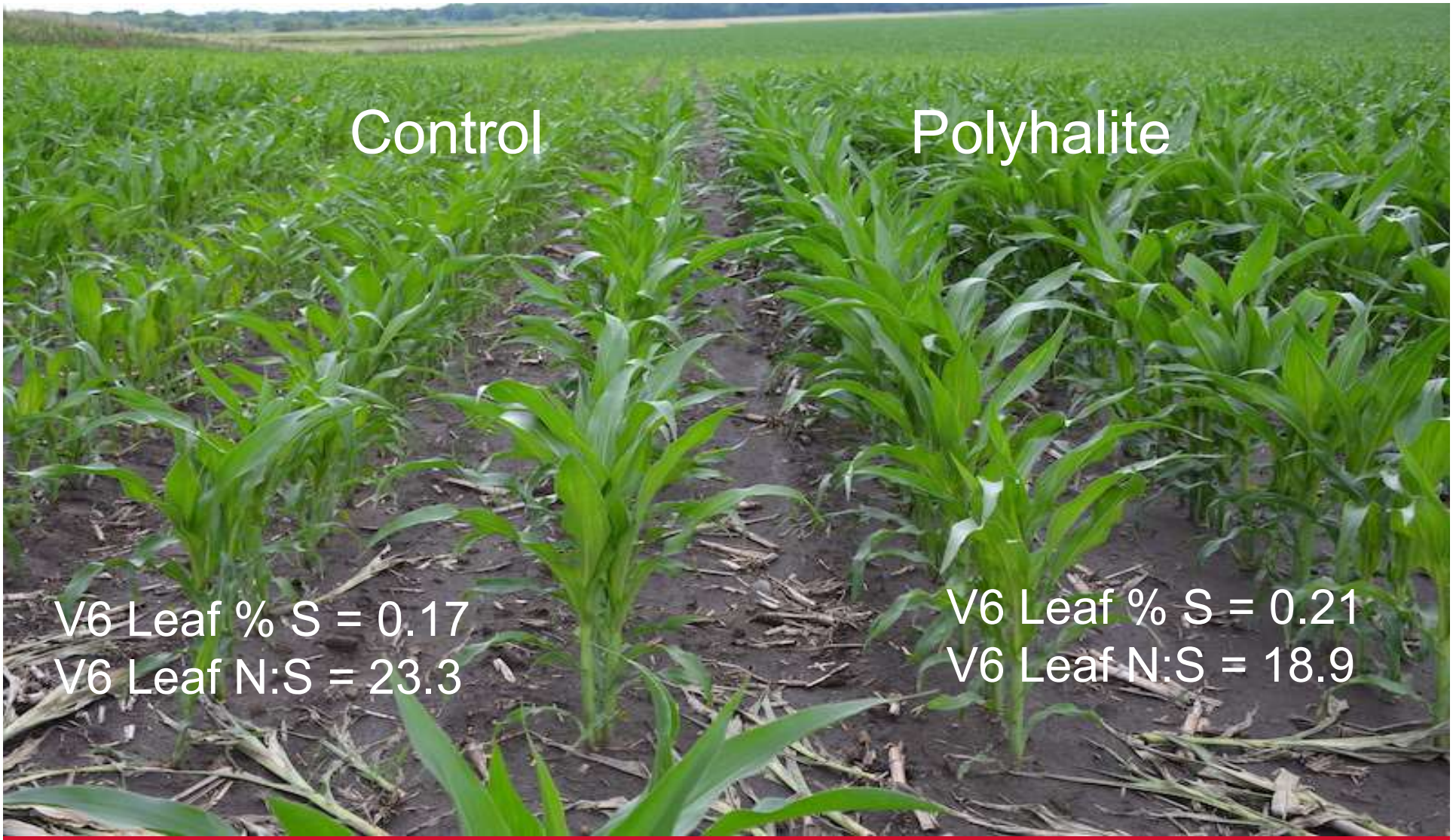
30 kg S ha^{-1}

RESULTS HIGHLIGHTS

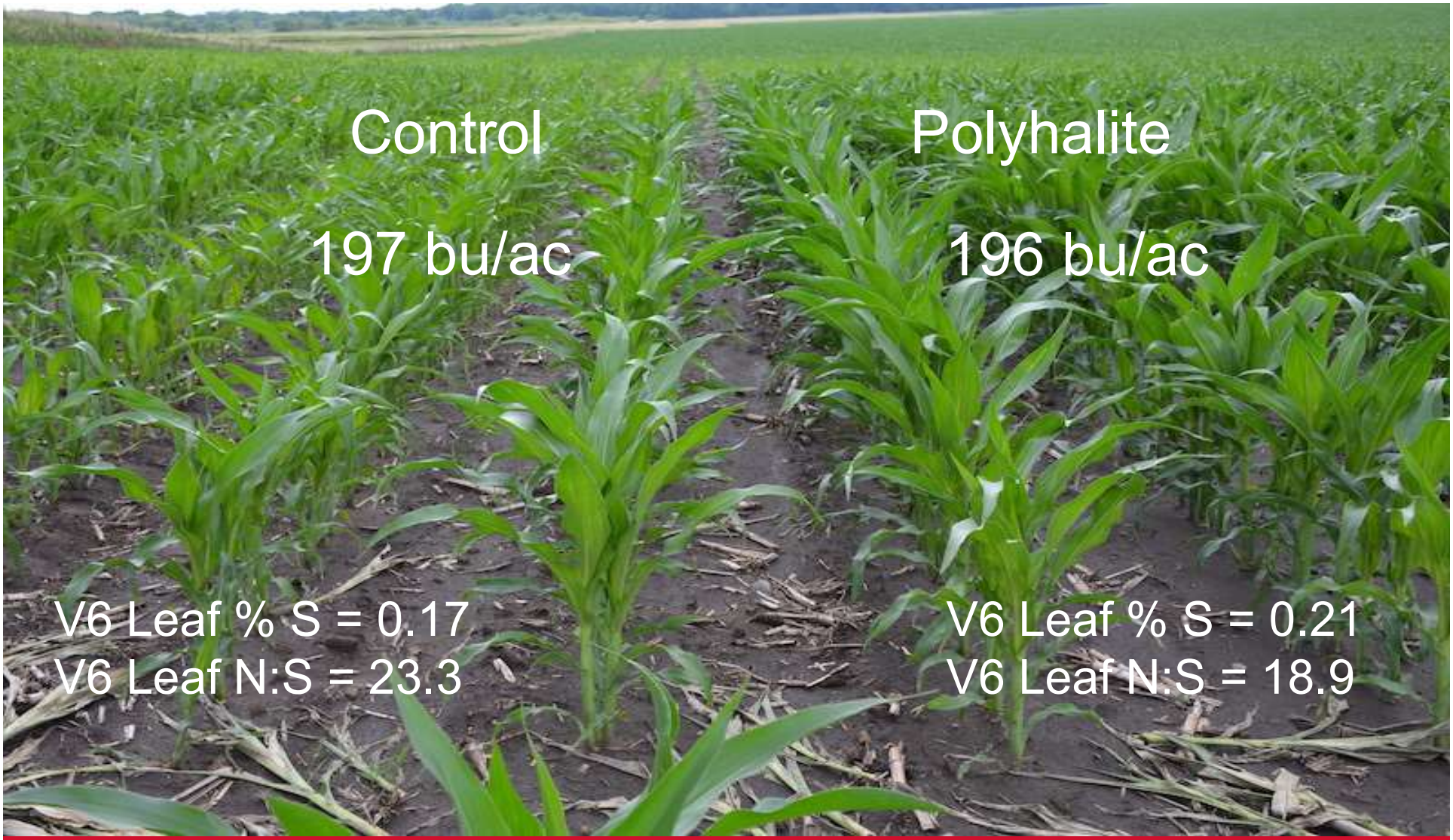
- Lab and field results were highly similar: Polyhalite balances 1st and 2nd year availabilities consistent with literature

- But, we still had some unanswered questions…

Mysterious disappearance of S deficiency: 3rd source of variability in yield response to S?



Mysterious disappearance of S deficiency: 3rd source of variability in yield response to S?



Mysterious disappearance of S deficiency: 3rd source of variability in yield response to S? **Drainage**?

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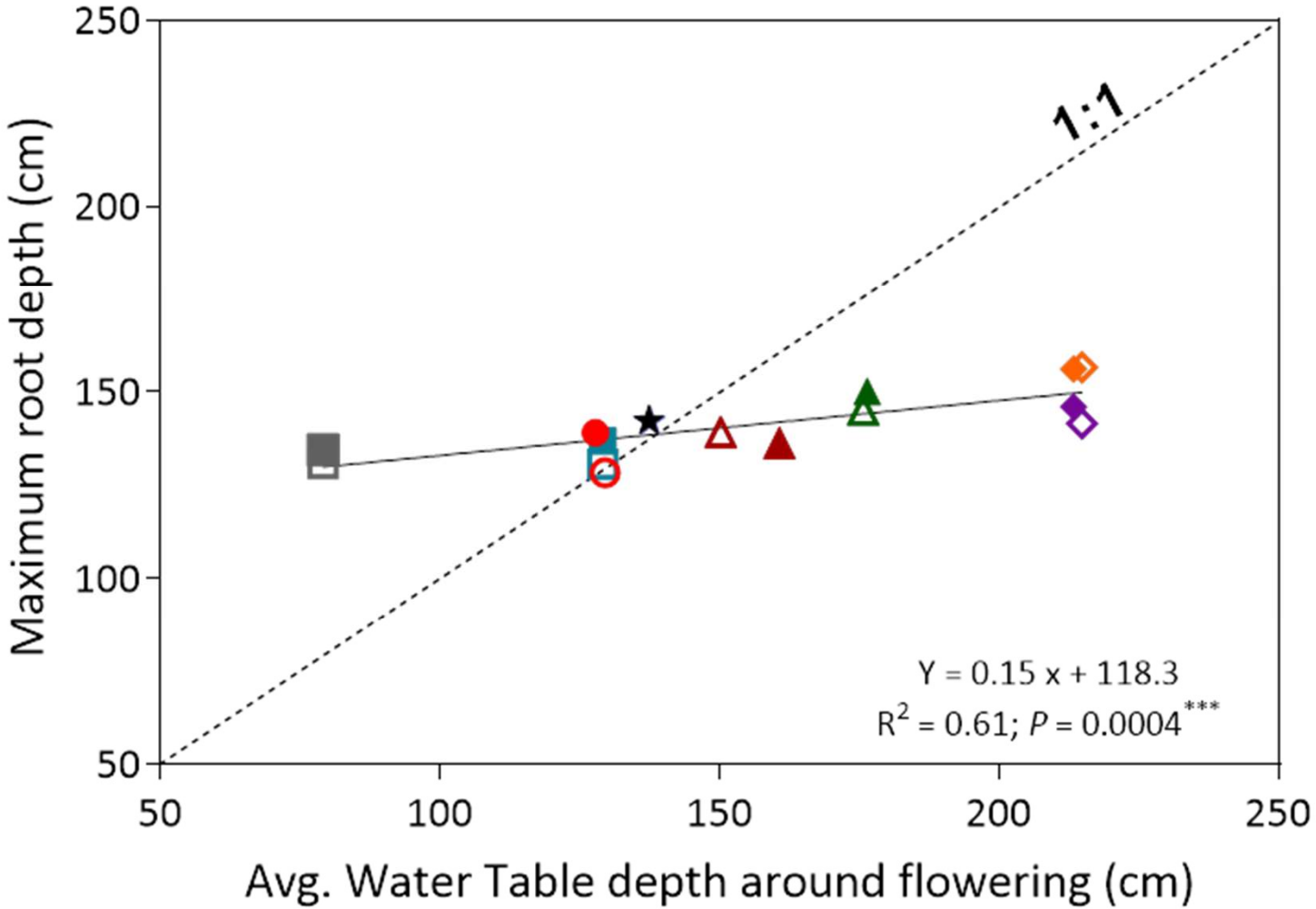
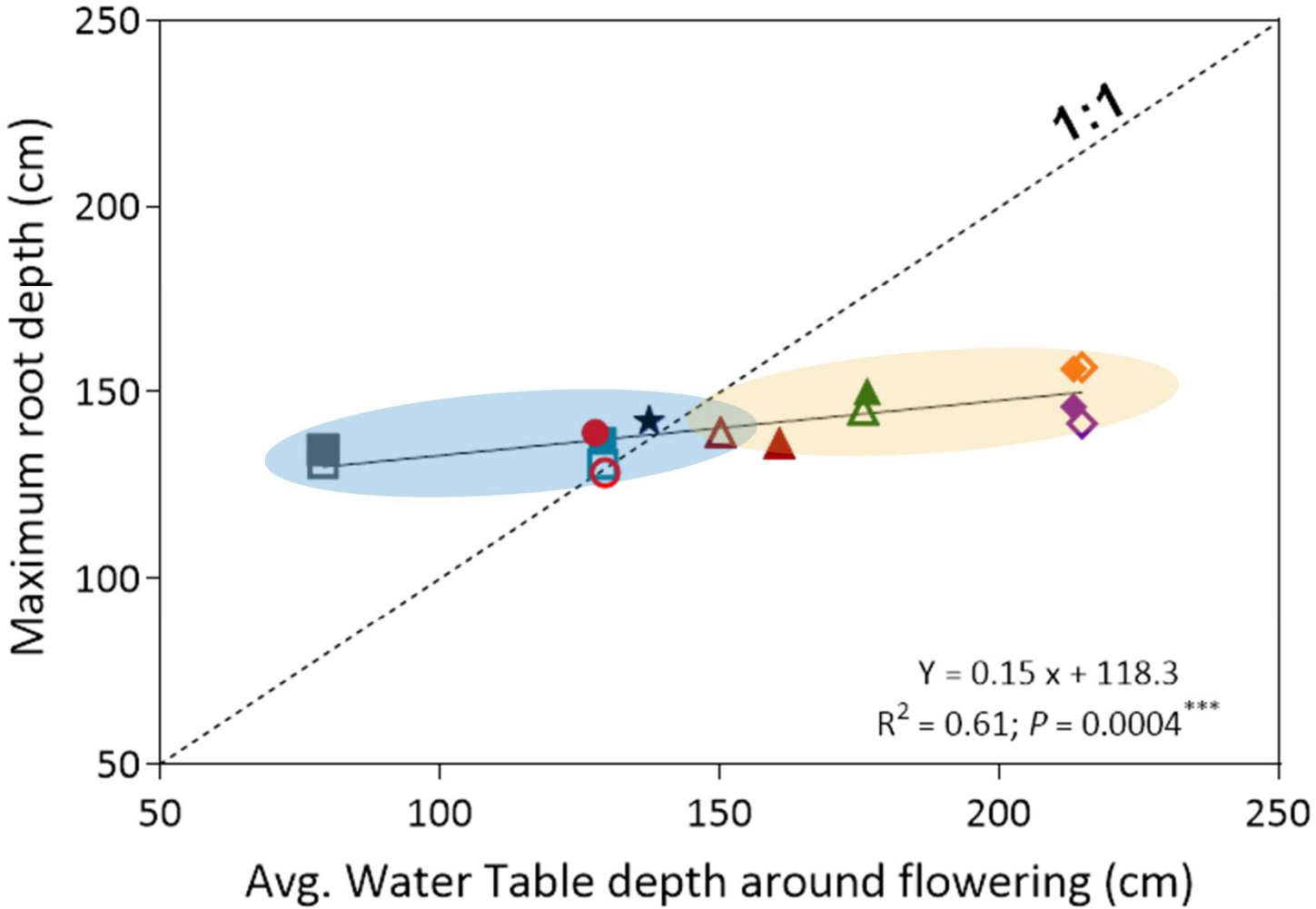
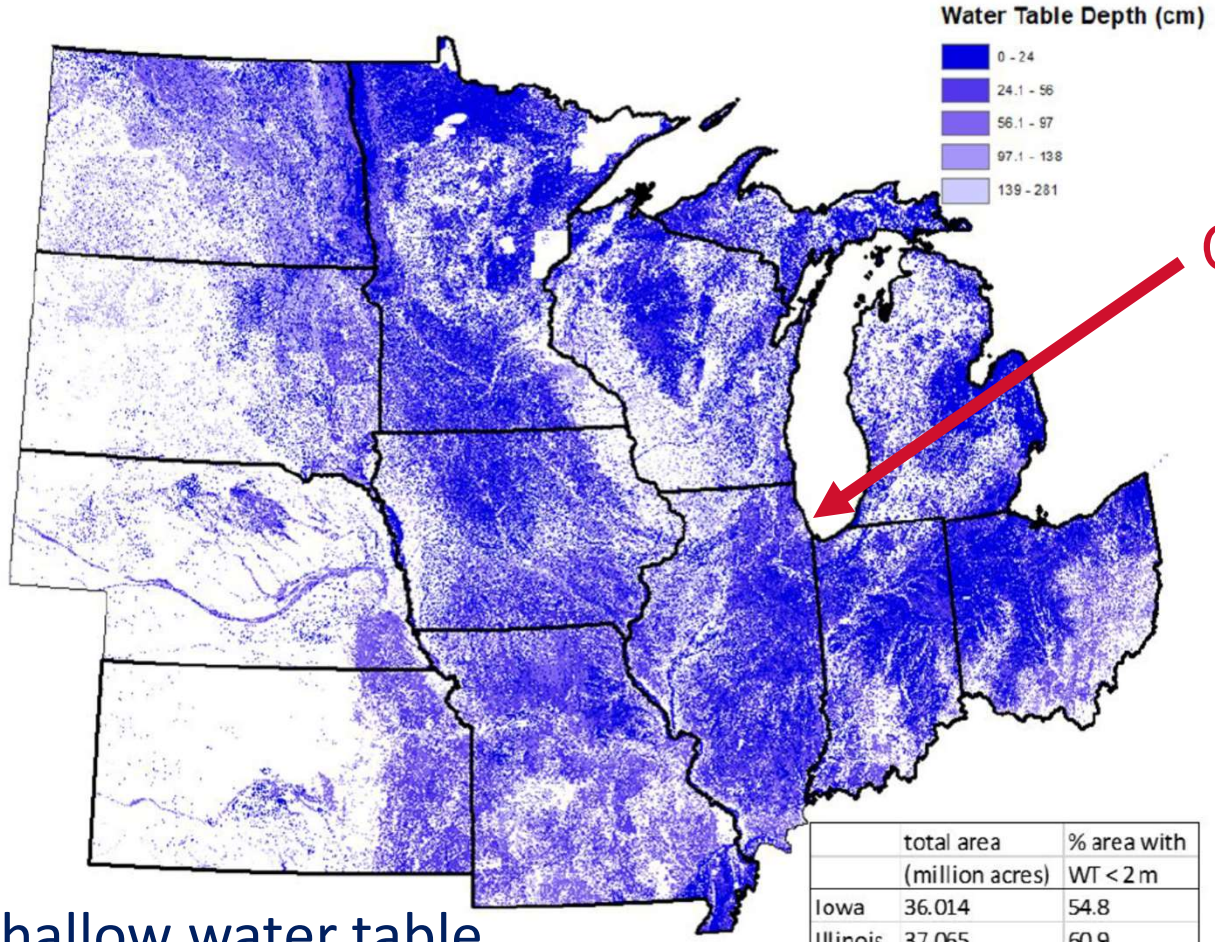


Antonio-Ordonez et al. 2018 Field Crops Research:
Maize and soybean root front velocity and maximum depth…



Antonio-Ordonez et al. 2018 Field Crops Research:
Maize and soybean root front velocity and maximum depth…

Water table is shallow and has enough S to meet crop demand (SO_4-S concentration x transpiration)…but…



	total area (million acres)	% area with WT < 2 m
Iowa	36.014	54.8
Illinois	37.065	60.9
Indiana	23.307	56.2

Dark blue = shallow water table

Archontoulis et al. Crop Science…coming soon

Farmers are intensifying drainage systems.
What will happen as farmers intensify drainage systems?

130-300 Mha with drainage…450 Mha could benefit from improved drainage: Smedema et al. 2004

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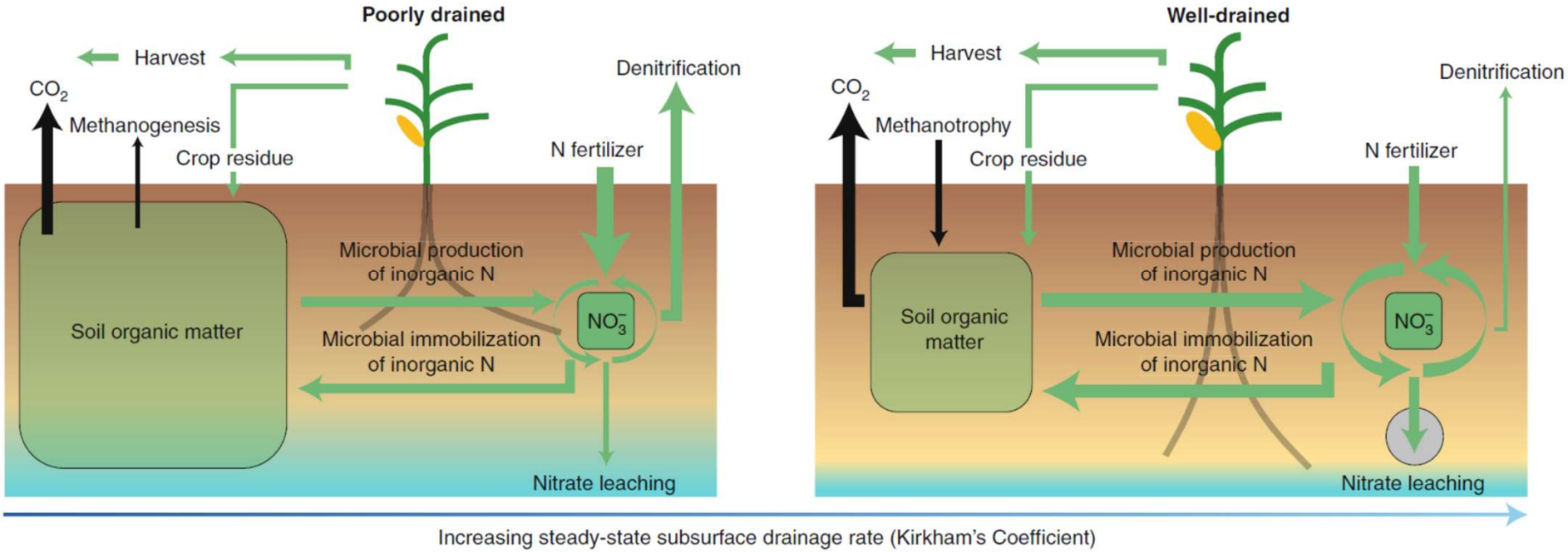
Sustainable intensification of agricultural drainage: Impacts on fertilizer use efficiency



Castellano et al. 2019, Nature Sustainability
https://www.nature.com/articles/s41893-019-0393-0

CONCLUSIONS

- Midwest US crops require sulfur fertilizers
- The source of S fertilizer has a significant effect on crop response
- Elemental S does not mineralize fast enough to benefit crop in year of application
- Sulfate-based fertilizers mineralize fast enough for first-year response
- However, compared to other sulfate-based fertilizers, lab and field results suggest Polyhalite balances first-year and residual-year availabilities thereby minimizing risk and uncertainty of economic return to S fertilizer.

THANKS

- John Sawyer, John Lundvall, Aaron Sassman (Iowa State)
- Funding from CFPN
- Farmer cooperators allowed us to conduct on-farm research