# SOIL BALANCING: SHOULD WE MANAGE SOIL CA:MG RATIOS?

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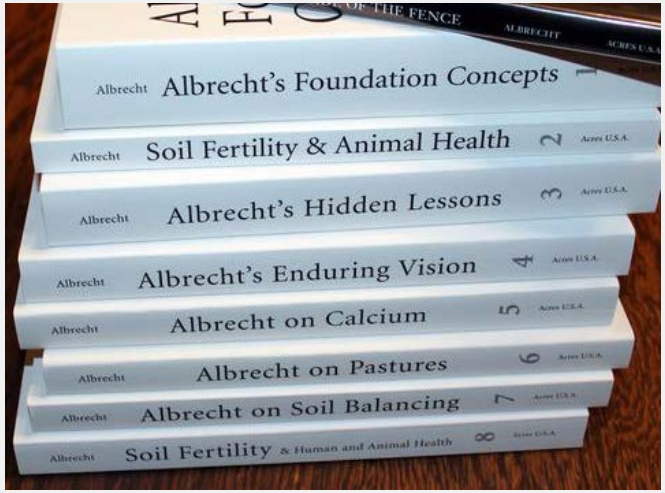
# Soil Management Philosophies

- Build-Up and Maintenance
  - Build soils up to and maintain at a specific levels
- Sufficiency Level of Available Nutrients (SLAN)
  - Apply nutrients to a minimum level required by plants
- Base Cation Saturation Ratio (BCSR)
  - Focus placed on base saturation of Ca, Mg and K (sometimes ratios of Ca:Mg)
  - Ideal base saturation: 60-75% Ca, 10-20% Mg, 2-5% K

# History of BCSR

- Loew 1892 – searched for ideal Ca:Mg
- Bear et al. 1945 – ideal soils 65% Ca, 10% Mg, 5% K
- Albrecht (and Graham) 1940-1977
  - Ideal base saturations 60-75% Ca, 10-20% Mg, 2-5% K
  - The Albrecht Papers
- Charles Walters 1970
  - ACRES U.S.A popularized BCSR



# Albrecht's Work

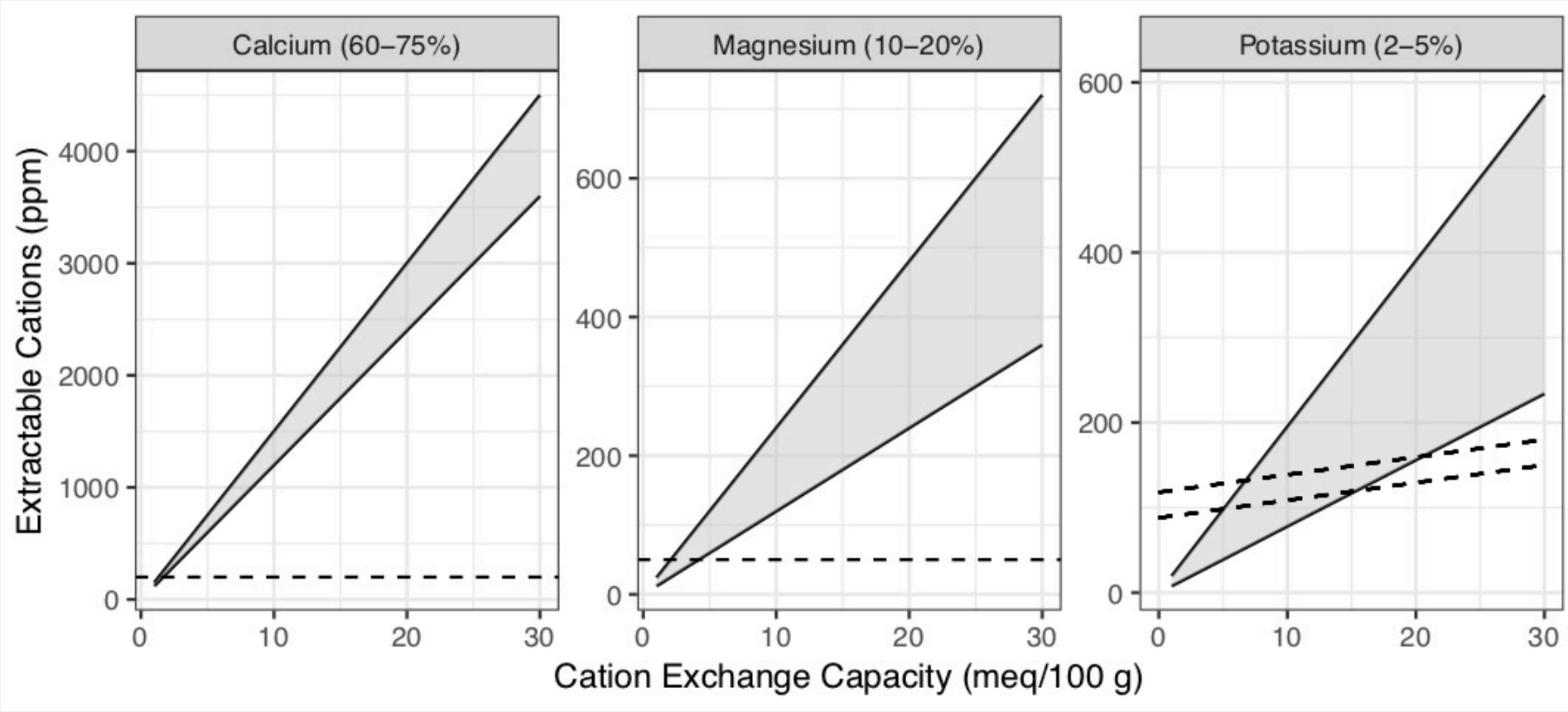
*"Albrecht concluded that it is important to maintain a high Ca saturation percentage. Indeed, it was this observation that would eventually form the basis for much of Albrecht's concept of the "balanced soil." It would seem, however, that the design and interpretation of the experiments used to demonstrate the need for a high Ca saturation were often flawed"*

Kopittke and Menzies, BCSR review, SSSAJ 2007

Albrecht did not control for pH changes when adding Ca

# Soil Balancing vs. SLAN

(Ex. Tri-State Fertilizer Recs)




*What are the economic implications?*

# Soil Fertility Specialists' – Soil Balancing Attitudes

| Statement | Strongly Agree | Somewhat agree | Neither Disagree or agree | Somewhat disagree | Strongly Disagree |
|---|---|---|---|---|---|
| There is no scientific merit to this approach and this has been shown repeatedly | 39% | 39% | 23% | 0% | 0% |

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| It is possible that farmers do see benefits from this approach | 2% | 20% | 22% | 28% | 28% |

# What does previous research on Soil Balancing show?

## Historical Perspective of Soil Balancing Theory and Identifying Knowledge Gaps: A Review

Vijayasatya N. Chaganti* and
Steve W. Culman

**Abstract**

The common philosophies that contextualize soil test results and fertilizer recommendations are sufficiency level of available nutrients (SLAN), buildup and maintenance, and basic cation saturation ratio (BCSR). The BCSR approach postulates maintaining an ideal ratio of basic cation ($Ca^{2+}$, $Mg^{2+}$, and $K^{+}$) saturations on the soil exchange sites to maximize crop yields. The practice of adding amendments to alter the ratios of basic cation saturations in soils is called "soil balancing." Bear, Graham, and Albrecht promoted this concept, with each suggesting a desired saturation ratio of Ca:Mg:K for optimum crop yields. Several researchers have tried to validate this theory with both greenhouse and field experiments but could not conclude that an ideal cation saturation ratio existed and


15 peer-review studies (7 field, 8 greenhouse)

Chaganti and Culman, 2017, Crops, Forage and Turfgrass Management

# Conclusions from previous research on BCSR and crop yield

- There is no ideal ratio where crop yields are maximum. Yields were not affected across a wide range of ratios.
- Can result in excessive fertilizer applications when trying to maintain base cation ratios at specific levels/ranges (ideal levels).
- Buildup/Sufficiency level approach is more economical than BCSR
- Maintaining sufficient levels to meet crop needs is more important than to achieve a favorable cation ratio.

With no scientific backing or Land Grant University endorsement, the only farmers on the fringe practice soil balancing, right?

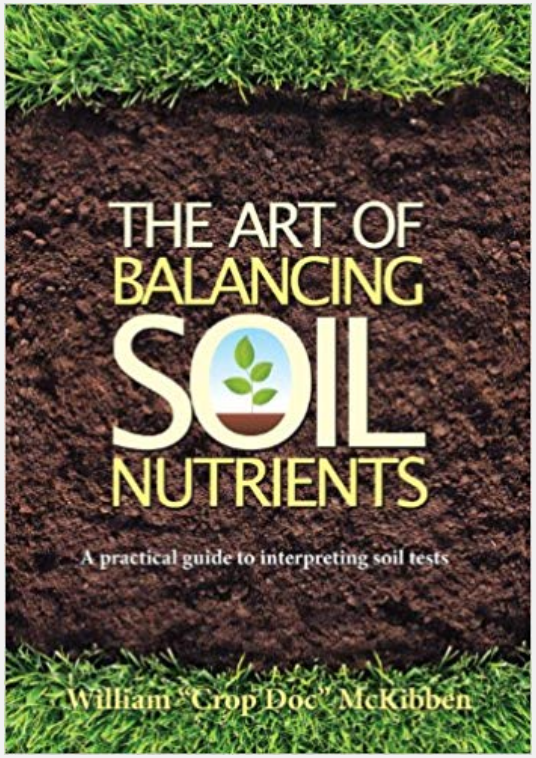
# Soil balancing is practiced

*"When we start working with guys we always have 'problem' fields…undoubtedly we find that the Ca:Mg relationship is their main challenge."*

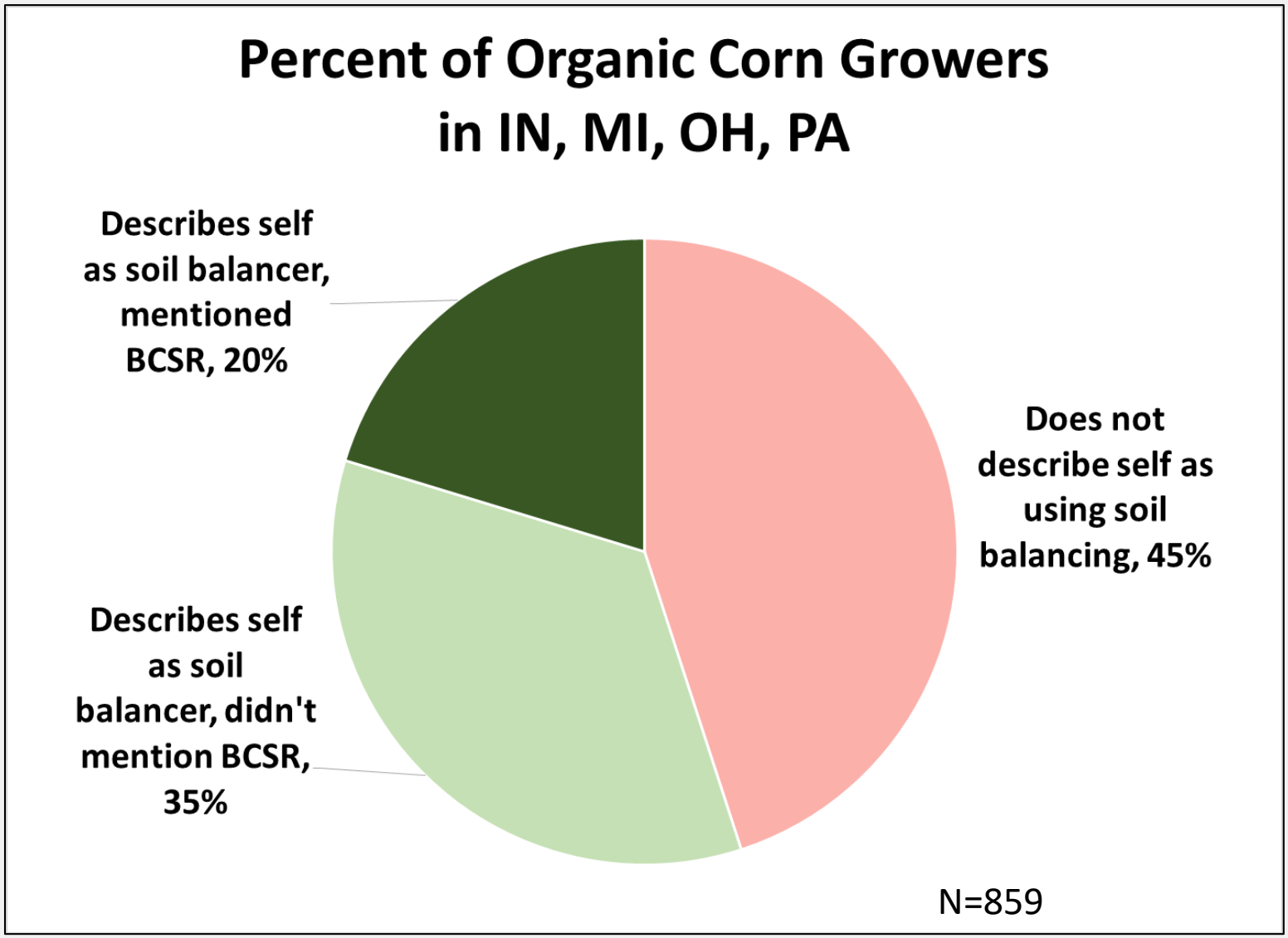
-Joe Nester, Prominent NW Ohio
crop consultant

Managing Ca = managing water:
too little/ not enough

10,000's of acres managed
with Ca:Mg in mind

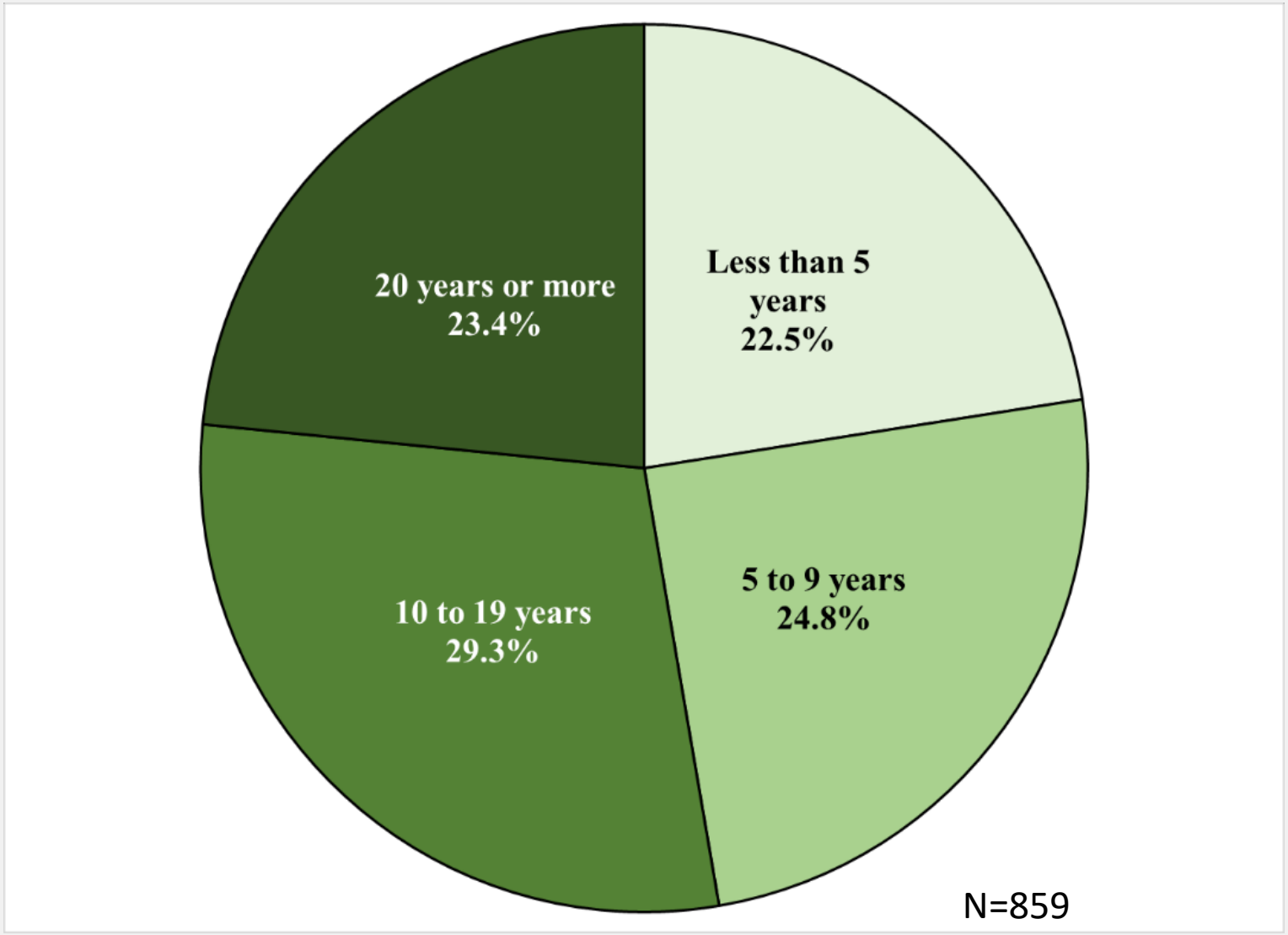


# How many organic soil balancers?




Brock et al, in review

# How long have you been soil balancing?



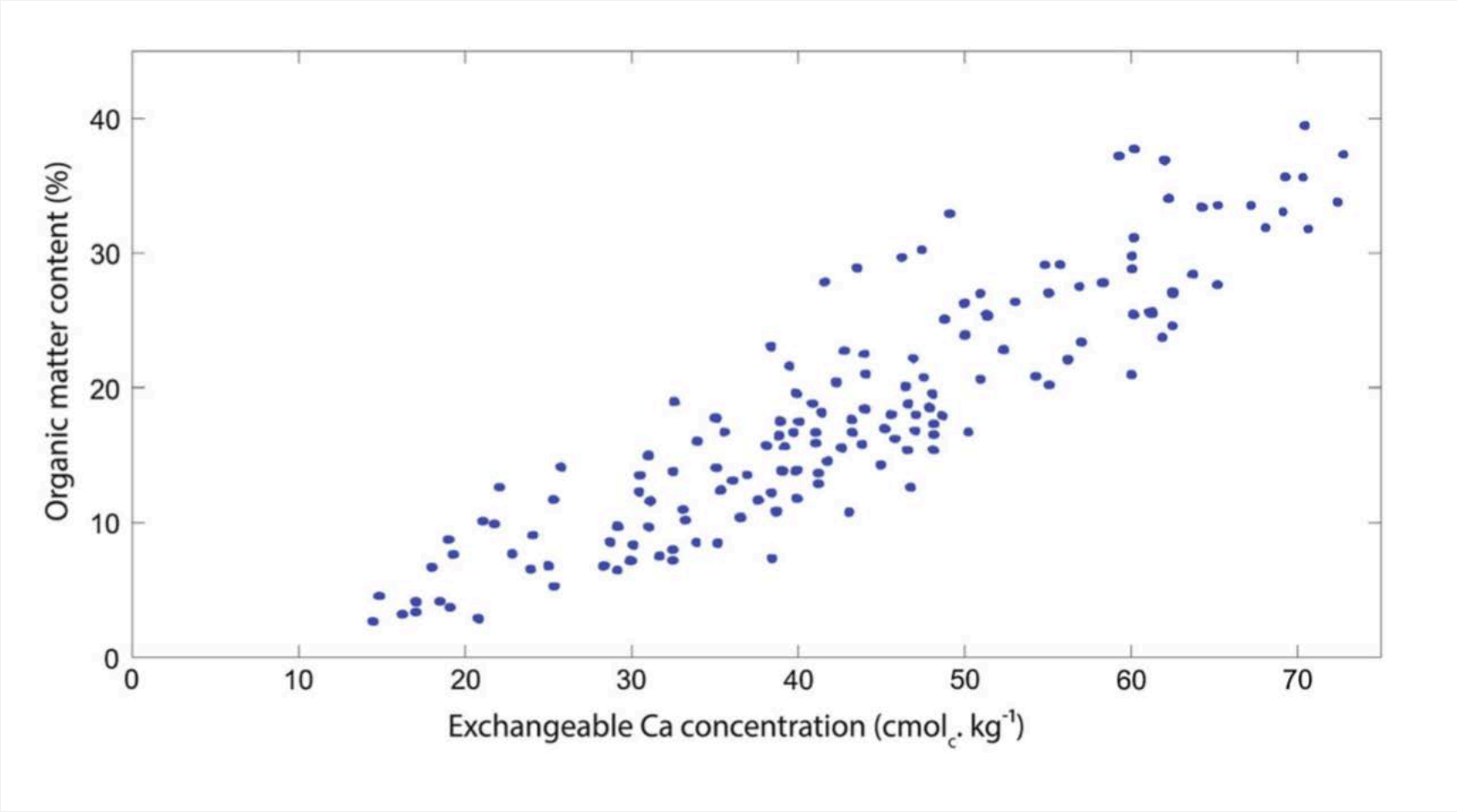

Brock et al, in review

# Why the disconnect??

Why does the agricultural community care about Ca:Mg ratios when no Land Grant Universities endorse??

Is it possible that soil Ca:Mg ratios do matter but were originally rooted in ~~bad~~ less than great science?

# *Soil Ca Saturation and Organic Matter*




Rowley et al., 2018, Biogeochemistr

# Increasing Ca:Mg Ratios in Practice

- Two products typically used:

- Hi-cal lime ($\underline{Ca}CO_3$)
  - Raises pH, effects on crop productivity well-documented

- Gypsum ($\underline{Ca}SO_4$)
  - Does not raise pH, crop effect inconsistent
  - Gypsum can be used as a soil amendment (physical structure)
  - Should farmers use gypsum for S nutrition or as a soil amendment?
    - S nutrition: <20-30 lb/ A
    - Amendment: 2000-4000 lb/A

# Underlying Questions

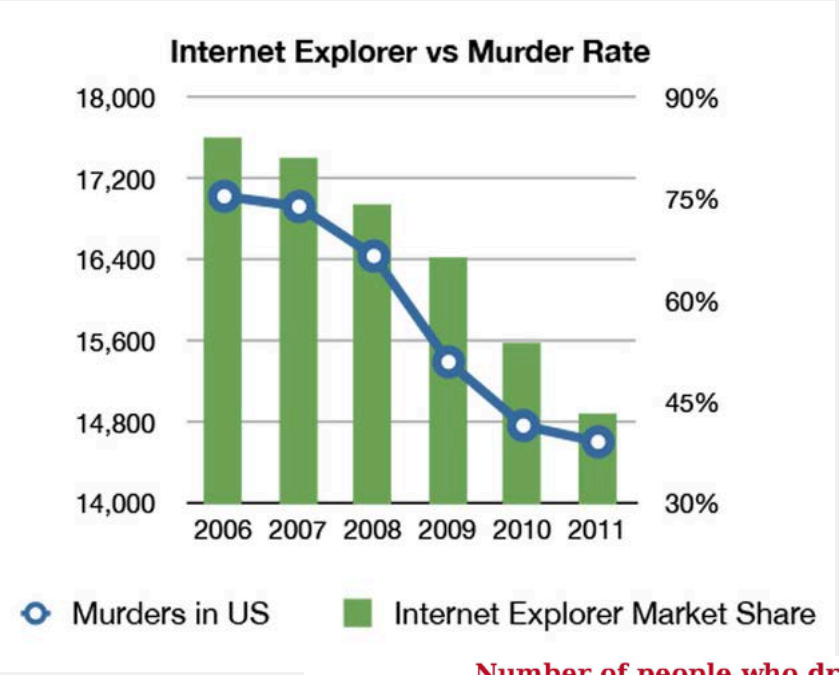
*When we add lime ($CaCO_3$), we always*

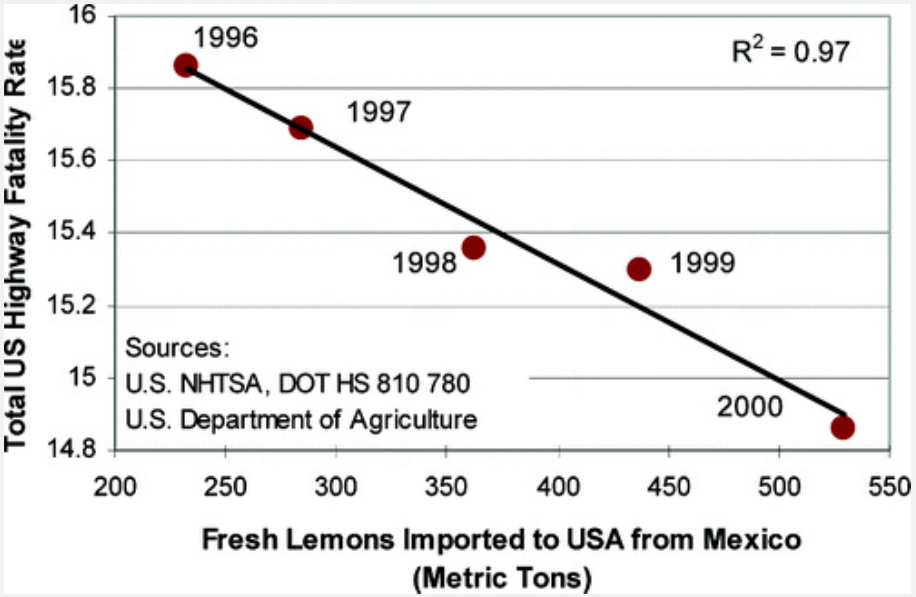
1) *Raise pH*
2) *Add calcium*

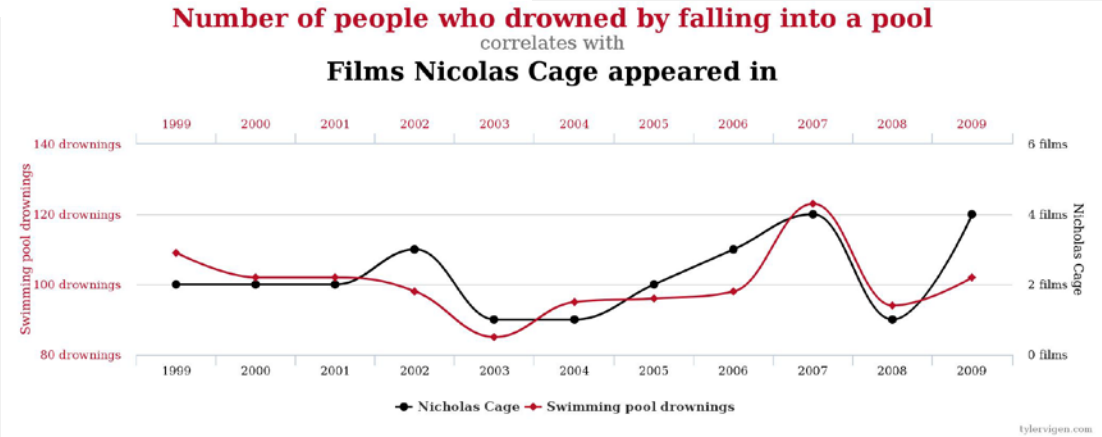
*Are there additional benefits from lime not related to increasing pH? Is the Ca providing benefits? Can these effects be teased apart?*

*Are effects of gypsum ($CaSO_4$) a sulfur response or soil conditioning response?*

# Correlation vs. Causation



# General Working Hypothesis

***Applying lime to the soil…***

- Increases nutrient availability and
- Increases soil biological activity
- Which improves crop growth

***Applying gypsum to the soil…***

- Increases soil aggregation and physical structure
- Which increases root growth, water/gas exchange, soil biological activity
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Established

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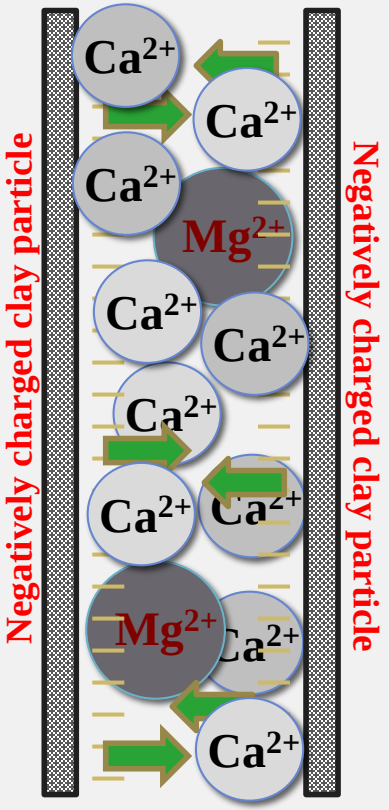
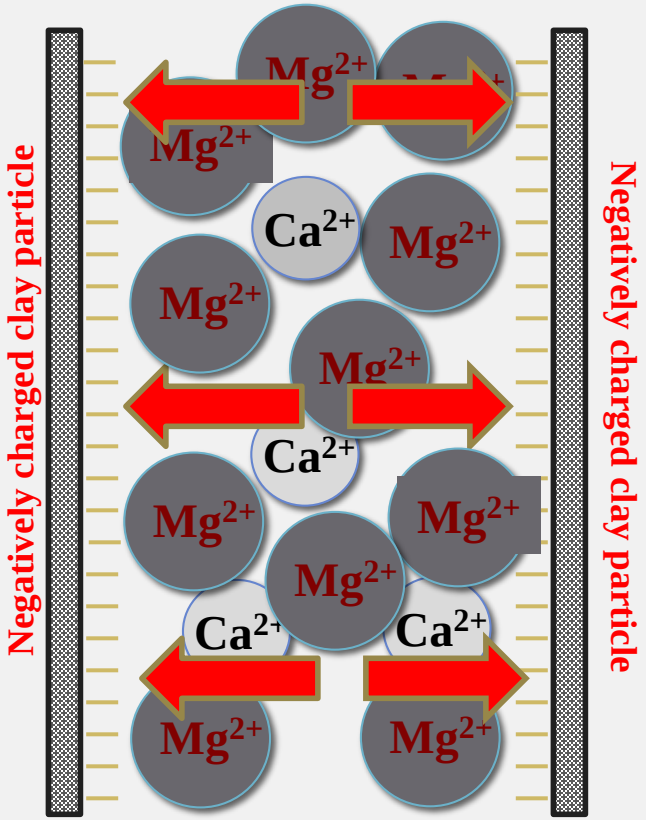
Theory

More calcium attracts clay particles together to form aggregates




More magnesium repels clay particles to disperse aggregates




Possible relationship between Ca and Mg in aggregate stability

# Ca:Mg and Soil Hydrology

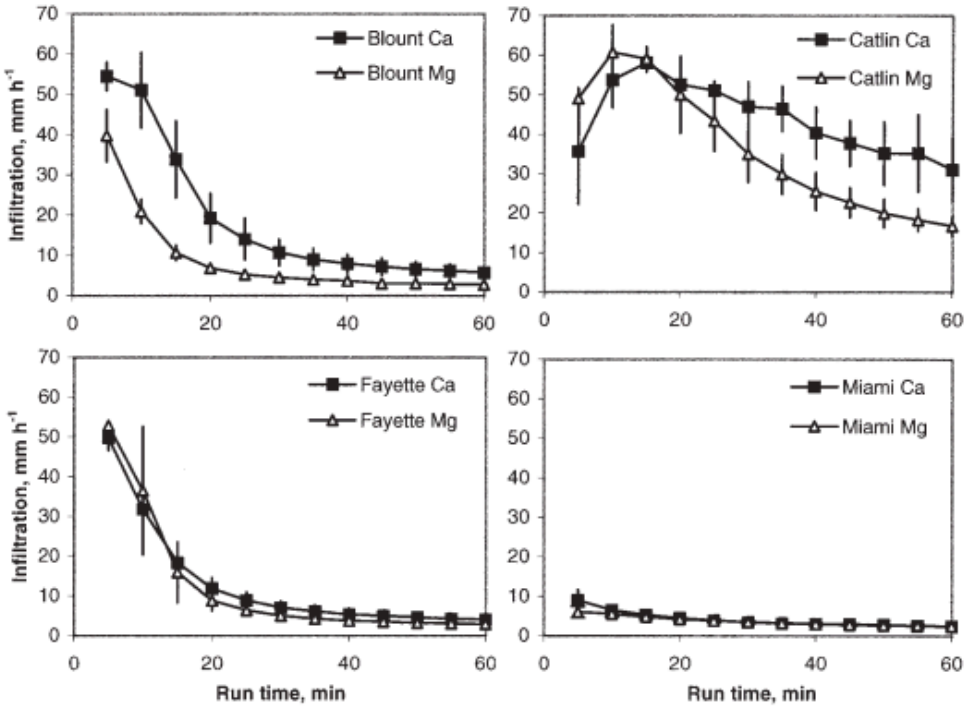
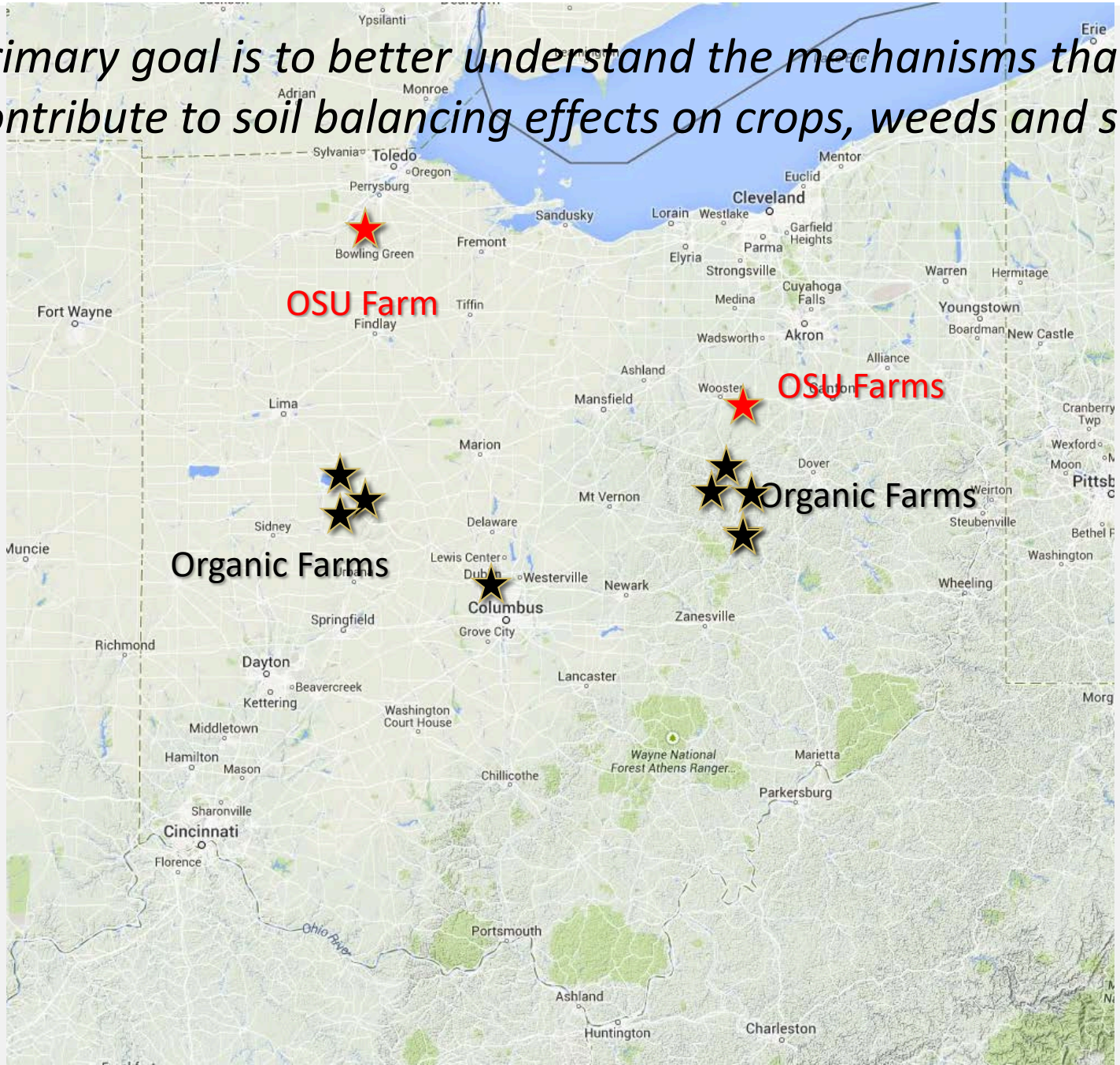



Fig. 3. Normalized infiltration rate (average of four replications) as a function of time for Ca- and Mg- saturated Blount, Catlin, Fayette, and Miami soils. Error bars equal one standard deviation.

- Dontsova & Norton (2002) reported Mg Saturations >80% resulted in soil dispersion, reduced water infiltration and elevated soil losses.

- How realistic is 80% Mg saturation in field?

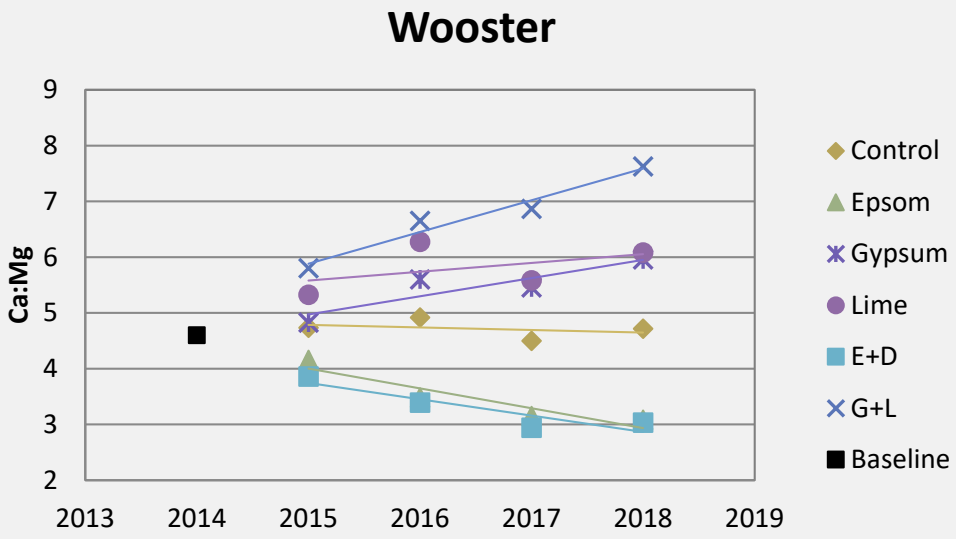
*Primary goal is to better understand the mechanisms that contribute to soil balancing effects on crops, weeds and soils*



# Measurements

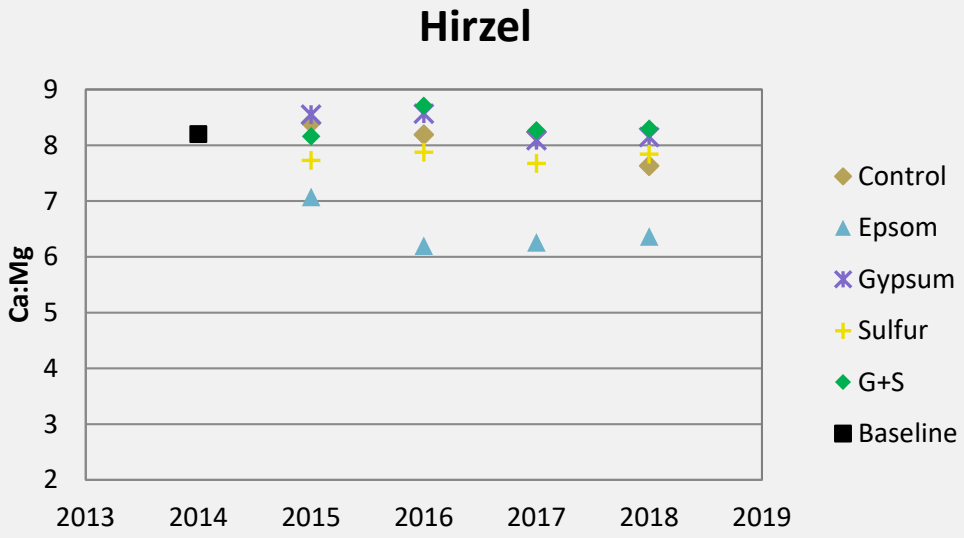
- Weeds
  - Weed emergence counts, weed community
- Crop
  - Tissue sampling (nutrient analysis at flowering)
  - Yields and grain nutrient analysis
- Comprehensive Soil Health
  - Standard nutrient analysis (chemistry)
  - Soil health testing (biology- Active C, Soil Protein, Respiration)
  - Soil physical structure (Aggregate Stability, penetration resistance, infiltration)

# Soil Mehlich-3 Ca:Mg




| | Total application (lb/A) |
|---|---|
| Gypsum | 7000 |
| HiCal Lime | 8500 |
| Gypsum + HiCal Lime | 6000+8000 |
| Epsom | 6500 |
| Epsom + Dolomitic Lime | 6500+8000 |

| | Total application (lb/A) |
|---|---|
| Gypsum | 4500 |
| Epsom | 9000 |
| Sulfur | 500 |
| Gypsum + Sulfur | 4500 + 500 |



# Overview of Findings (First 4-5 yrs)

- Grain yield responses have been rare and not consistent among treatments
- No significant treatment effects for soil health indicators
  - POXC, Respiration, Soil protein
- Crops (tissue, grain concentration) and soils
  - Most differences found in S and Ca concentrations
  - No other differences found in soil measures
- Inconsistent responses in weed communities

# Other work

Conventional Corn

- 2 sites in Ohio, 4yrs
- Gypsum applied at
  - 3 rates (0, 1 ton/acre, 2 tons/acre)
  - 3 timings (every year, every other year, every four years)
- Only 1 year was there an increase in yield
  - Chaganti et al., Agronomy Journal, 2019

On-farm work (19 sites, 2 yrs each – mixed crops)

- No significant yield increases with gypsum
- No consistent trends in soil health, 2 sites had reductions in penetration resistance

# Conclusions

- Despite widespread use of soil balancing in Ohio and surrounding states, demonstrating positive benefits in the field remain elusive
- Survey work and in-depth interviews with farmers and consultants show the complexity of perspectives
  - Ca:Mg isn't practiced in isolation
  - Often times not a primary focus of management
- Soil Balancing as a case study
  - Many questions raised here about how farmers learn and validate truths, where/how they get information

# Thank You

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