Elephant in the room: Why do so many farmers practice ‘soil balancing’ despite the lack of scientific evidence?

2019 Conservation Tillage Conference
Ada, Ohio

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COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

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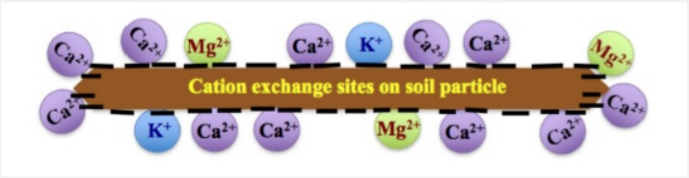
Soil Balancing Research Team

What is Soil Balancing?

For most farmers and scientists, soil balancing generally refers to the theory and practice of attaining an optimum ratio of the plant nutrients, calcium (Ca), magnesium (Mg), and potassium (K), in the soil. For many soils, achieving balance requires relatively large inputs of calcium-rich minerals (limestone and/or gypsum), in order to raise Ca to the desired level. A balanced soil is rarely achieved quickly and often requires an investment of resources.

Soil balancing is based on Base Cation Saturation Ratio (BCSR) theory that calls for approximately 65, 10, and 5 percent of a soil's cation exchange sites (Cation Exchange Capacity or CEC) (Figure 1) to be occupied by Ca, Mg, and K, respectively. CEC refers to a soil's innate ability to retain nutrients and make those nutrients available to crops; soils high in CEC hold more nutrients and thus, can release more, than soils low in CEC. As illustrated in Figure 1 below, soil particles contain sites that can hold positively charged ions (e.g., Ca, Mg, and K). Soil balancing calls for specific percentages of these sites to be occupied by these three ions. Thus, at its core, soil balancing is about managing soil chemistry.



Brief History: Who, Where, When

Soil balancing concepts were first proposed in the late 1800's by German scientist, Oscar Loew, and then built upon by others starting in the mid-1900's (Figure 2). However, the main concepts are commonly associated with William A. Albrecht (Figure 3), a Professor at the University of Missouri during the 1930s – 1960s. Albrecht believed that crops responded to limestone or gypsum because of increasing Ca levels, rather than as a result of effects on soil pH.

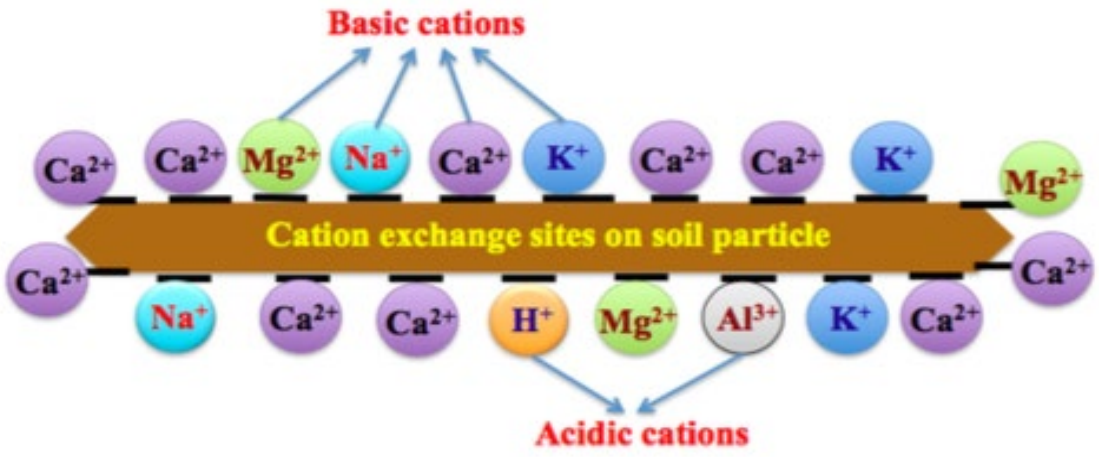
	% Ca	% Mg	% K
Bear (1945)	65	10	5
Graham (1959)	60-85	6-12	2-5
Albrecht (1975)	60-75	10-20	2-5

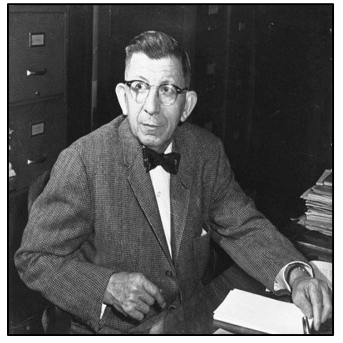
Courtesy of Chaganti VJ and Culman SW (2016)

Figure 2. Percent saturations of base cations suggested by different researchers.

Figure 3. Dr. William A. Albrecht. Courtesy of http://www.acresusa.com/history/

Soil Balancing Concept – Base Cation Saturation Ratio (BCSR)





- Focuses on the important role that cations play in plant function
- Balance of Base Cations = Key. "Ideal range is 60 to 75% **Ca** 10 to 20% **Mg**, 2 to 5% **K**, 10% H, and 5% of other cations to maximize crop yields" (Albrecht, 1975)

Contrasts with SLAN

"Sufficient Level of Available Nutrients"

The idea that crops yields will be responsive to fertilization if the fertility levels of that nutrient are below a certain level and will not be if they are above a certain level (e.g. Eckert, 1987 Gasper, 2016; Black, 1993)

The Puzzle: Widely Used, Little Scientific Support

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 found that crop yields were similar across a wide range of ratios. While the scientific community disregards this theory, some farmers, crop consultants, and commercial soil-testing laboratories still use BCSR to guide their fertilizer recommendations. It is believed that soil balancing effectively controls weeds, insects, and pests and improves overall soil health for better plant growth, ultimately producing better crop yields. Some even argue that soil balancing improves nutritional quality of the harvested crop. However, contemporary research to objectively demonstrate such perceived benefits of practicing soil balancing is missing. This review presents a holistic overview of soil balancing, presents a literature review on BCSR, and identifies knowledge gaps, which need to be addressed to better understand the merits and demerits of soil balancing.

Reviews

ACCEPTED

Core Ideas

- A soil with an ideal basic cation saturation ratio (BCSR) is said to maximize crop yields.
- Previous studies concluded higher crop yields are possible over a wide range of ratios.
- Scientific community disregards BCSR theory but its proponents believe in opposite.
- Soil balancing effects on weeds, soils, and crop quality are critical knowledge gaps.

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TODAY:

3 Key Research Questions

1. How is ‘soil balancing’ actually practiced?
2. How common is soil balancing?
3. How well does soil balancing work?

Methods

<u>INTERVIEWS</u>

- 33 w/ individuals assumed to be soil balancers
  - 9 consultants
  - 24 farmers

    (*Veg/Fruit N=10; Cash grain N=5; Dairy=6; Veg/Livestock=2; Retired Dairy farmer=1*)

<u>Review of literature</u> – books, articles, websites

MAIL SURVEY

- Spring 2018
- Organic corn growers (OH, IN, PA, MI)
- Focus: soil management practices, including soil balancing
- Questions addressed 2017 production practices

2017 ORGANIC CORN & SOIL MANAGEMENT SURVEY

A Collaborative Effort of Ohio State University & Organic Certification Organizations

Why are we sending this survey?

The acreage under organic corn in the U.S. has increased rapidly in recent years, rising from 32,650 to 234,470 acres between 1995 and 2011. Because organic corn producers cannot rely on conventional chemical inputs to supply nutrients or control weeds and pests, they have adopted a wide range of innovative crop and soil management practices. Our research team is particularly interested in **how organic farmers manage their soil, and how the use of different soil amendments and management practices affect crop productivity, soil and crop quality, and farm profitability.**

The best place to learn about the effectiveness of different organic corn management practices is from the experiences and observations of working farmers. **To do this, we need your help.** We are inviting a group of randomly-selected, certified organic corn farmers to share information about their 2017 production year. Participation in the survey is entirely voluntary, but we need responses from everyone to ensure that the results are representative of the experiences of organic corn farmers in this region. Results of our analysis will be shared with the organic farming community to help identify the relative performance of alternative soil management practices.

Initially, we want to check if your farm qualifies for this study.

A1. **Did you raise certified organic corn in 2017?** *(Check ✓ one)*

- ○ NO → *If not – please return the survey in the enclosed stamped envelope.*
- ○ YES → *If yes – continue.*

Next, we want to begin by learning more about your overall farm operation.

B1. **What kinds of farm products did you produce in 2017?** *(✓ all that apply, note if organic)*

Crop Enterprises	Raised organic	Raised conventional	Livestock Enterprises	Raised organic	Raised conventional
Corn	○	○	Dairy	○	○
Soybeans	○	○	Beef	○	○
Wheat	○	○	Hogs	○	○
Barley or oats	○	○	Poultry	○	○
Alfalfa or other hay	○	○	Horses	○	○
Vegetable crops	○	○	Sheep or goats	○	○
Other (specify):			*Other (specify):*		
	○	○		○	○
	○	○		○	○

B2. **Please circle the one crop or livestock enterprise above that provided the most amount of gross income on your farm in 2017.**

Response Rates

Table 1: Sample Size, Response Rates Accuracy Estimates

RESPONSE BY STATE	IN	MI	OH	PA	Overall
Adj sample size	323	290	430	452	1495
Responded	214	137	267	238	858
Response Rate	66.3%	47.2%	62.1%	52.7%	57.4%

Accuracy +/- 2%

HOW IS SOIL BALANCING PRACTICED?

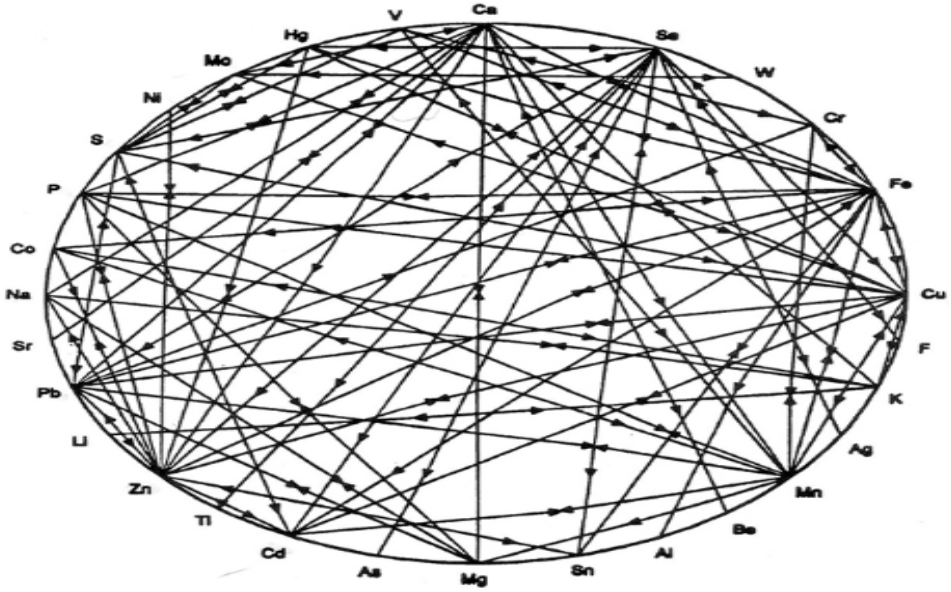
BCSR = a common core idea/practice

CONSULTANT INTERVIEWS & BOOKS:

- Calcium plays vital role in crop growth, soil physical properties, and in availability of other nutrients
- Soil structure and infiltration related to Ca:Mg ratio
- SB = associated with use of Hi-Cal lime and Gypsum for the purpose of raising Ca rather than just pH

Chemistry Beyond BSCR

“Everything works together”



Ag – Silver Al – Aluminum As – Arsenic Be – Beryllium Ca – Calcium Cd – Cadmium Cu – Copper Cl – Chlorine Co – Cobalt Cr – Chromium F – Fluorine Fe – Iron I – Iodine K – Potassium Li – Lithium Mg – Magnesium Mn – Manganese Mo – Molybdenum N – Nitrogen Na – Sodium P- Phosphorus S – Sulfur Se – Selenium Zn – Zinc

Figure 1. Mulder Mineral Wheel

(Watts 1995)

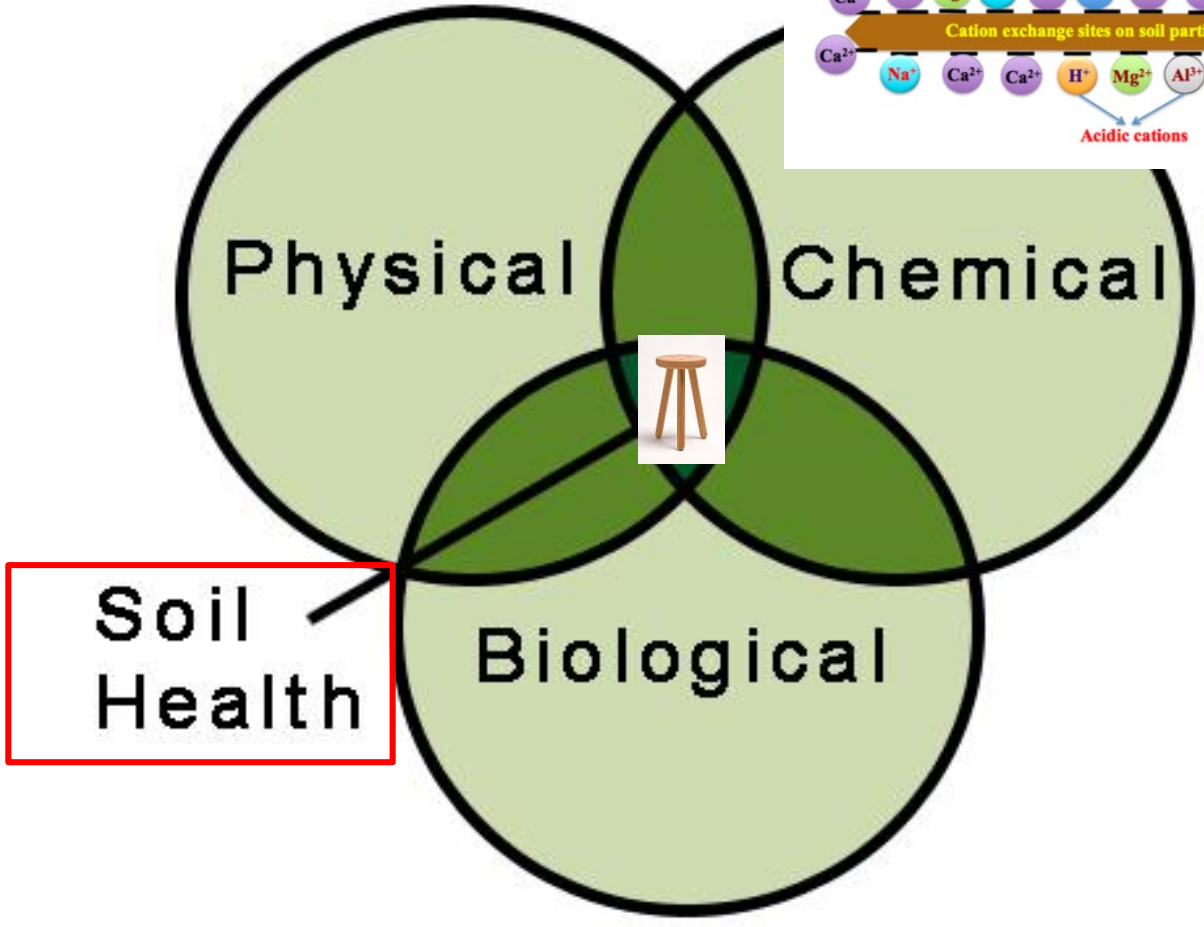
Nutrient Levels vs. Availability

Micronutrients

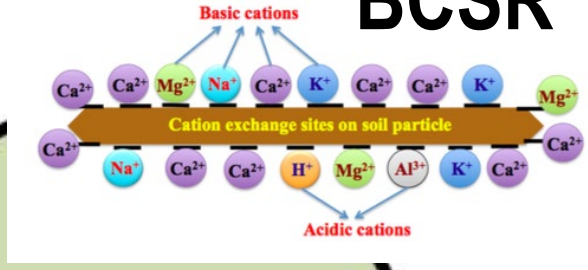
Boron

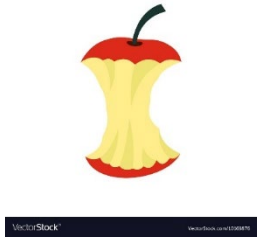
Calcium

BCSR is “core” of 3-legged stool



BCSR





To succeed = rely on mix of practices

<u>Amendments</u>

- Ca; Mg; S; Micro
- NPK
- Manure & compost

<u>Cultural practices</u>

- Tillage
- Crop rotations

Other insights from experience w/ SB…

http://www.notbeinggoverned.com/wp-content/uploads/2015/01/FALSE-DICHOTOMY-copy.jpg

CONTEXT MATTERS

- Cation exchange capacity (CEC)

SLAN STILL MATTERS

- Critical of 'overemphasis' on N,P,K, pH, but SLAN still viewed as vital

QUALITY OVER YIELD

LONG-TERM COMMITMENT

Soil Consultants

DIVERSE – not a single story

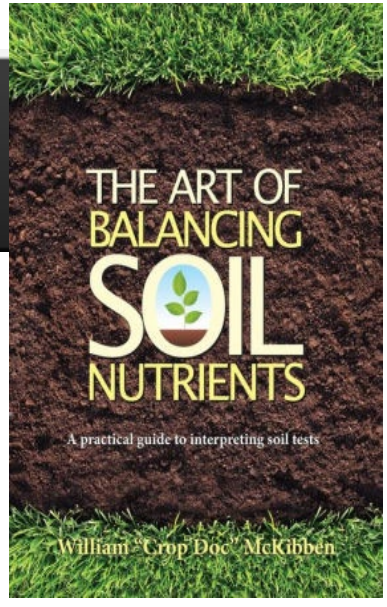
Biology is emphasized a lot more with some than the others

For some biology trumps chemistry

Midwestern BioAg™

KinseyAg

AGRI DYNAMICS



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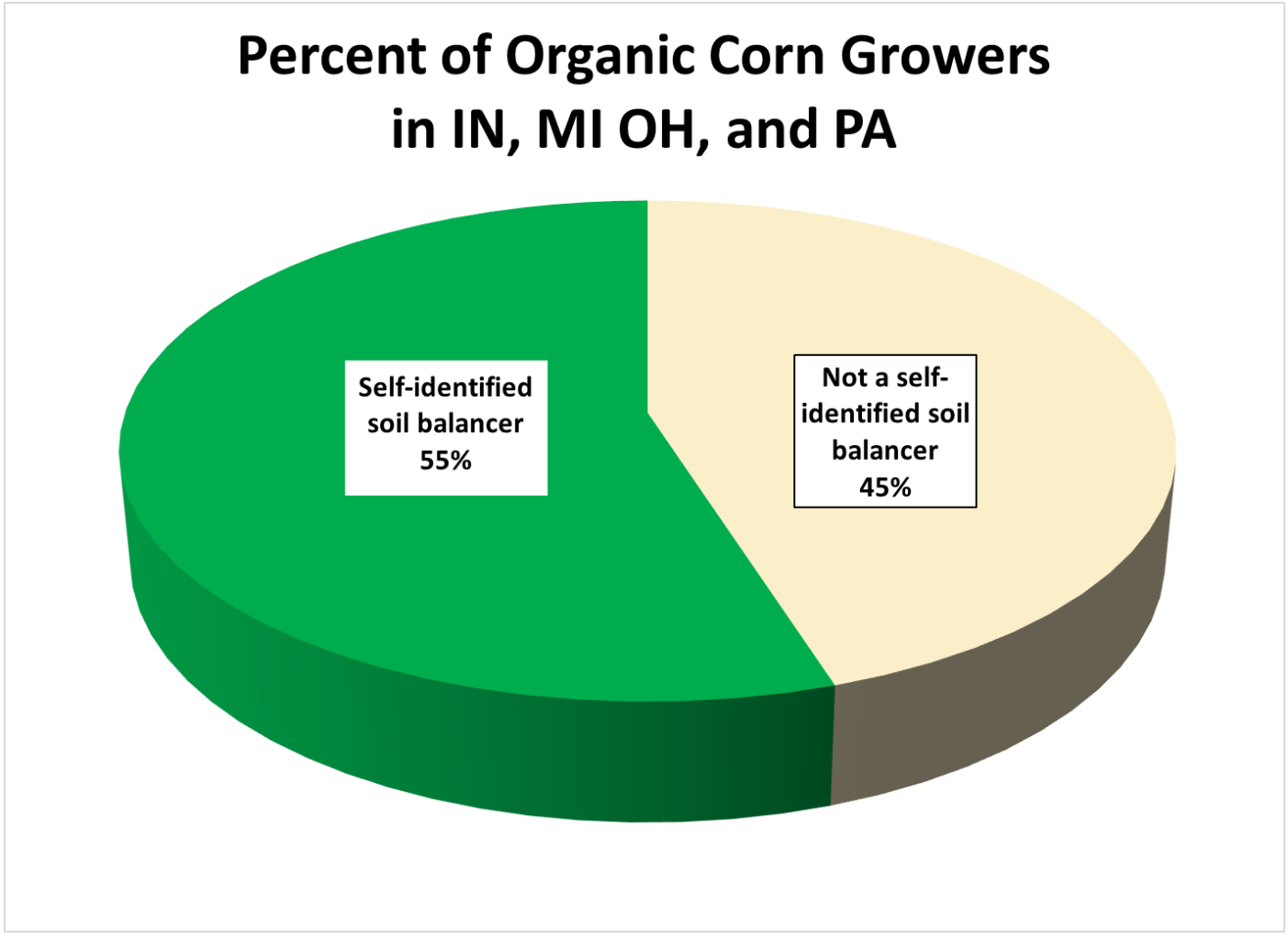
Farmers' soil balancing practices

- Even more diverse ways of thinking and practicing than consultants
- Emphasis on practices, outcomes (not philosophy/theory)
- Wide range of information sources to guide their decisions

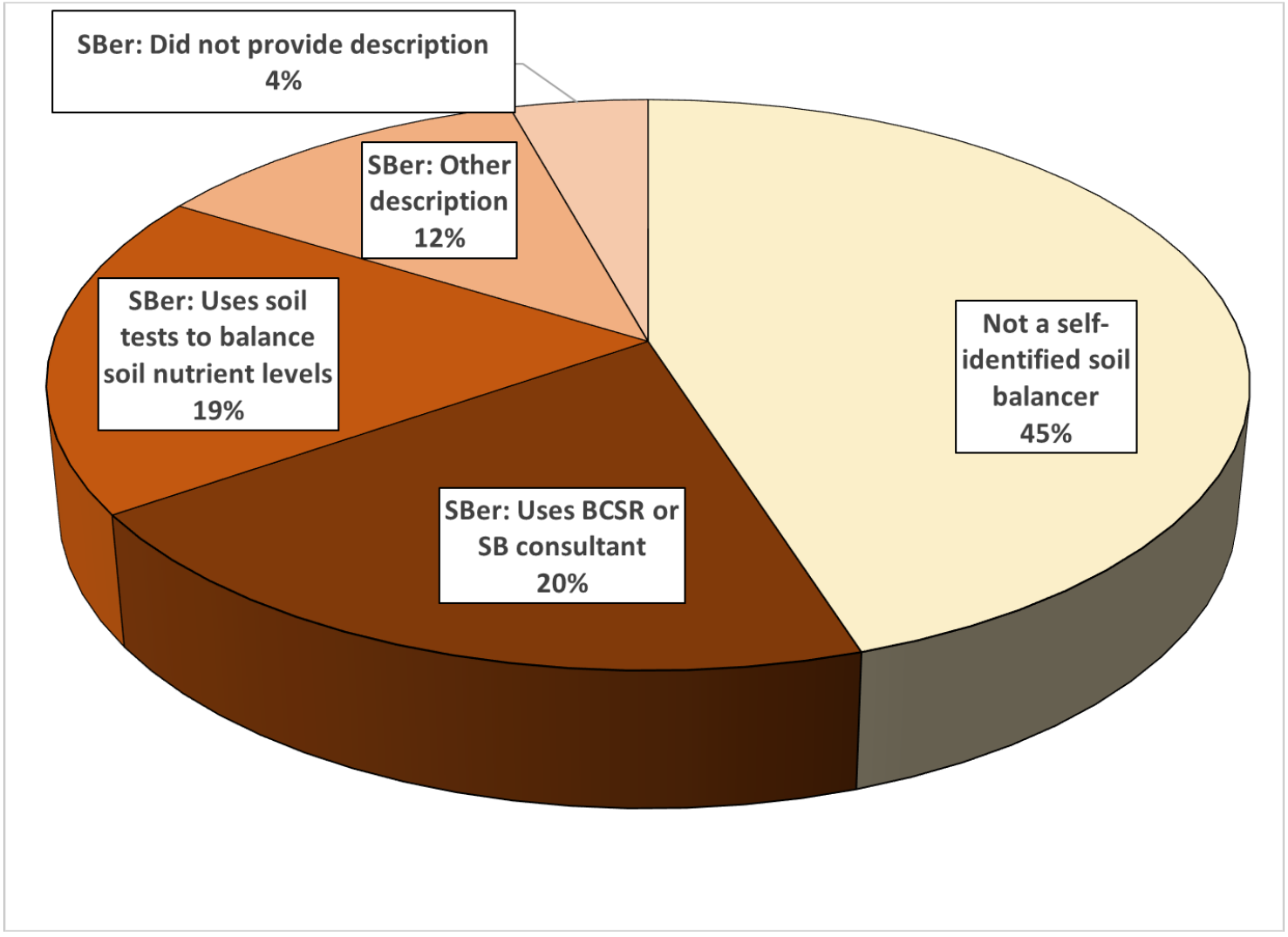
HOW COMMON IS SOIL BALANCING?

Self-Identified “Soil Balancers”

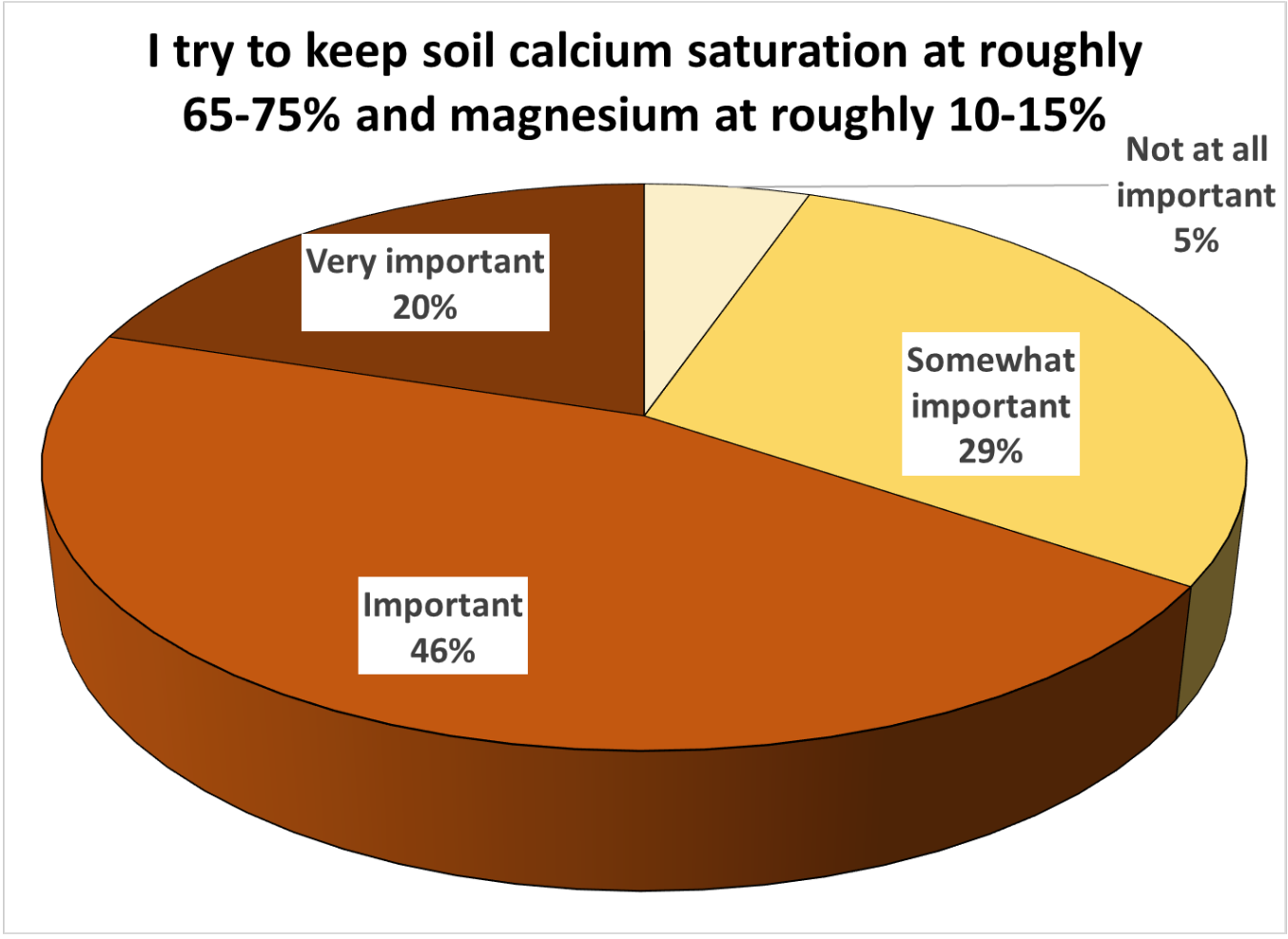


2018 survey results

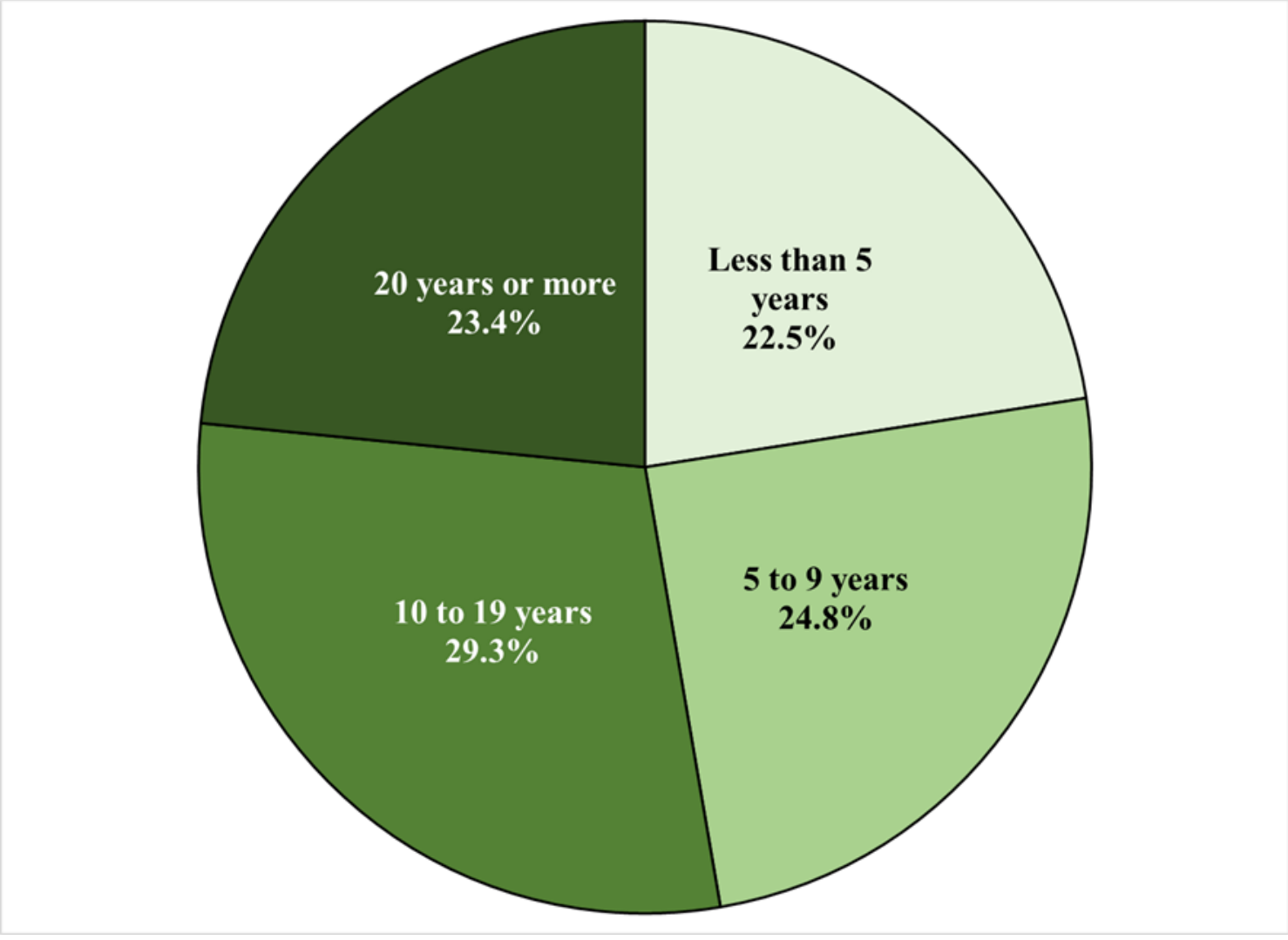
IF SBer: **Describe what you do and what you are trying to accomplish**



How important is this consideration to you when managing your organic farm fields?



Soil Balancing is a long standing practice



Overall, “Soil Balancers” apply more soil amendments

	Not a Self-Described Soil Balancer	Self-Described Soil Balancer	*Combined Full Sample*	
	N=364	*N=444*	*N=859*	
Hi-Cal -4years	18.7%	30.4%	*25.5%*	***
Gypsum-4years	15.7%	33.1%	*25.3%*	***
Any manure	88.5%	90.5%	*89.2%*	
Any NPK input[1]	30.5%	53.2%	*42.1%*	***
Any Micronutrients	11.8%	35.4%	*24.7%*	***
Microbial Stimulants & Inoculants	12.9%	25.9%	*20.0%*	***

NO DIFFERENCE: tillage, crop rotations, and cover crop management

What about non-organic producers?

- No good source of data to estimate…
- Discussions with consultants suggest it is common among grain farmers in midwest

How well does soil balancing work?

Interviewees and surveys

Common reports:

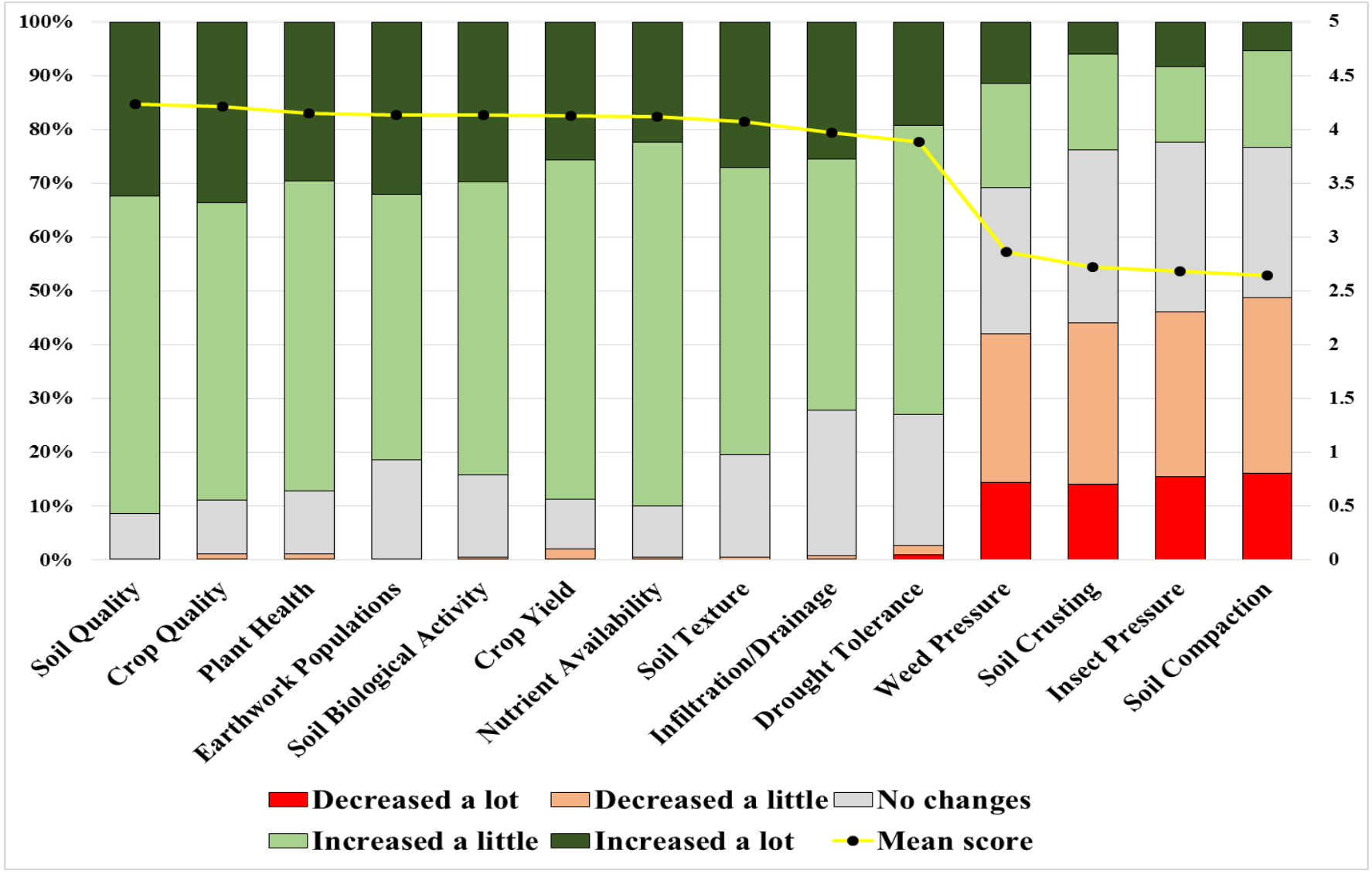
- Improved soil texture/drainage (less tight, better flocculation)
- Greater crop nutrient availability
- Enhanced crop quality

Other

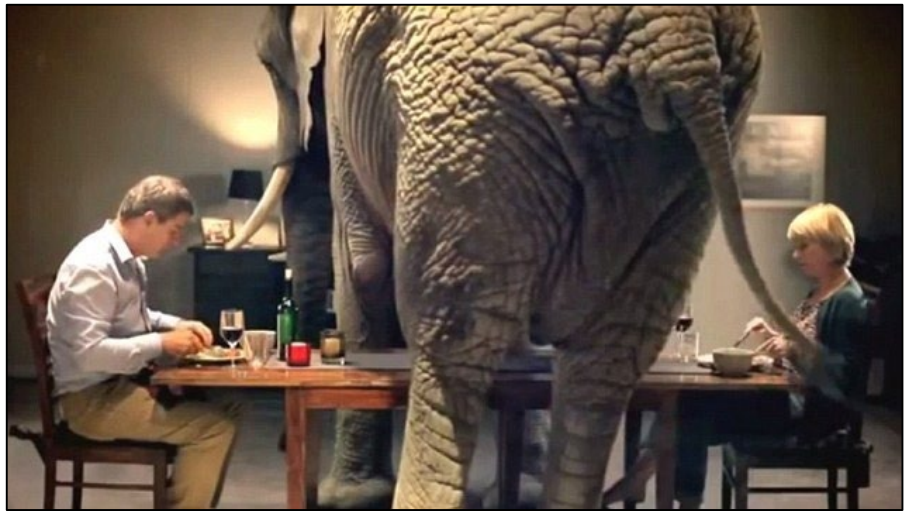
- Lower weed, insect pressure
- Better plant health
- More soil biological activity

Interconnected nature of benefits

Percent of Self-Identified Soil Balancers Reporting Positive and Negative Outcomes



The Elephant in the Room



http://www.stjameslaf.org/church/the-elephant-in-the-room/?tag=Philippians

- How reconcile widespread use of 'soil balancing' with lack of scientific 'proof'?
- Some ideas
  - Practice of SB is more complex than simple BCSR
    - Results observed in field reflect impacts of combinations (or just other practices)
  - Science = limited
    - Few studies
    - Short term
    - Limited set of outcomes (mainly yield)
    - Not under realistic production conditions

THANK-YOU!

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QUESTIONS?

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