Soil Health: What Is All The Fuss?

Tim Reinbott

Crop Management Conference 2025

Soil Health Background

William Albrecht Saturday Evening Post- September 1945

Are We Starving to Death?

By NEIL M. CLARK

An eminent soil doctor warns that, unless we attack the problem of mineral-depleted land on a national scale, we face slow extinction from "hidden hunger."

WHEN Jim was driving me to the station, he abandoned the old-college-days kidding attitude that he had maintained at dinner before his wife and daughter, and spoke seriously of his personal tragedy. He mentioned his father, who had lived to be eighty-six and was strong and active almost to the last. "My aunts and uncles, too," he said—"none of them died under seventy-five. And look at me," bitterly. "Just look at me!" I had already looked and been shocked. "It's my heart, the doctor says. Why should I have a bad heart? I've always taken care of myself. But here I am, a little past fifty, and I know as well as anybody that I might pop off at any time. Neil, can you tell me—can anybody tell me why I'm not so good a man as my dad was—why I'll never live as long as he did?"

I couldn't, and didn't try. It occurred to me, too, that I couldn't explain why Jim's wife has been anemic as long as I have known her, nor why their daughter, as a child, gave signs of rickets.

Two things in the next few weeks reminded me of Jim's desperate questions. While I was having an inlay replaced, my dentist took occasion to say that his own teeth weren't so good as his Texas father's, and that few of his patients had teeth as good as their parents'. I wondered if that might not have some bearing on Jim's questions. Still later I was sitting in Dr. Wm. A. Albrecht's office at the University of Missouri, in Columbia, listening to an absorbing and almost unbelievable story about health in America and the particular chapter in that story which he has helped to write, and I interrupted to mention Jim. "Could it be," I asked him, "that he is simply hungry?"

"It could be," Doctor Albrecht answered.

I had come to ask Albrecht if America could expect to keep on eating well. "America," he said grimly, "is not eating well now."

Dr. Wm. A. Albrecht *(right)* and Dr. H. S. Wittwer checking results of some soil tests on spinach.

stand that more diseases than they ever suspected could be traced to dietary deficiencies, and that many sick people were hungry people. They called it 'hidden hunger' because people who ate three squares a day, numbers many physiologists, physicians, surgeons and dentists among his close friends. He is a doctor of soil, a student and teacher of soil chemistry, head of the Department of Soils at the University of Missouri. However, he has never believed in hard-and-fast boundaries between sciences, and when it became clear there must be a tie-up between human health and the soil, he made that the major goal of his research. How, he asked himself, do soil and plants work together? Strangely, though agriculture is mankind's oldest industry, nobody knew; not as scientists insist on knowing. What, Albrecht asked himself, is plant health, and how does it depend on soil health, and what does it mean for those of us who can't explain or doctor our chills and fevers away?

Two things that Albrecht did have helped to revolutionize scientific thought and practice in this whole field. First, he developed a complete hypothesis as to why some soils in constant agricultural use become sick and others stay well; some of the soils of China have been in yearly use for forty centuries and are still healthy. Next, he developed a fully controlled technique for testing treatments designed to produce healthy soils and healthy plants. These two steps are somewhat comparable to the development in medicine of the germ hypothesis, plus a laboratory technique for finding out how germs act. To describe Albrecht's hypothesis and technique in detail would take more space than can be allowed in this article. But enough must be told for the reader to understand in a general way what happens. Perhaps the easiest approach is through Hans Jenny and his experiment that failed.

Jenny, fresh over from Zurich, was one of Albrecht's research assistants from 1927 to 1936; now he is associate professor of soil chemistry at the University of California. He was experimenting with soybeans fed

Dr. Albrecht Showed This Relationship Between the Soil and Human Health

other plants eaten by domestic animals, and what they from treated soil made nearly three times as much gain their minerals. The loss (Continued on Page 88)

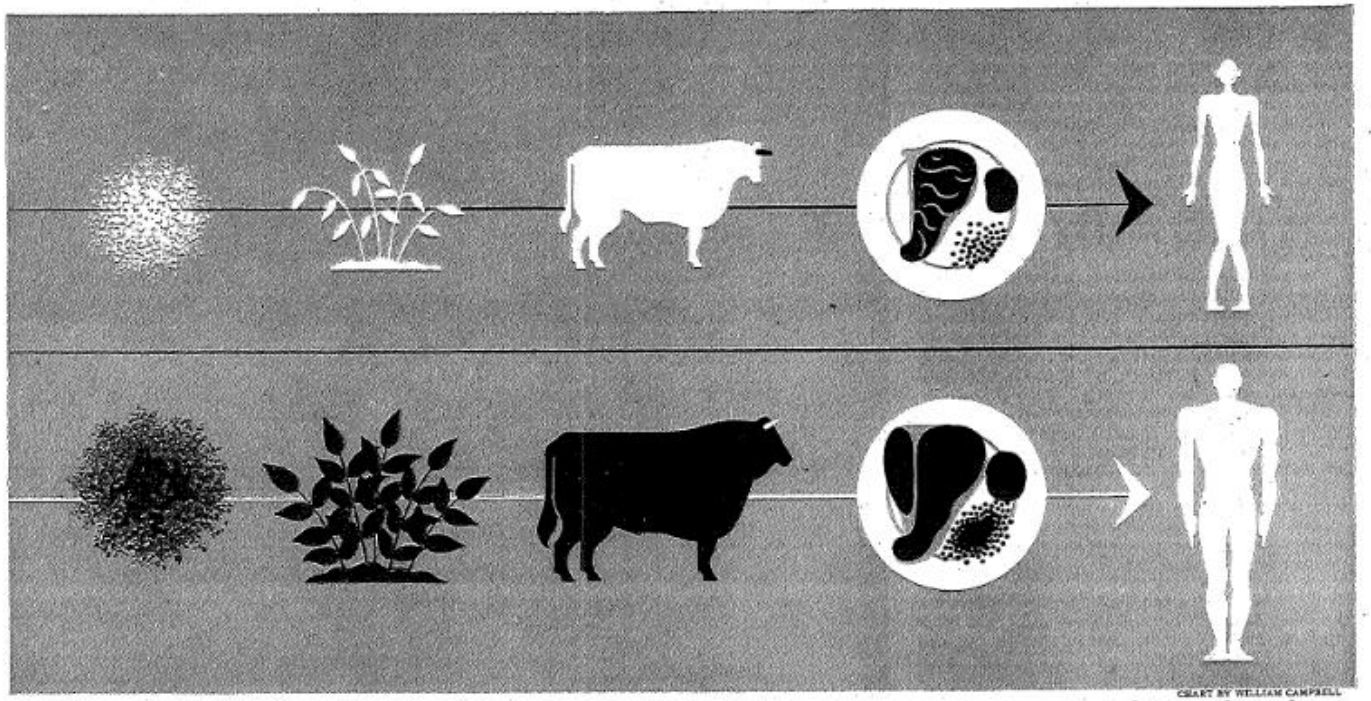

CHART BY WILLIAM CAMPBELL

How to starve on three big meals a day. *Upper:* Soil deficient in minerals produces a crop similarly lacking; the livestock raised on it, and you who eat the livestock, suffer from "hidden hunger." *Lower:* Mineral-rich soil means fuller growth and sturdier health for the crop, for the livestock and for you.

What is the Definition of Soil Health? From USDA NRCS

Continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.

- **Regulating water**
  Soil helps control where rain, snowmelt, and irrigation water goes. Water flows over the land or into and through the soil.
- **Sustaining plant and animal life**
  The diversity and productivity of living things depends on soil.
- **Filtering and buffering potential pollutants**
  The minerals and microbes in soil are responsible for filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposits.
- **Cycling nutrients**
  Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and cycled in the soil.
- **Providing physical stability and support**
  Soil structure provides a medium for plant roots. Soils also provide support for human structures and protection for archeological treasures.

Modern Soil Health (Soil Quality) Was Brought Back To The Forefront By Diann Jordan and Bob Kremer In The mid 1990s

Potential use of soil microbial activity as an indicator of soil quality.

Book chapter: Soil biota: management in sustainable farming systems., 1994, 245-249 ref. 18

Authors: D. Jordan, R. J. Kremer

Editors: C. E. Pankhurst, B. M. Doube, V. V. S. R. Gupta, P. R. Grace

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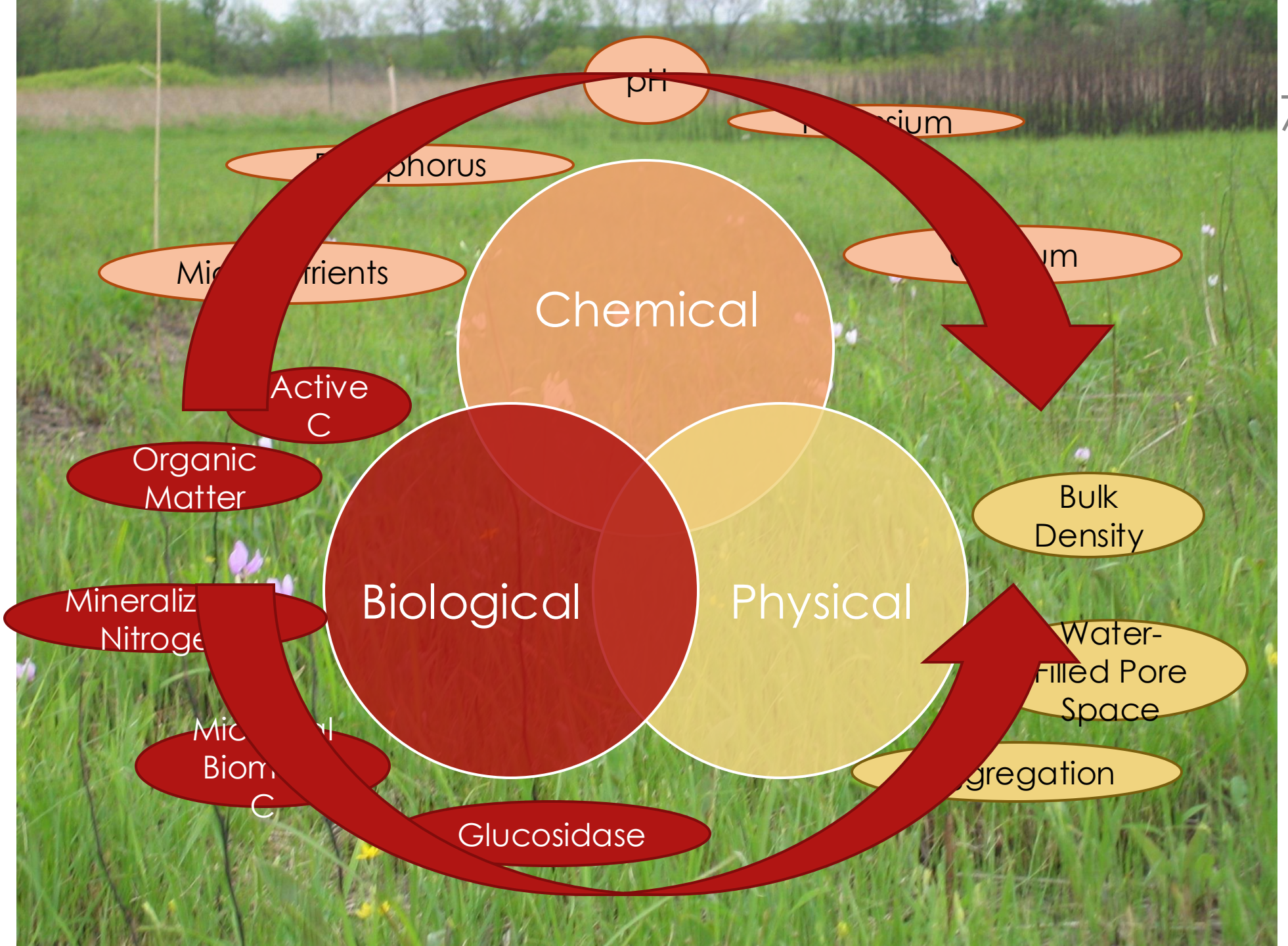

pH
Chemical
Active C
Organic Matter
Biological
Physical
Bulk Density
Water-Filled Pore Space
Glucosidase

Mother-in-Law-56 Years of the Same Garden Site: Her First Garden Was Her Best Garden

Grandma and Grandpa In Their Garden When They Are In Their Late 70’s.

Often When You Plow Up a Pasture You Have A Bumper Yield The First Year, Maybe the Second and Then It Goes Down. Why?

Tilled vs No-Till-We Have Destroyed Much of Our Soil Structure-Lets Talk About Regenerative Agriculture

Long Term Pasture

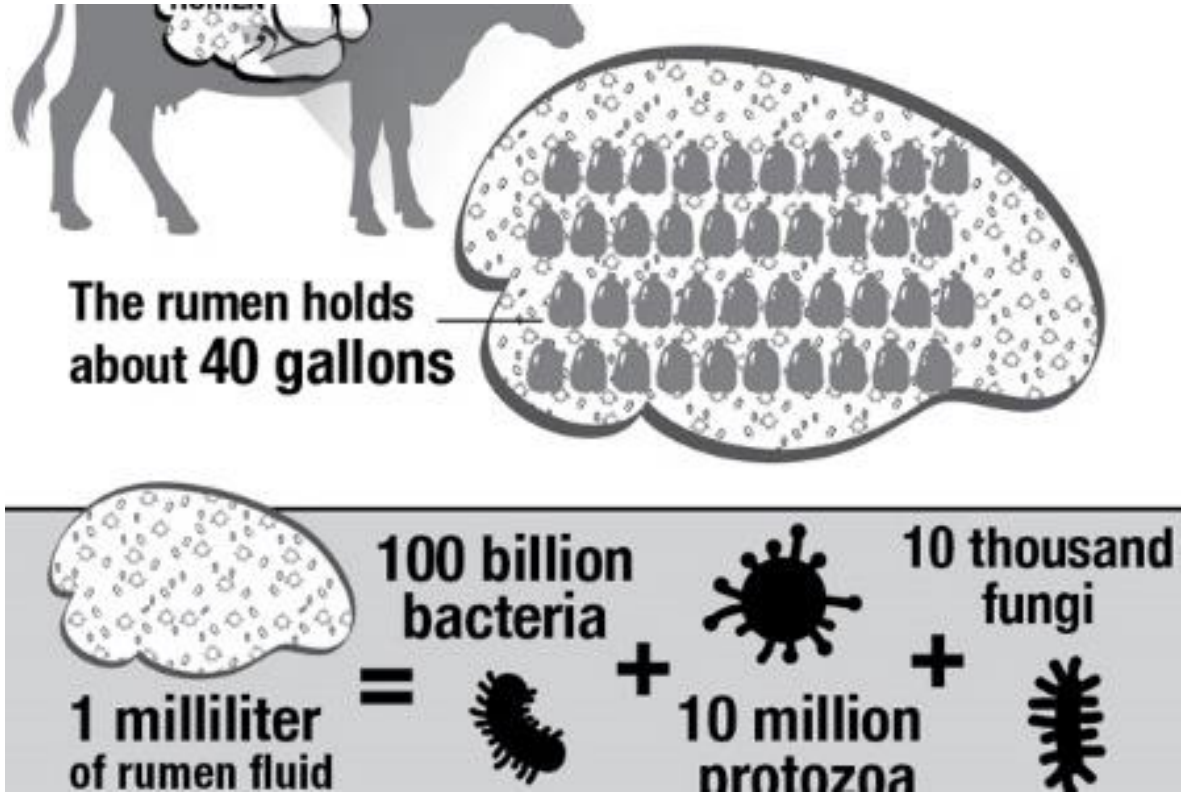
Tilled in an Annual Crop

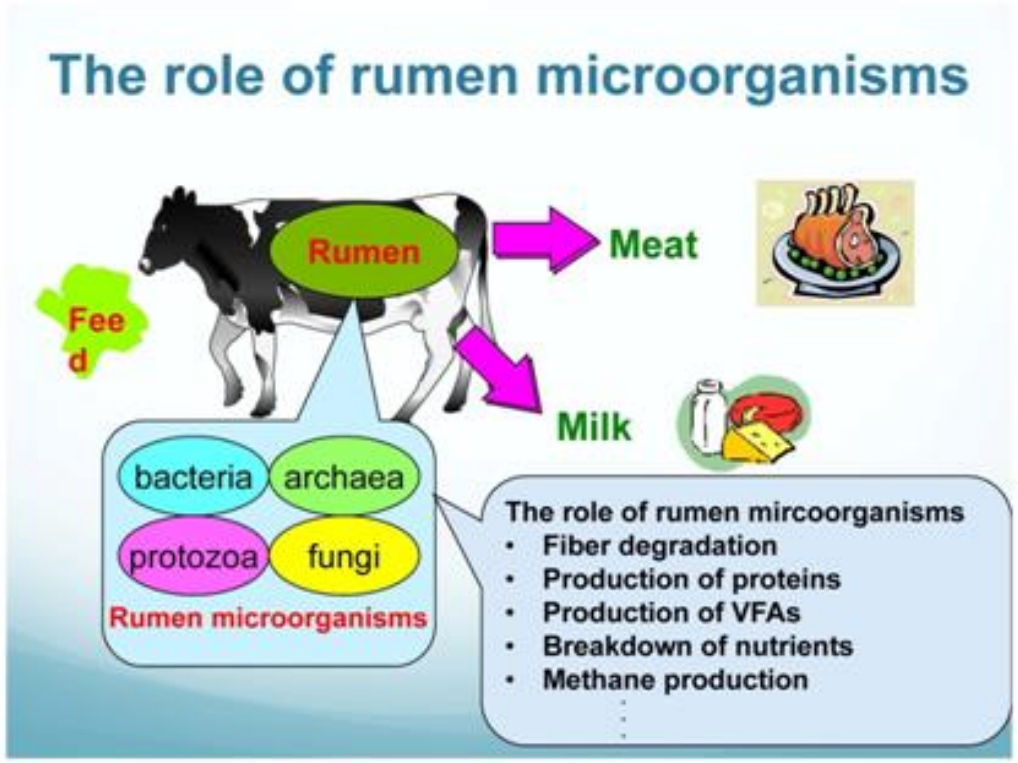
Take A Look At Soil Health Components

Soil Biology: Microorganisms:

- Bacteria-100 million-1 Billion!
- Fungal Filaments-Several Yards
- Protoza-Several Thousand
- Nematodes-10-20

Cow's Stomach and The Soil-Feed The Microbes Fed The Cow and Plant





Annual Cover Crops and Perennial Crops Are a Way To Increase Soil Biology

Cover Crops Nothing New: My Dad Did This is the 1930's.

Cover Crop (left) Larger and More Robust Than No Cover Crop (right)-Dry Year and Better Soil Health=More Soil Water

Longer Rotations Using Cover Crops, Using Perennial Crops Can Also Improve Soil Health

Lengthening the Rotation Resulted In Greater Soybean Yield In Dry Years

Rotation	Cover Crop	Crop(s)	Soybean Yield
			Bu/acre
Continuous	none	Soybean	39
	Yes		46
Two-Year	none	Corn/soybean	42
	Yes		42
Three-Year	none	C/Soy/Wheat	42
	Yes		52
Four-Year	none	C/Soy/W/Red Clover	52
	Yes		52
Five Year	none	C/Soy/W/2 Alfalfa	54
	Yes		58
LSD (0.05)			9
LSD (0.10)			8

Lengthening Rotation and Cover Crops Increased Soybean Yield in a Wet Year Too

Rotation	Cover Crop	Yield
		bu/acre
Continuous-no-till	none	70
	Yes	70
Continuous-tilled	none	64
	Yes	66
Corn/soybean	none	68
	Yes	73
Corn/soybean/wheat	none	72
	yes	71
Corn/soybean/wheat/red clover	none	70
	Yes	72
Corn/soybean/wheat/2 years alfalfa	none	72
	Yes	78
LSD (0.05)		4
LSD (0.10)		3

In Only Two Years A Perennial Cover Crop Can Make Huge Differences In Soil Health

Treatment	Aggregate Stability	Active Carbon	B-Glucosidase	Soil Organic Carbon	Total Nitrogen
	g/kg	g C/kg soil	µg PNP/g soil/hr	g/kg	g/kg
Alfalfa	33.0	0.39	65.8	1.53	0.15
Tilled annual	13.3*	0.33*	45.6*	1.33*	0.12*

- * Indicates significant difference at the 0.05 probablity level

Living Cover Crop-White Clover-A Perennial Clover

What About Soil Chemistry-Nutrients?

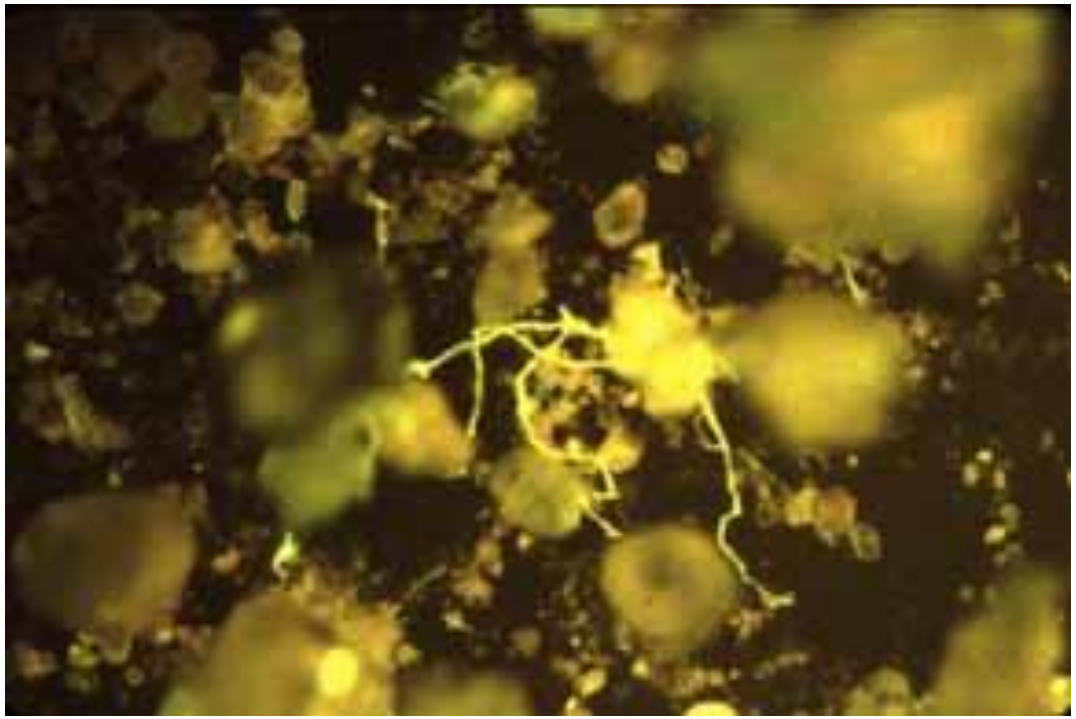
Is there an interaction with Soil Biology?

What Does Recent Data From Sanborn Tell Us About the Interaction of Soil Chemistry and Biology?

	Chemical				Biological
Fertility	**pH**	**TN**	**P**	**SOC**	**Microbes**
		g/kg	**mg/kg**	**g/kg**	**pmols/g**
No Fertility	**5.5 a**	**1.15 a**	**5.2 a**	**10.7 a**	**72,334 a**
Full Fertility	**5.7 a**	**1.45 b**	**37.0 b**	**14.0 b**	**90,902 b**
Manure	**6.9 b**	**1.78 c**	**56.2 c**	**17.5 c**	**121,854 c**

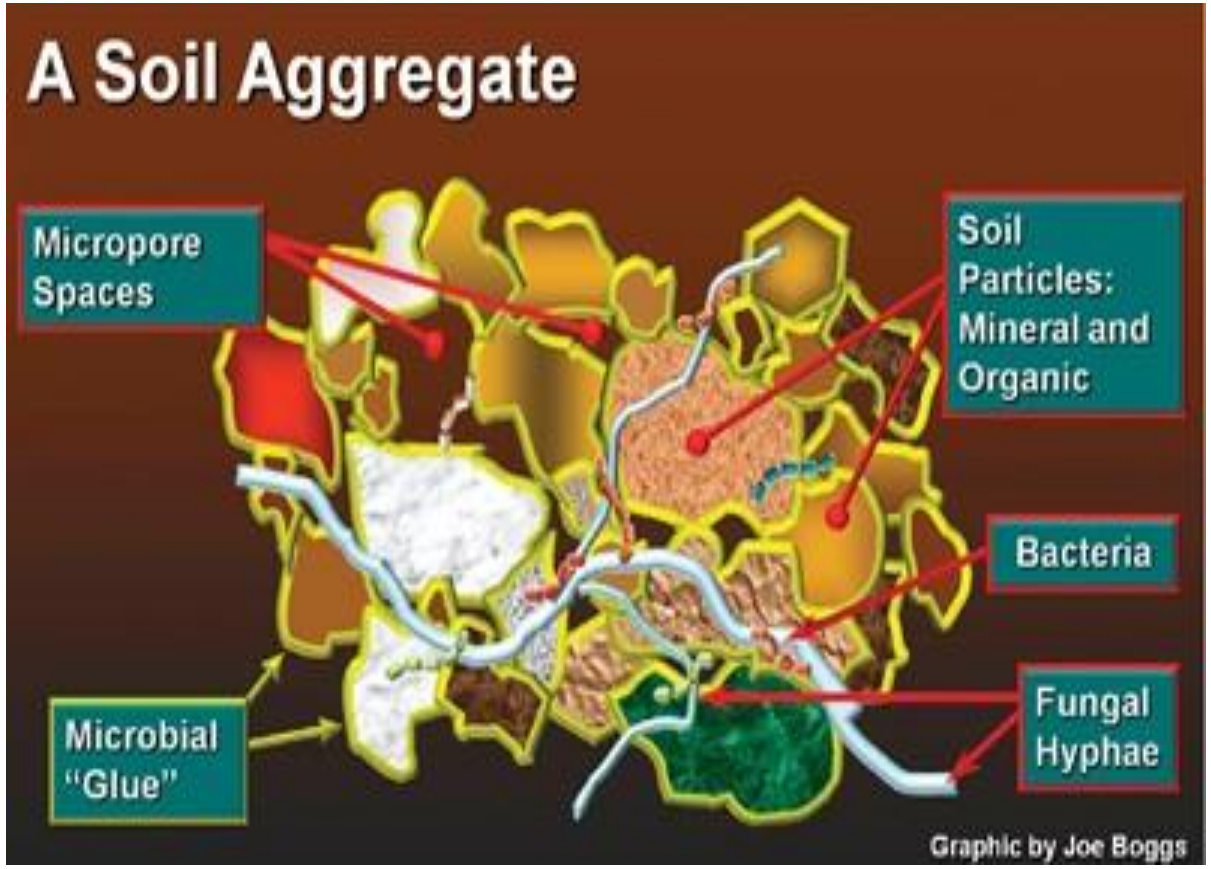
Different letters indicate significance at the 0.05 probability level

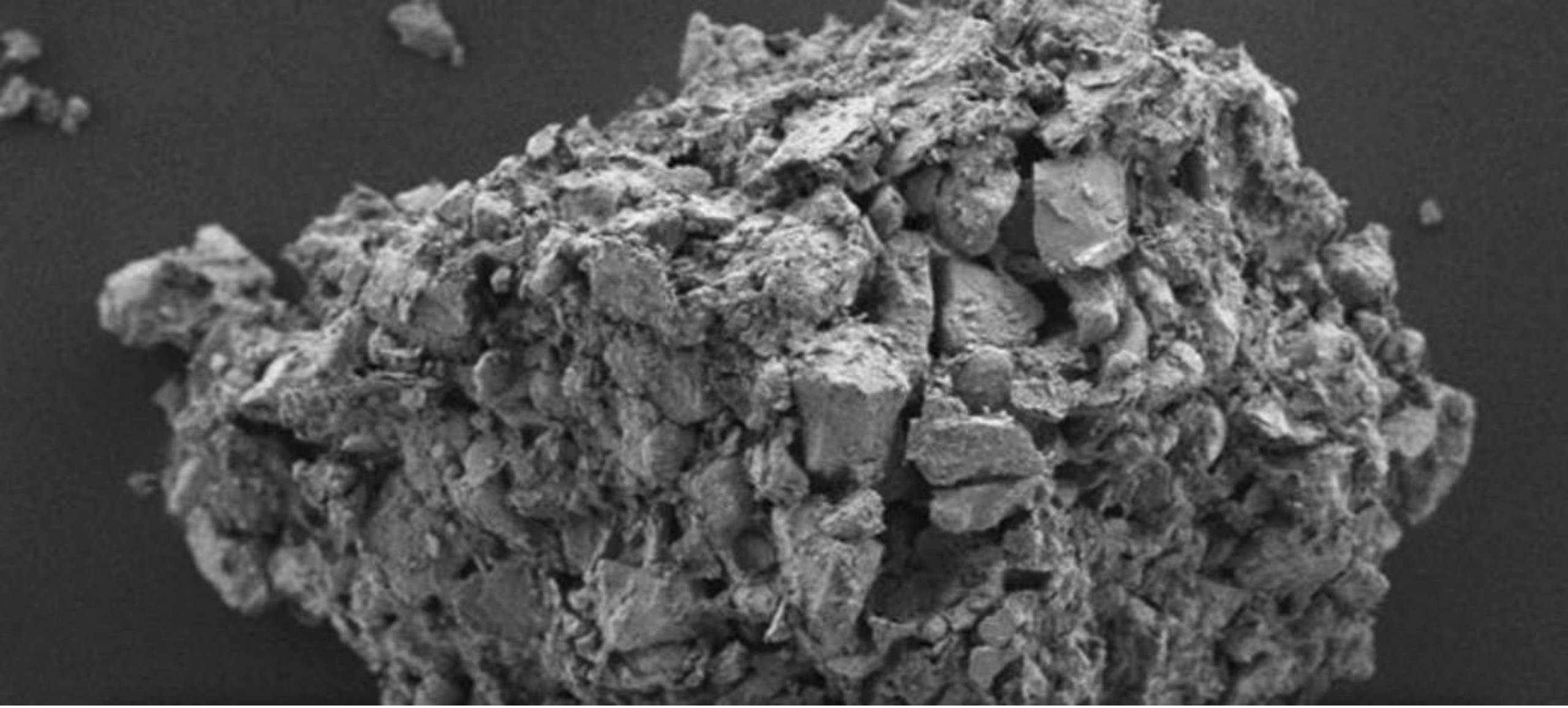
Living Plant Roots Exudates Feeds The Bacteria, Fungi, and other Life-20-40% of Carbon Fixed By The Leaves Is Exuded By the Roots



Soil Physical Properties:

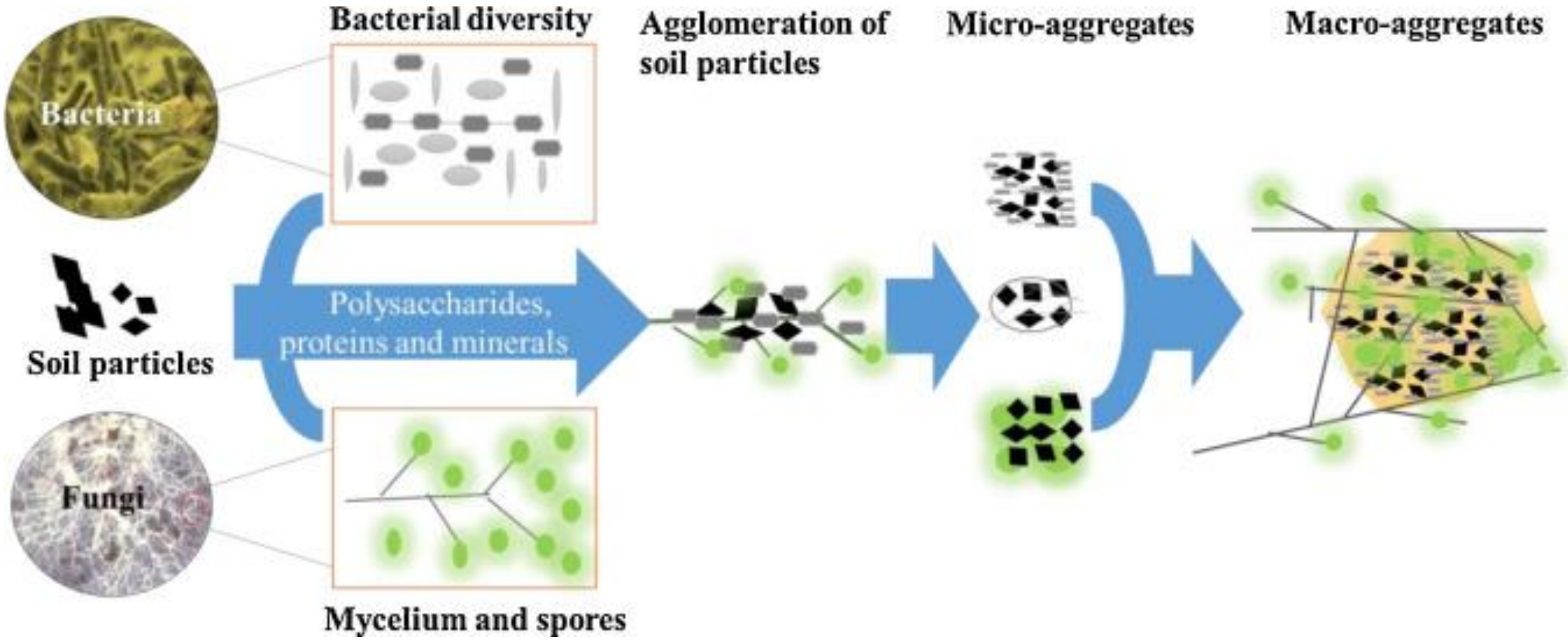
The End Product of the Interaction of Soil Chemistry and Biology is Good Physical Soil Properties=Aggregate Stability

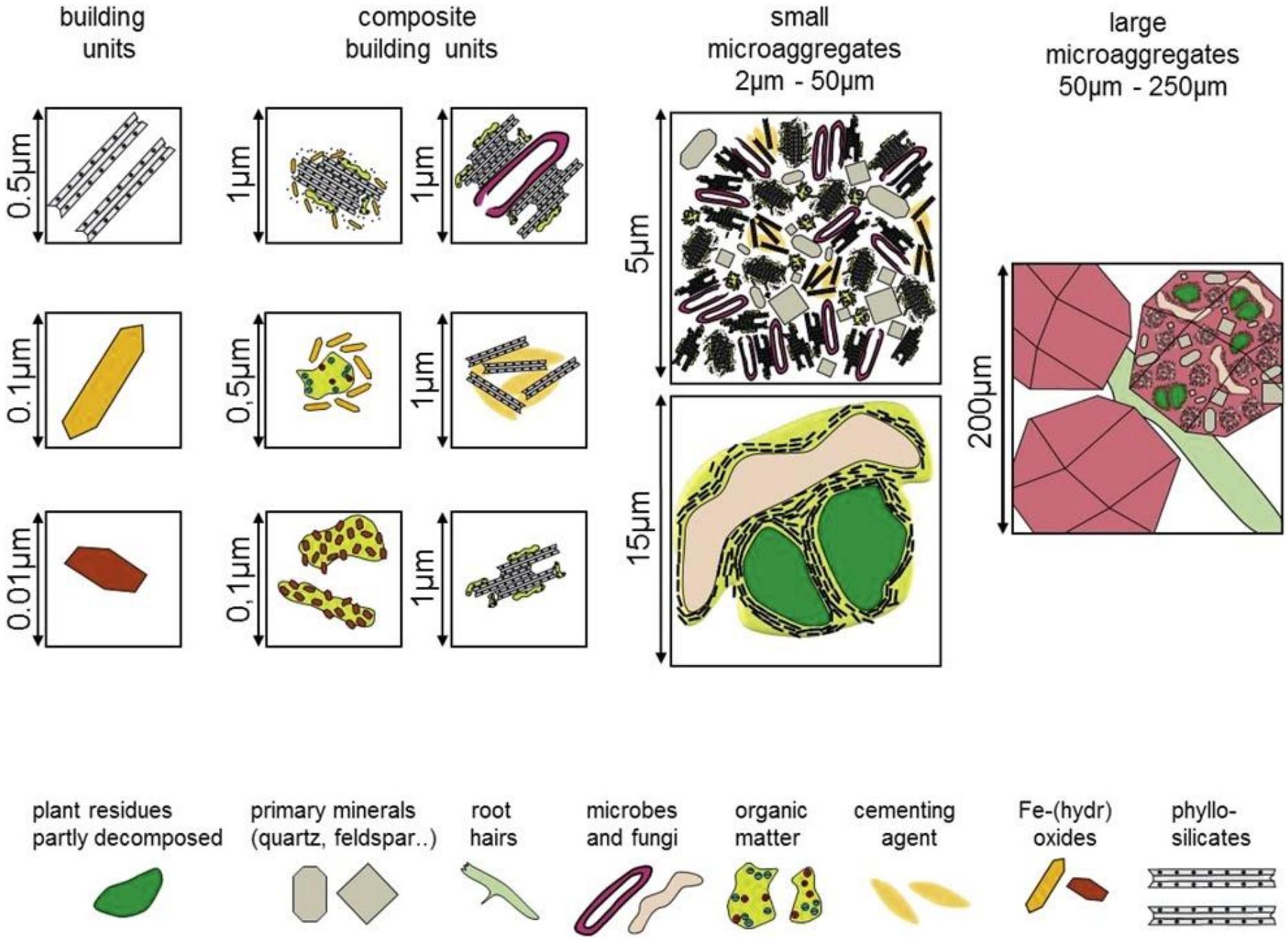




A Soil Aggregate

How Are Aggregates Formed? Soil Biology Microorganisms-Hyphae and Glomulin




building units
composite building units
small microaggregates 2µm - 50µm
large microaggregates 50µm - 250µm
0.5µm
0.1µm
0.01µm
1µm
1µm
0,5µm
1µm
0,1µm
1µm
5µm
15µm
200µm
plant residues partly decomposed
primary minerals (quartz, feldspar..)
root hairs
microbes and fungi
organic matter
cementing agent
Fe-(hydr) oxides
phyllo-silicates

Aggregates Formed By The Attraction of Cations Like Ca and Mg to Clay and Organic Compounds.

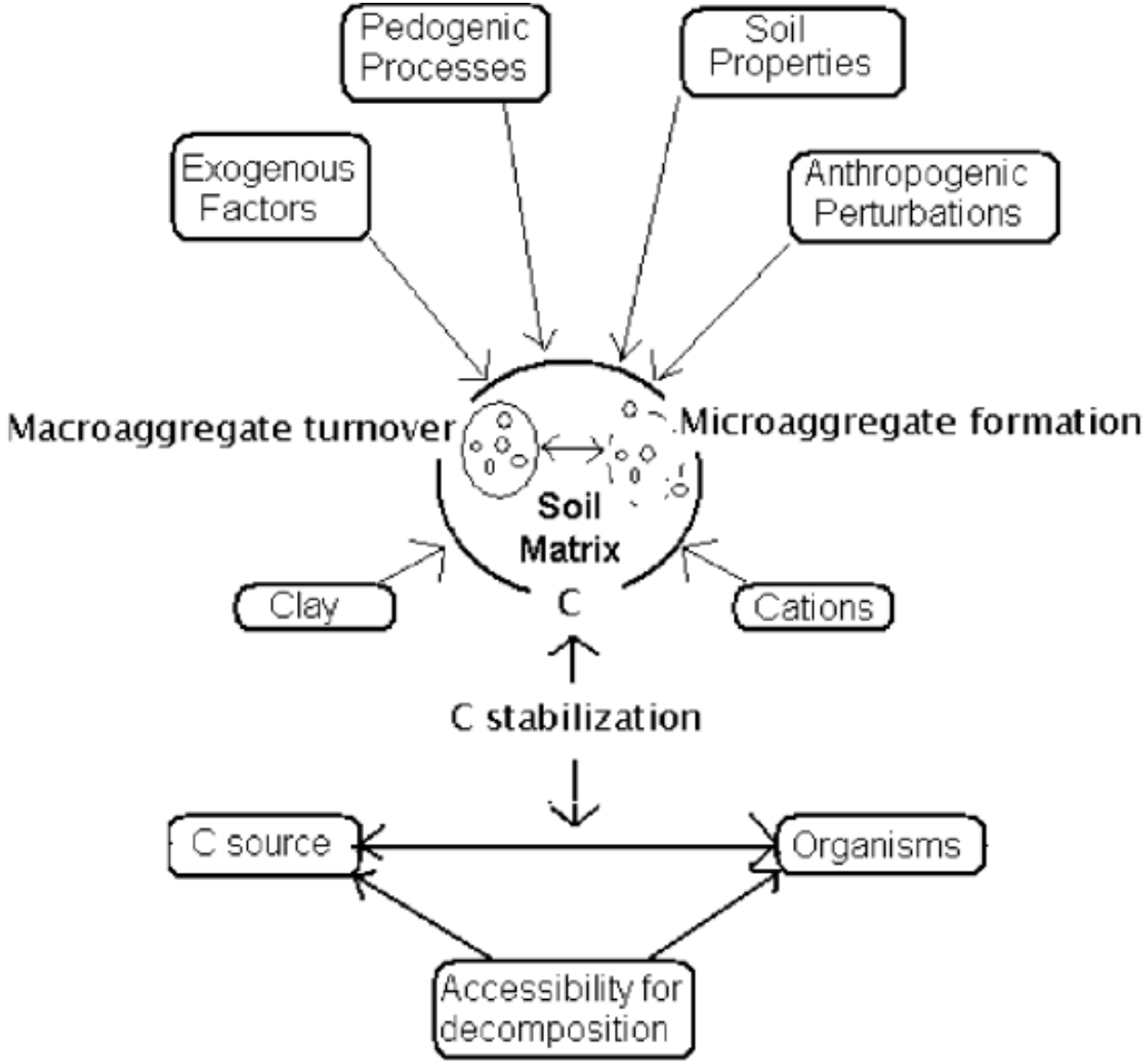
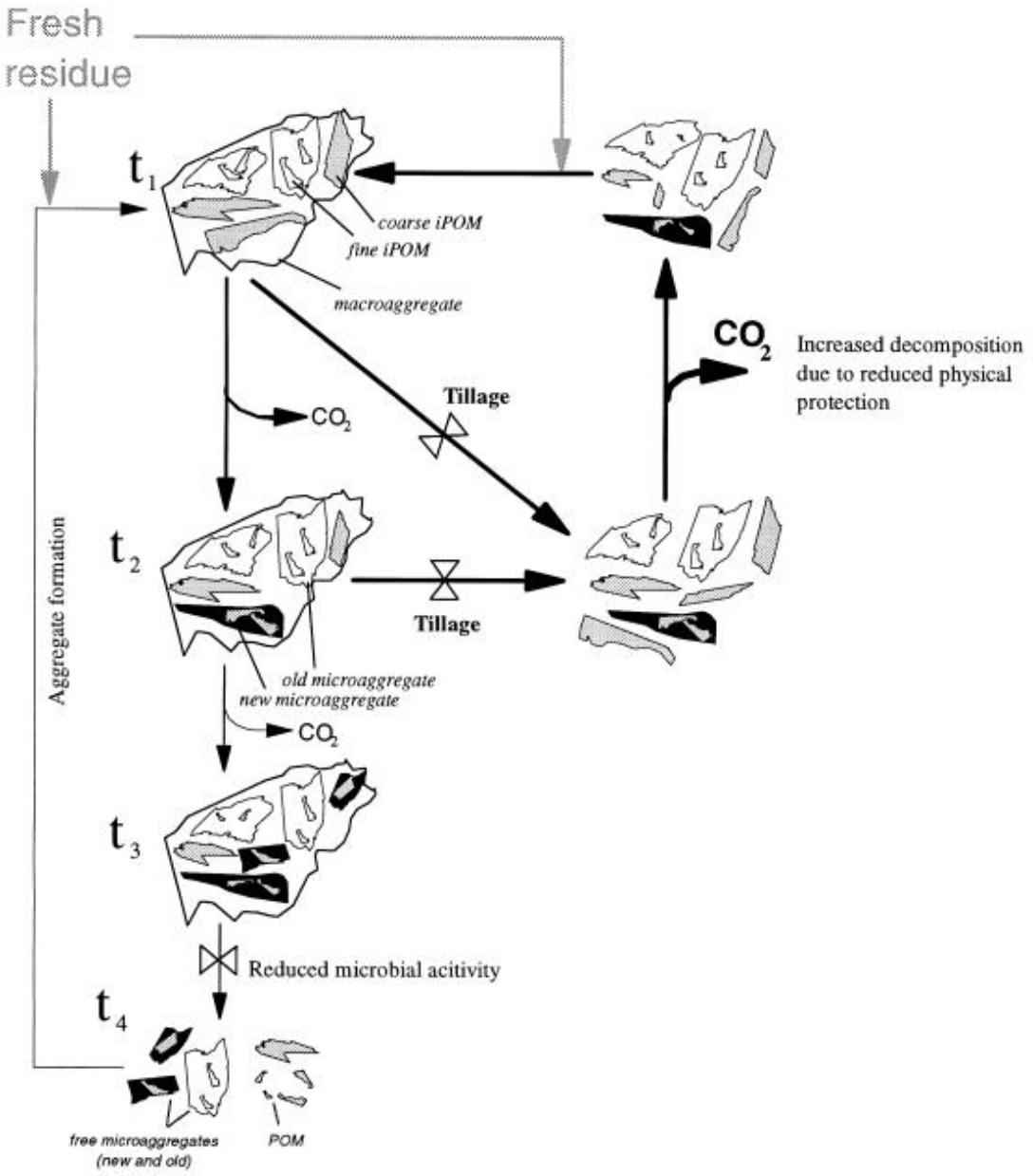


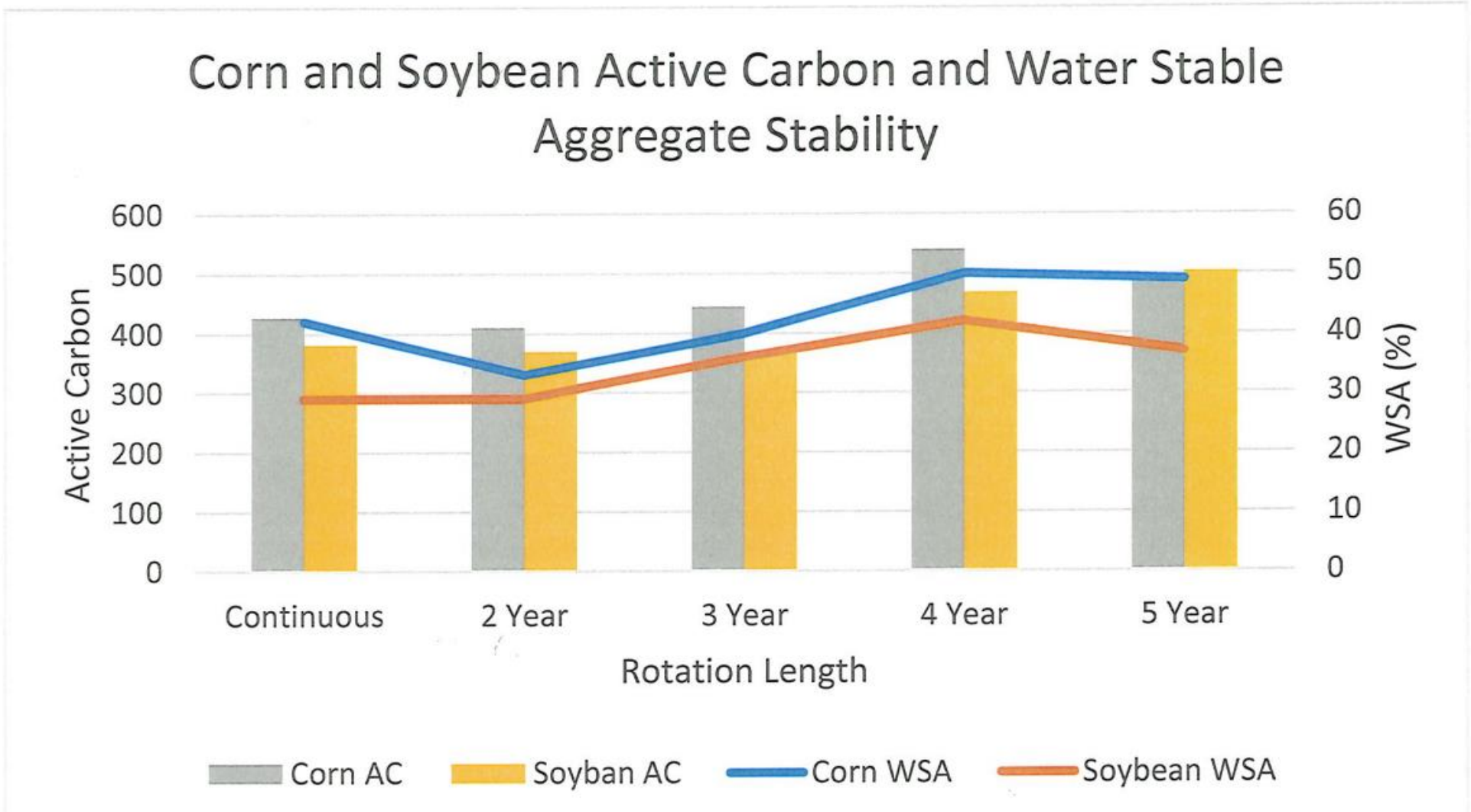
Fig. 2. Factors affecting soil aggregation.

Macroaggregates Are Constantly Being Broken Down to Microaggregates. Tillage Speed This Up

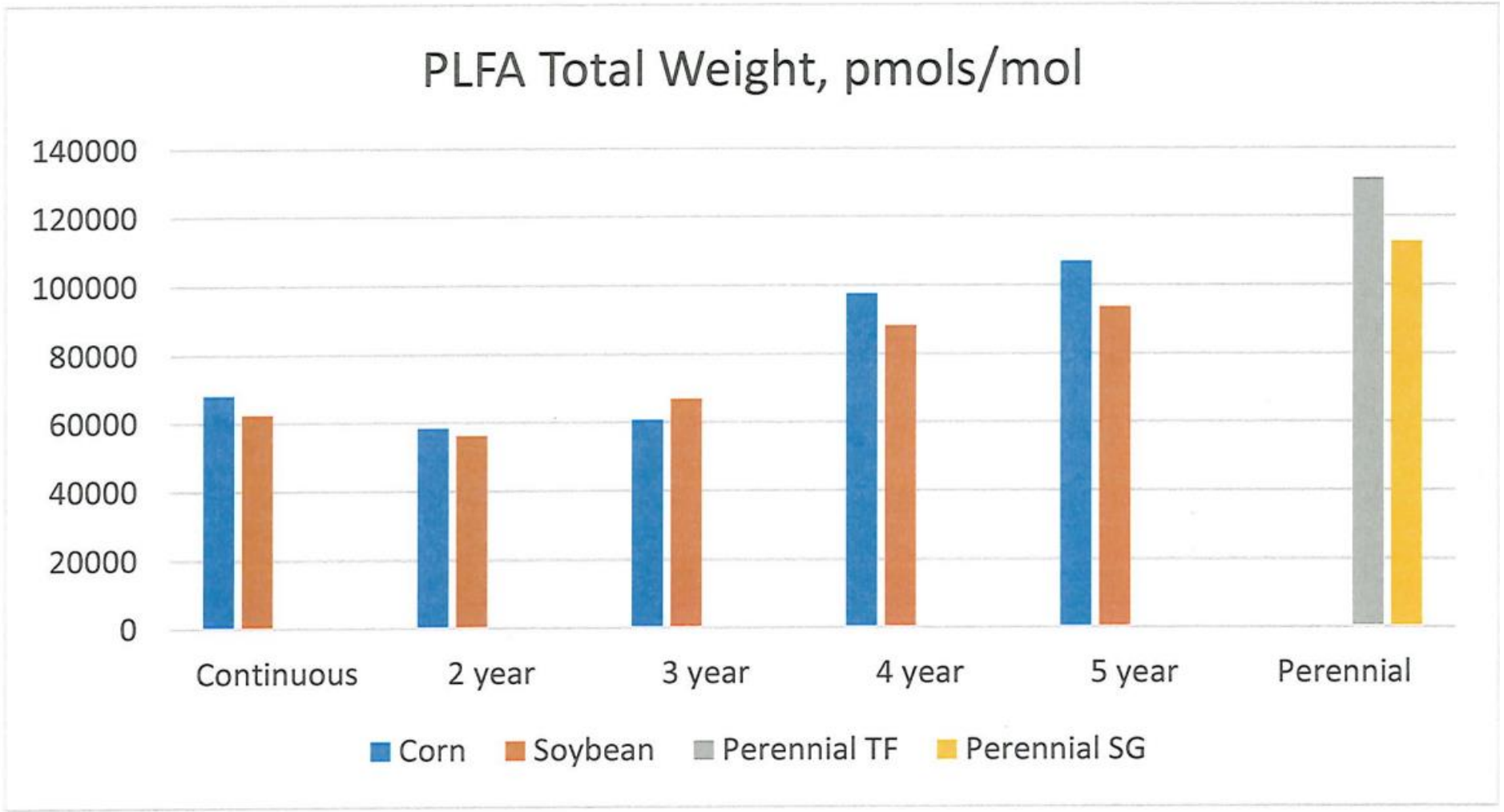


Longer Rotations Using Cover Crops, Using Perennial Crops Can Also Improve Soil Health By Improving Soil Biological, Chemical and Physical Properties

Lengthen Rotation Increase POXC (Active Carbon) and Aggregate Stability. Note that Soybeans were Generally Lower Than Corn in Soil Health Indicators.

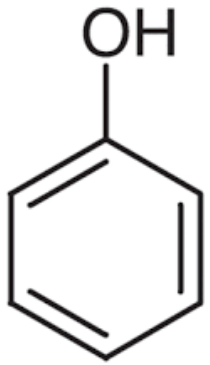


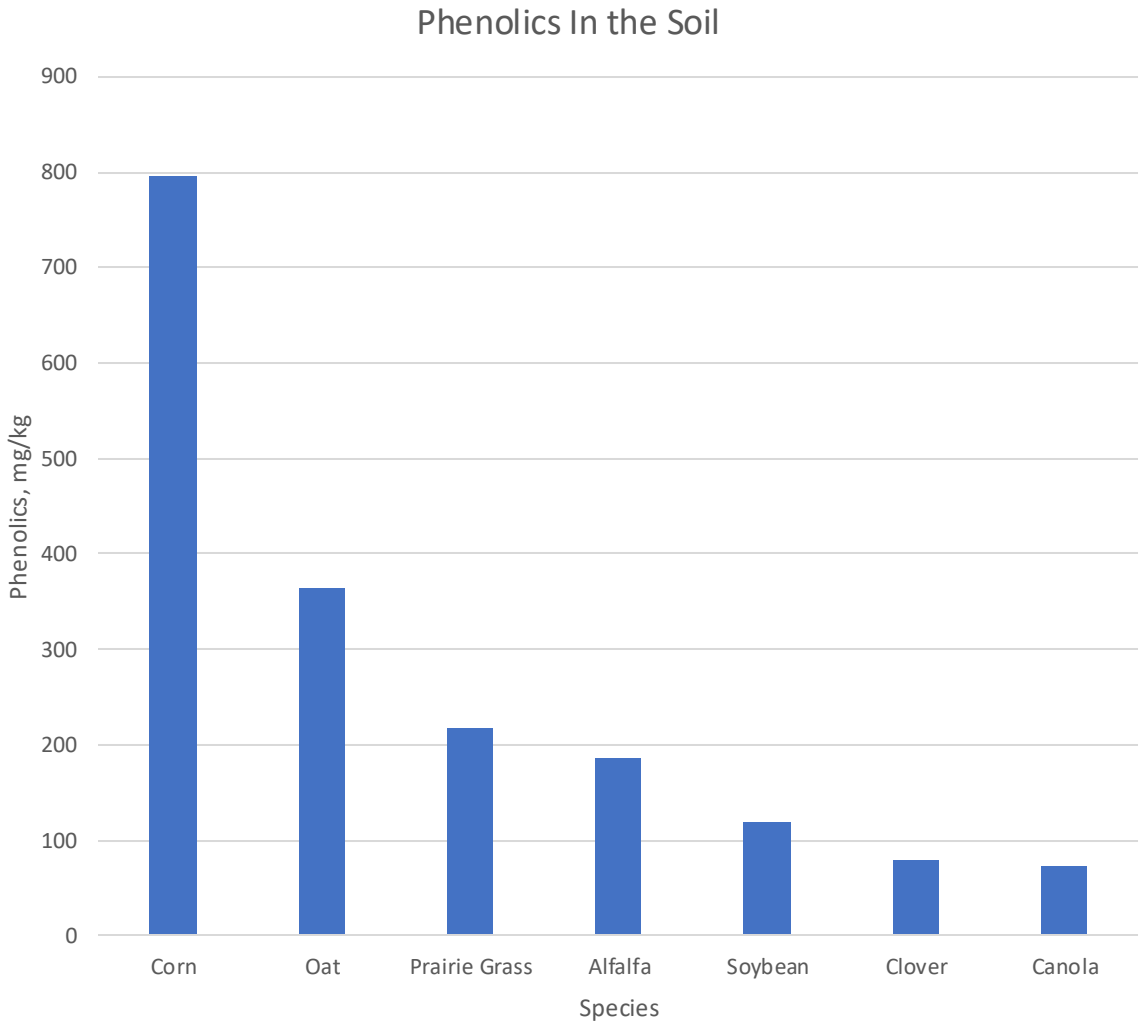
Longer Rotation More Soil Biology, PLFA-Total Microbial Weight, pmols/g



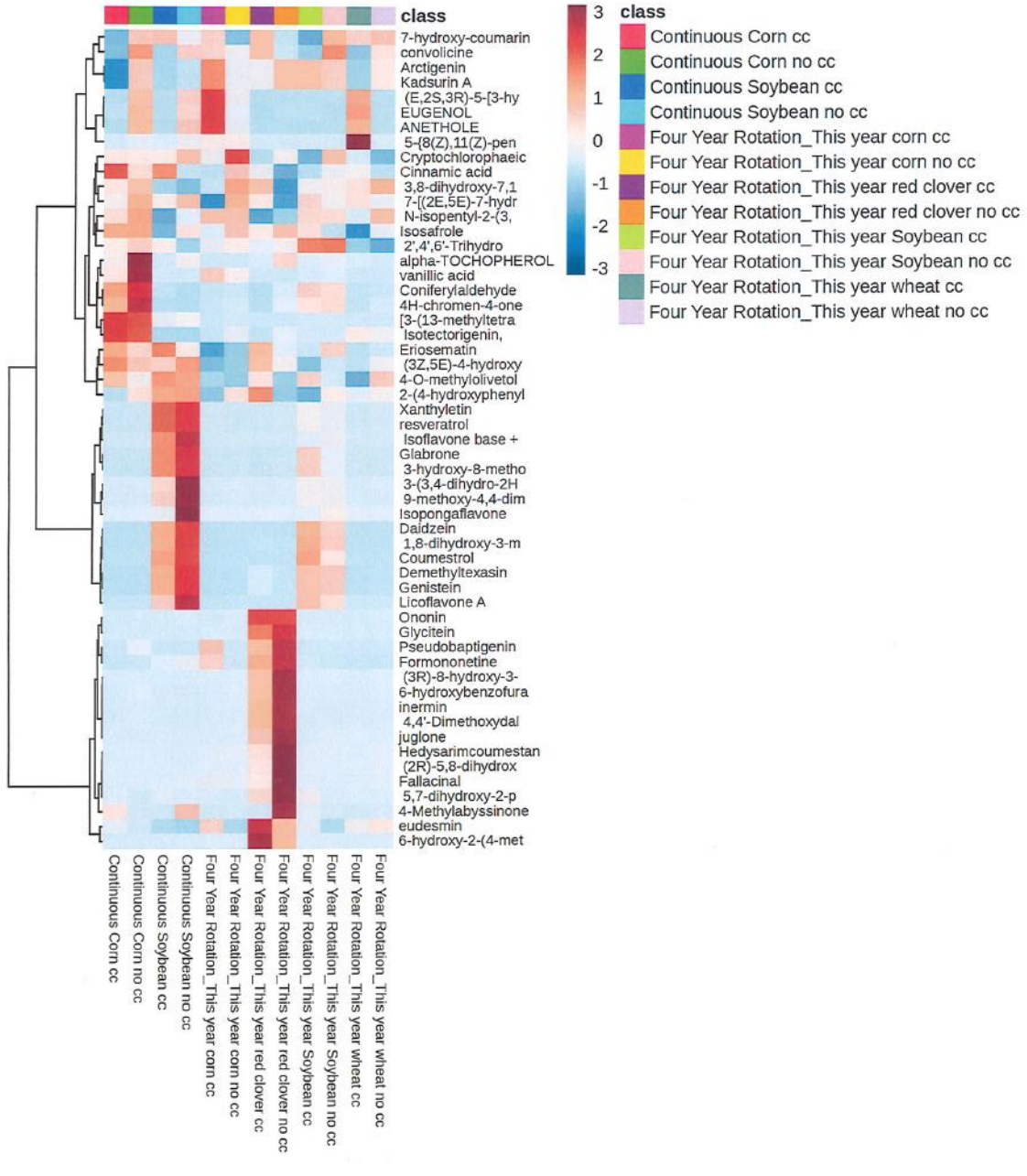
Different Crops Affect Soil Aggregation Differently: Cereal Crops and Corn Much Better Than Soybeans-Why?

- Corn and Cereals Produce A lot of Phenolic Compounds
- Soybeans Produce Very Little Phenolic Compounds
- Phenolic Compound Help Bind Soil Aggregates
  - **-Phenolic Synthesis I Dependent**
  - Produce Aromatic Ar





Heat Map Showing Different Phenolic Compounds Released Into the Soil Based Upon Crop



How Does Soil Aggregate Stability Relate Back To Soil Chemistry and Biology?

The Interaction of Chemical, Biological and Physical Properties at Sanborn Field

	Chemical				Biological	Physical
Fertility	**pH**	**TN**	**P**	**SOC**	**Microbes**	**Agg. Stab.**
		g/kg	**mg/kg**	**g/kg**	**pmols/g**	**%**
No Fertility	**5.5 a**	**1.15 a**	**5.2 a**	**10.7 a**	**72,334 a**	**15 a**
Full Fertility	**5.7 a**	**1.45 b**	**37.0 b**	**14.0 b**	**90,902 b**	**17 b**
Manure	**6.9 b**	**1.78 c**	**56.2 c**	**17.5 c**	**121,854 c**	**25 c**

Different letters indicate significance at the 0.05 probability level


Plot 25
Plot 26
Note the Difference in Drought Stress,
June 2024

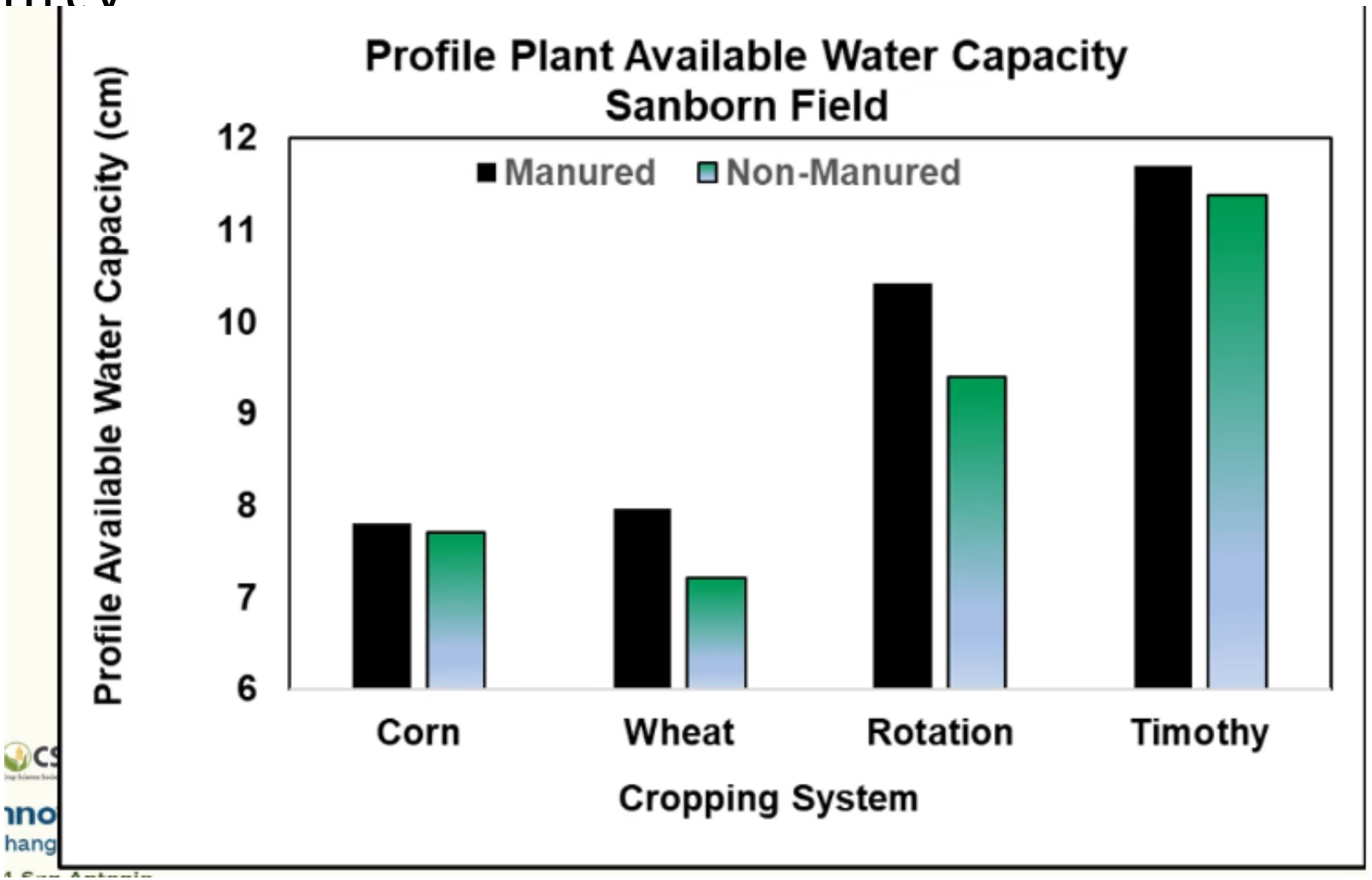

Plot 25 (left) Compared to Plot 26 (right)


166 bu/acre
191 bu/acre
Plot 26-Aggregate Stability-22%
Plot 25-Aggregate Stability-39.5%

Sanborn Field-Increase Water Availability As Aggregate Stability and Total Carbon Increase

Treatment	Profile Available Water	Aggregate Stability	Total Carbon
	cm	%	%
Continuous Corn	7.75 a	11 a	0.87 s
Continuous Wheat	7.59 a	33 b	1.18 b
3-Year Rotation (C-W-RC)	9.91 b	40 b	1.23 b
Continuous Timothy	11.54 c	55 c	2.30 c

Adding Manure Increased Soil Water Capacity At Sanborn Field-Greater C, Biology and Aggregate Stability



5 Year Rotation (left), Continuous Soybean (right)

2024-Water in the Top 6 inches With Various Rotation Length-Soybeans

Treatment	percent Water	soil water	aggregate stability	total carbon
	%	inches	%	%
Continuous Soybean Tilled	17	1.50	21	1.27
Continuous Soybean No-Till	16	1.42	28	1.40
Corn/Soybean	16	1.42	29	1.30
Corn/Soybean/Wheat	22	1.95	36	1.40
Corn/Soybean/Whea/Red Clover	21	1.85	40	1.49
Corn/Soybean/Wheat/Alfafa-2 years	19	1.68	41	1.61

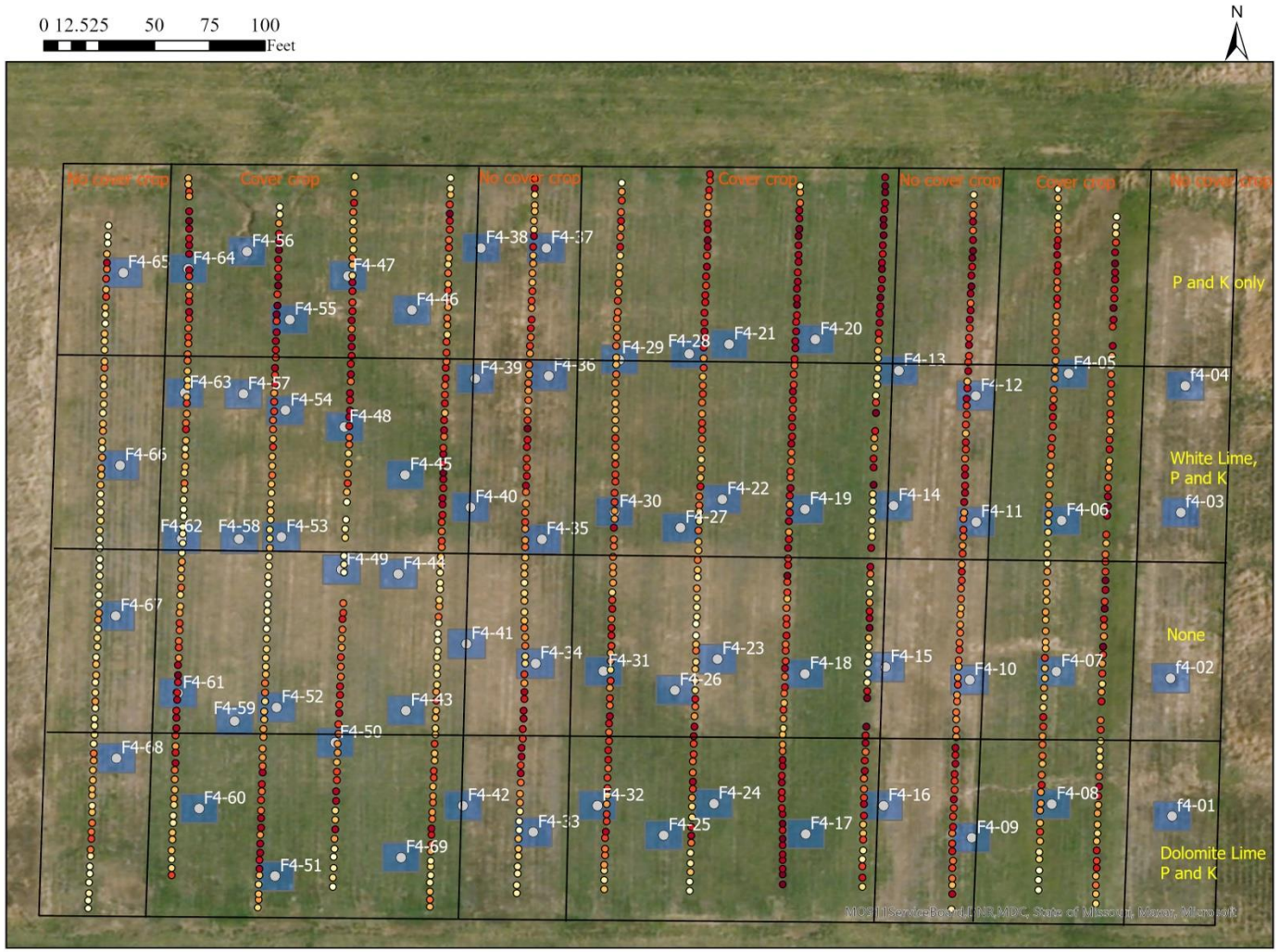
2025-Water in the Top 6 inches With Various Rotation Length-Soybeans

2025

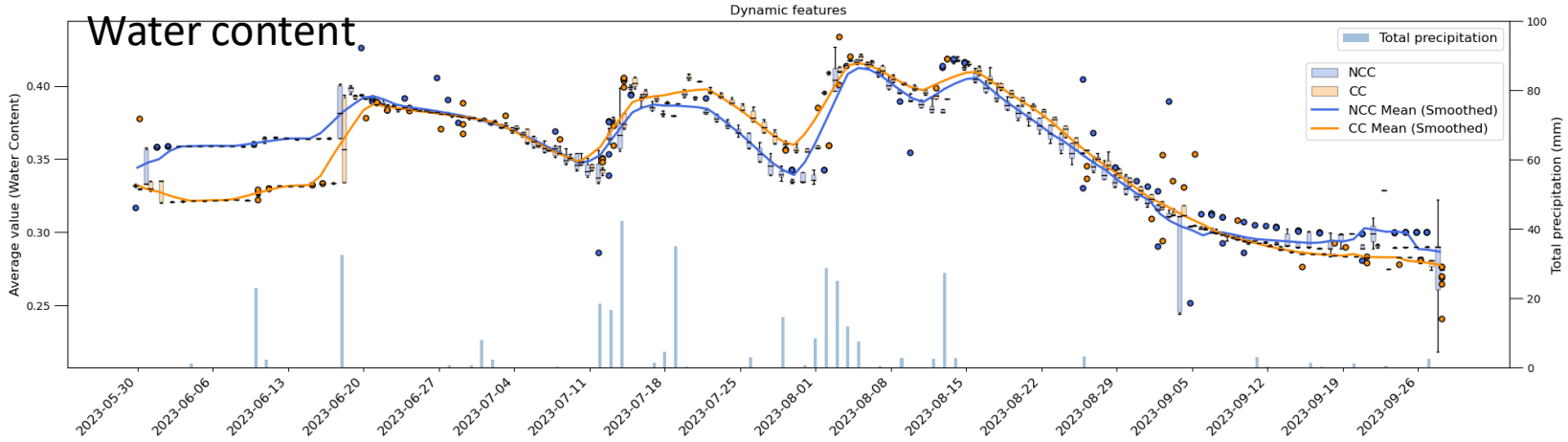
Treatment	percent Water	soil water	aggregate stability	total carbon
	%	inches	%	%
Continuous Soybean Tilled	19	1.68	9	1.35
Continuous Soybean No-Till	21	1.85	16	1.55
Corn/Soybean	19	1.68	19	1.41
Corn/Soybean/Wheat	22	1.95	15	1.44
Corn/Soybean/Whea/Red Clover	24	2.12	19	1.84
Corn/Soybean/Wheat/Alfafa-2 years	24	2.12	17	1.67

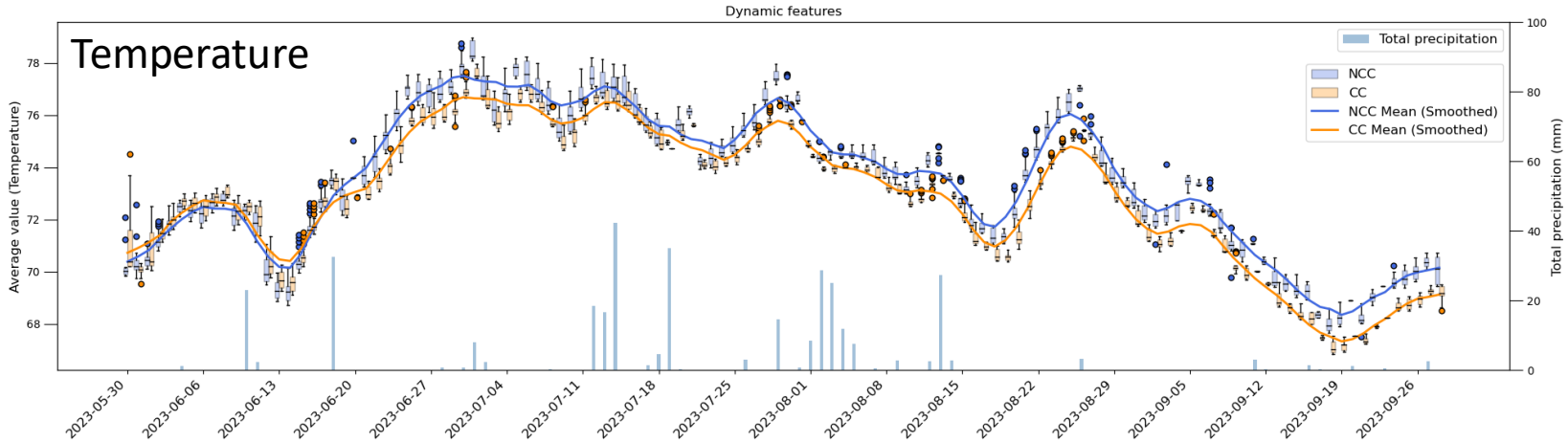
Soybeans Following Cover Crops (right) Were Taller and Bushier that those Without Cover Crops

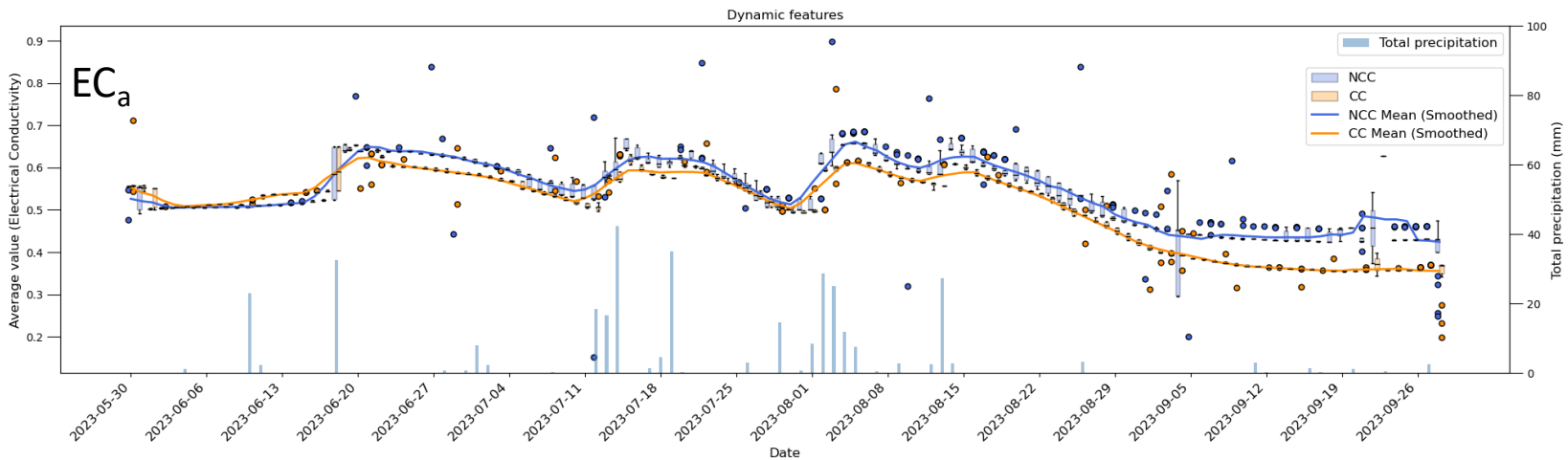
What About Soil Water Content Throughout The Growing Season?



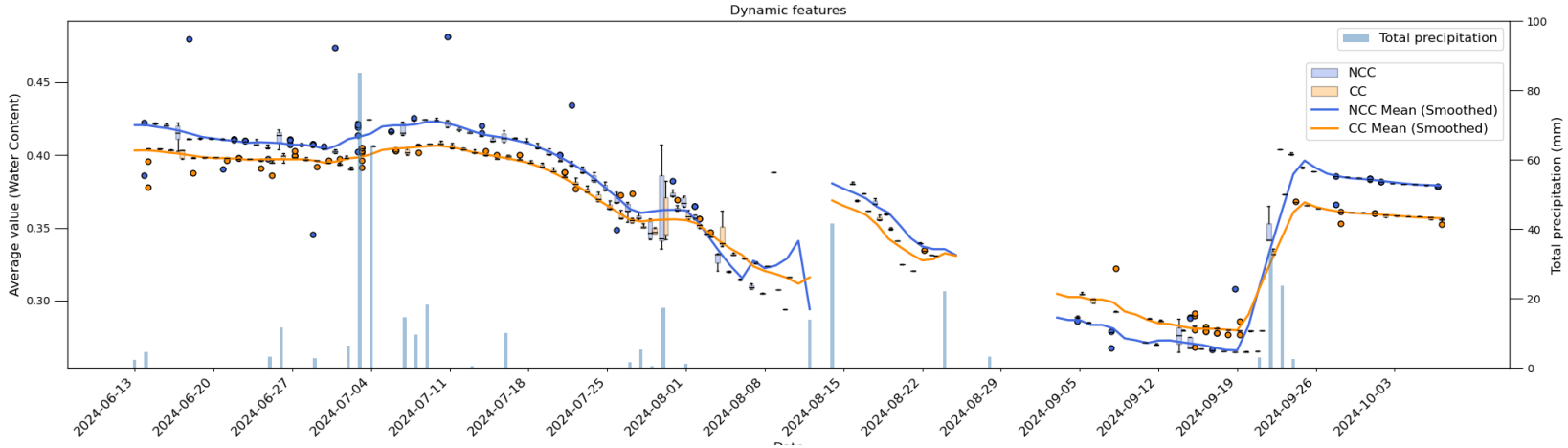
Bradford 2023 (Differences Between cover crop and non cover crop plots)

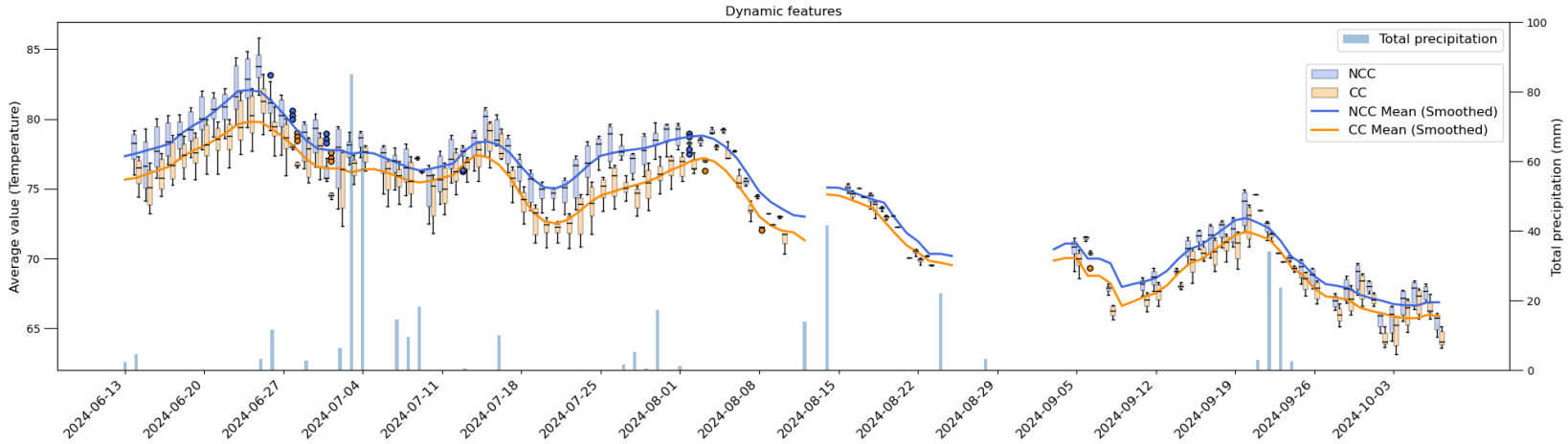


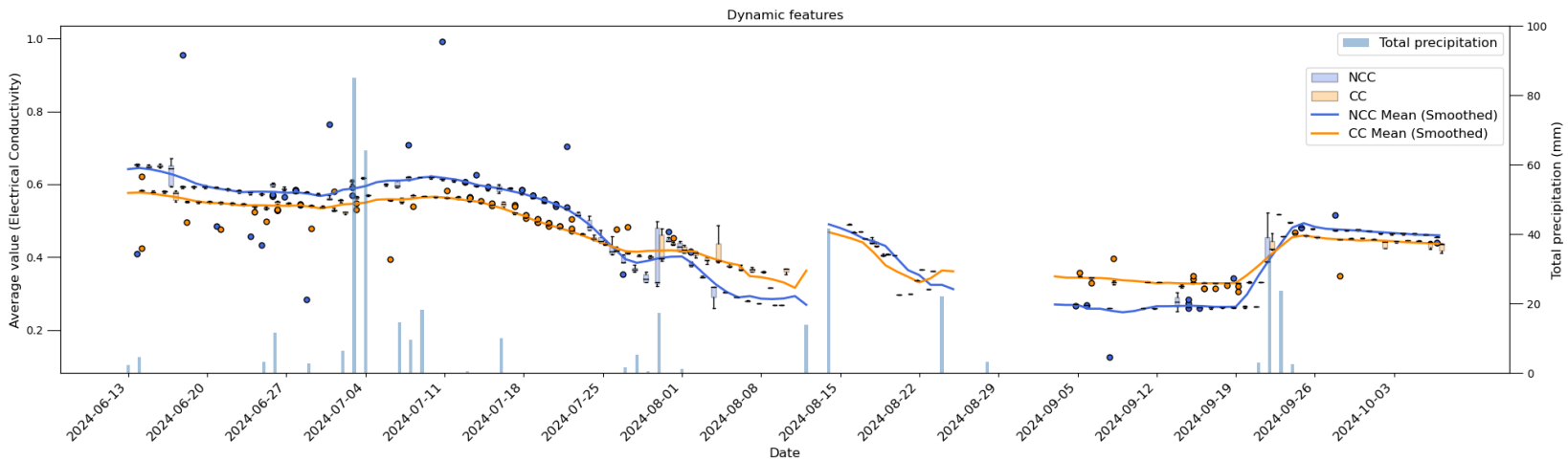




Bradford 2024 (Differences Between cover crop and non cover crop plots)

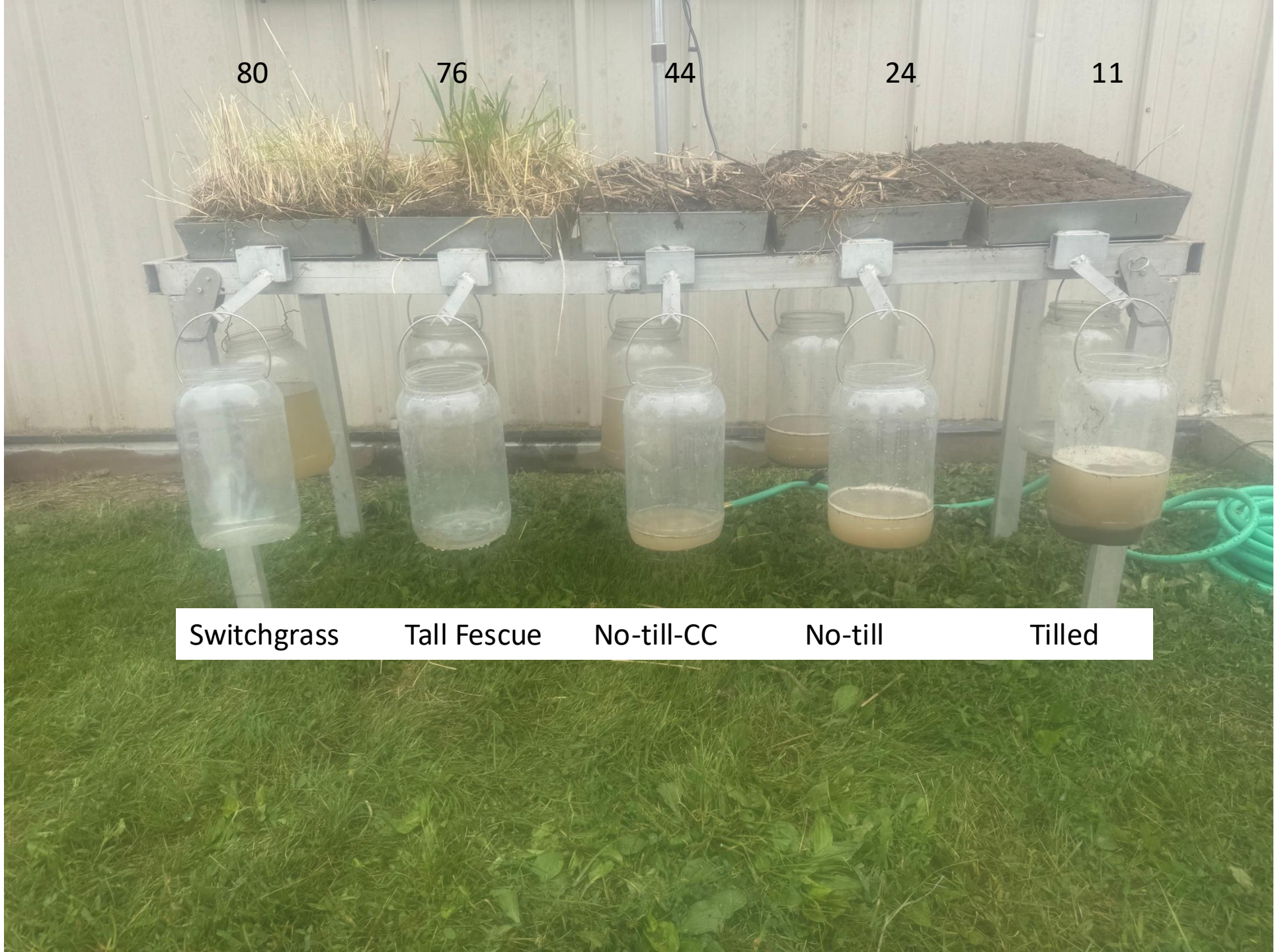






Comparison of Different Management Treatments On Water Runoff and Infiltration

Aggregate Stability



Infiltration

Switchgrass

Tall Fescue

No-till Cover Crop

No-till

Tilled

Conclusions

- Soil health is composed on three Properties: Soil Biology, Soil Chemistry and Soil Physical Properties
- These are integrated with one another-If you change one you will change the others
- Improvement in soil health indicators can lead to better soil structure which results in better soil water holding capacity

Without the Help of The Missouri Soybean Merchandizing Council, United Soybean Board and NRCS This Research Could Not Have Been Accomplished

Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE

Missouri Agriculture Experiment Station YouTube Channel. Weekly Video Stories and Monthly Podcast-Tim's Take