Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

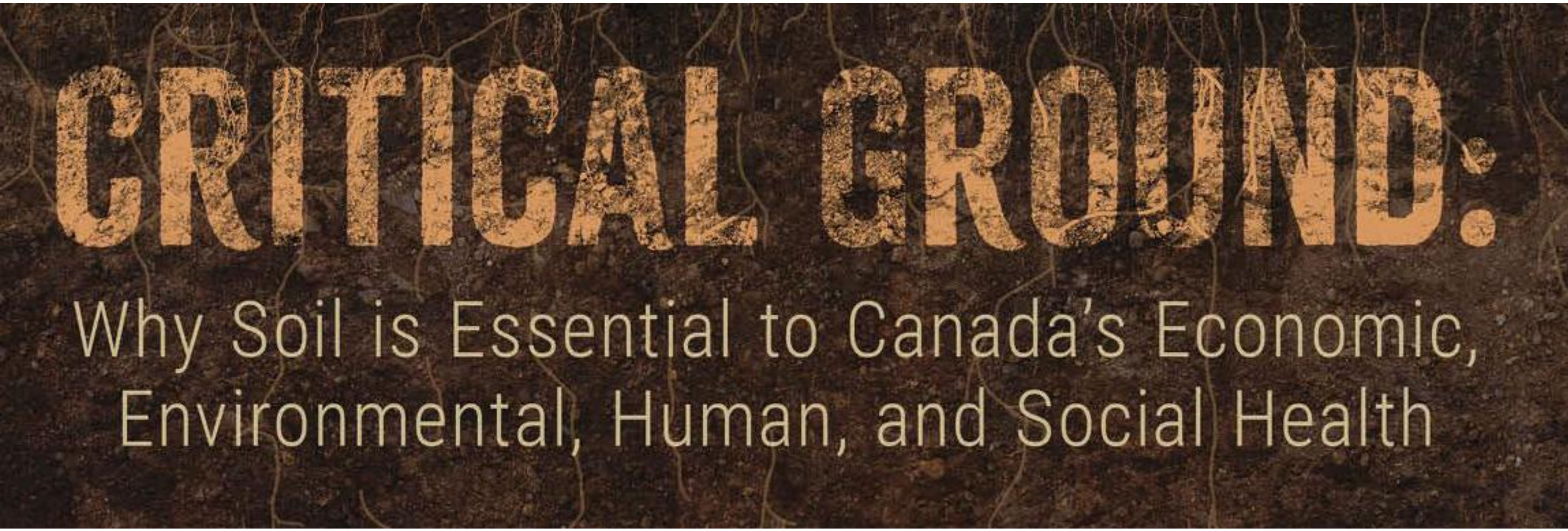
Soil Health Indicators for Prairie Cropping Systems

Dr. Stephen Crittenden

AGVISE Soil Fertility Seminar 11 & 13 March, 2025

Canada

Senate Report on Soil Health



"Soil is as critical as the air we breathe and the water we drink. Soil health is human health is *One Health*."

The Government of Canada should designate soil a strategic national asset

[Critical Ground: Why Soil is Essential to Canada's Economic, Environmental, Human, and Social Health]

National Soil Health Strategy in Canada

SOIL CONSERVATION COUNCIL OF CANADA
CONSEIL CANADIEN DE CONSERVATION DES SOLS

GREEN BELT
Possibility grows here.

crsc
Canadian Roundtable for Sustainable Crops

canolacouncil OF CANADA

NUTRIENTS FOR LIFE
NUTRIMENTS POUR LA VIE

Conseil canadien du COMPOST Council of Canada

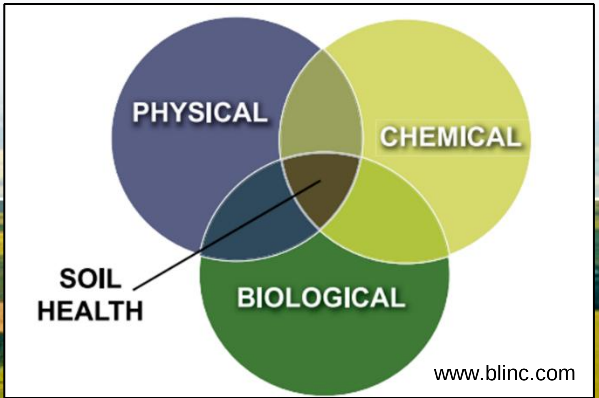
Towards a National Soil Health Strategy in Canada

The NSHS will be an industry-led framework and plan for collective action to maintain and enhance the soils in Canada, with an immediate view (by 2030) and for the longer term (by 2050) . Elements of that framework will be:

1. Articulation of the objectives the soil health strategy, including the selection of a definition of soil health for the purposes of the NSHS.
2. Setting goals for soil health and identifying tools to assess soil health at different scales, in order to better monitor how the state of soil is progressing.
3. Selection of priority actions that need to be taken to achieve the goals that are set.
4. Identification of priority research and analysis to assist in effectively implementing those actions.
5. Securing of resources, whether by individual stakeholders or collectively, to undertake both priority research and measurement and priority measures.
6. Establishment of a strategy governance system to enable continuing commitment and collaboration on meeting the soil health targets.
7. Creation of stakeholder engagement processes that permit the constant renewal of the NHSH and its implementation.

Soil health or healthy soil?

- Soil health is how the soil works together (functions)
- Interplay of biological, chemical, and physical aspects
- A ‘healthy soil’ depends on what you want
- The soil health balancing act
- Building climate resilient agro-ecosystems



What is soil health?

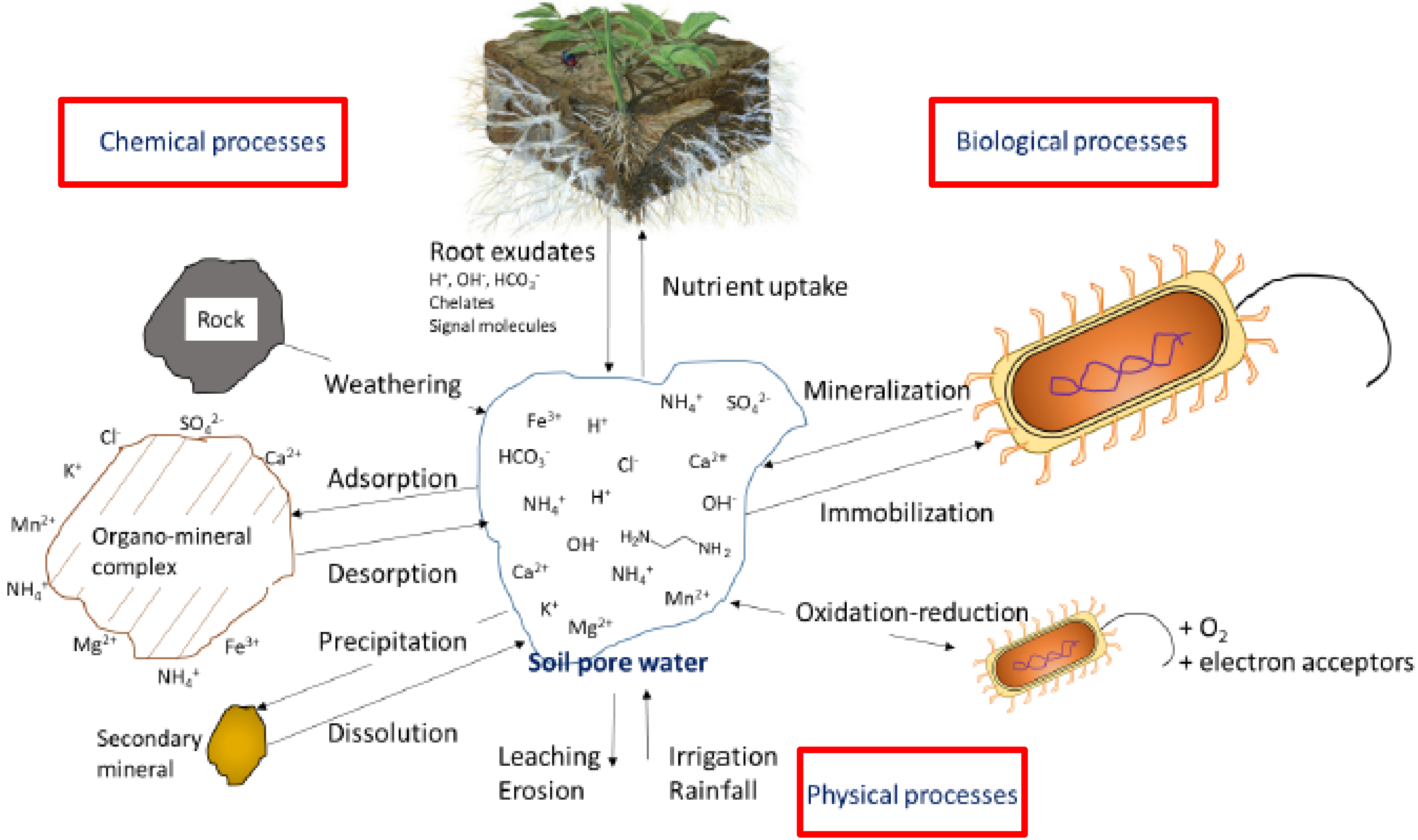


Figure 7.2 Biological, chemical and physical processes that affect the concentration of nutrient ions in the soil pore water.

Digging Into Canadian Soils https://openpress.usask.ca/soilscience/

Soil biology: *Aporrectodea tuberculata*

Photo Credit: Dana Eliuk

Soil Microbiome

13 phyla, dry year

16 phyla, wet year

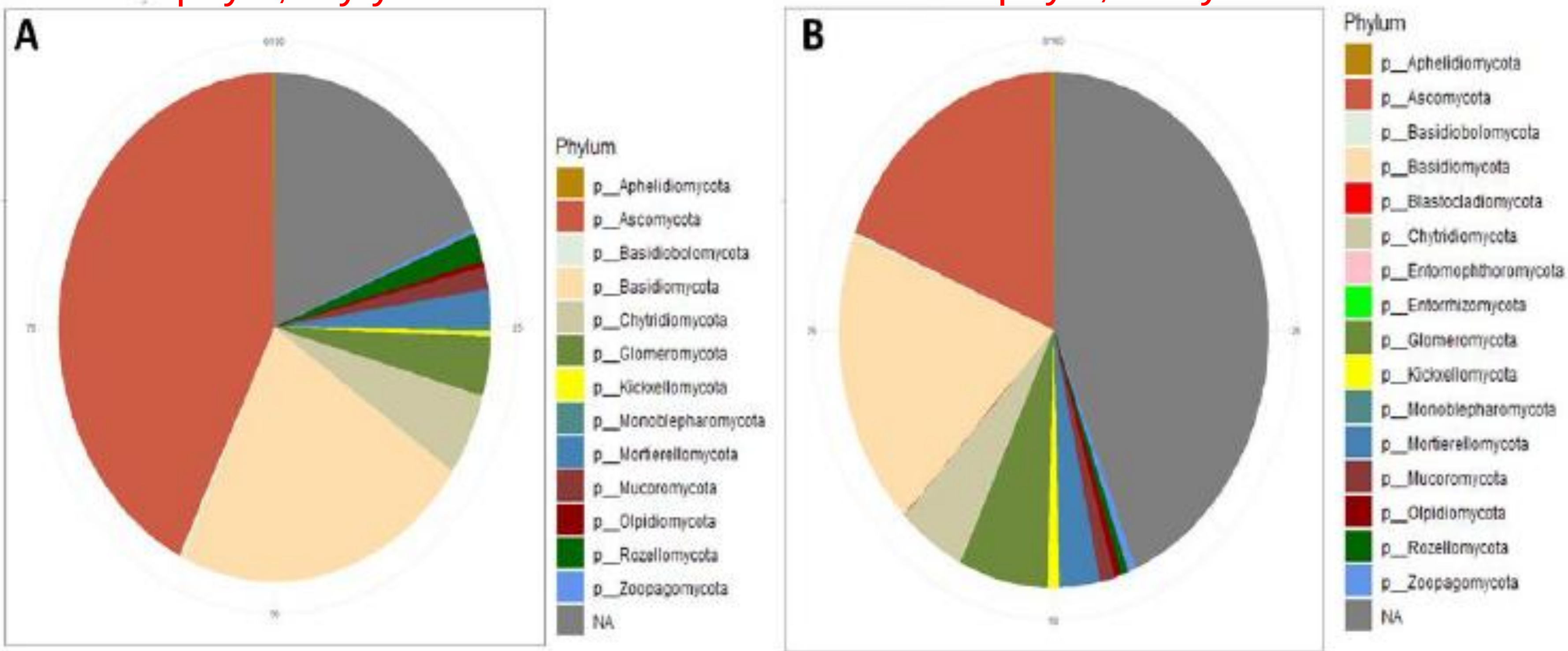
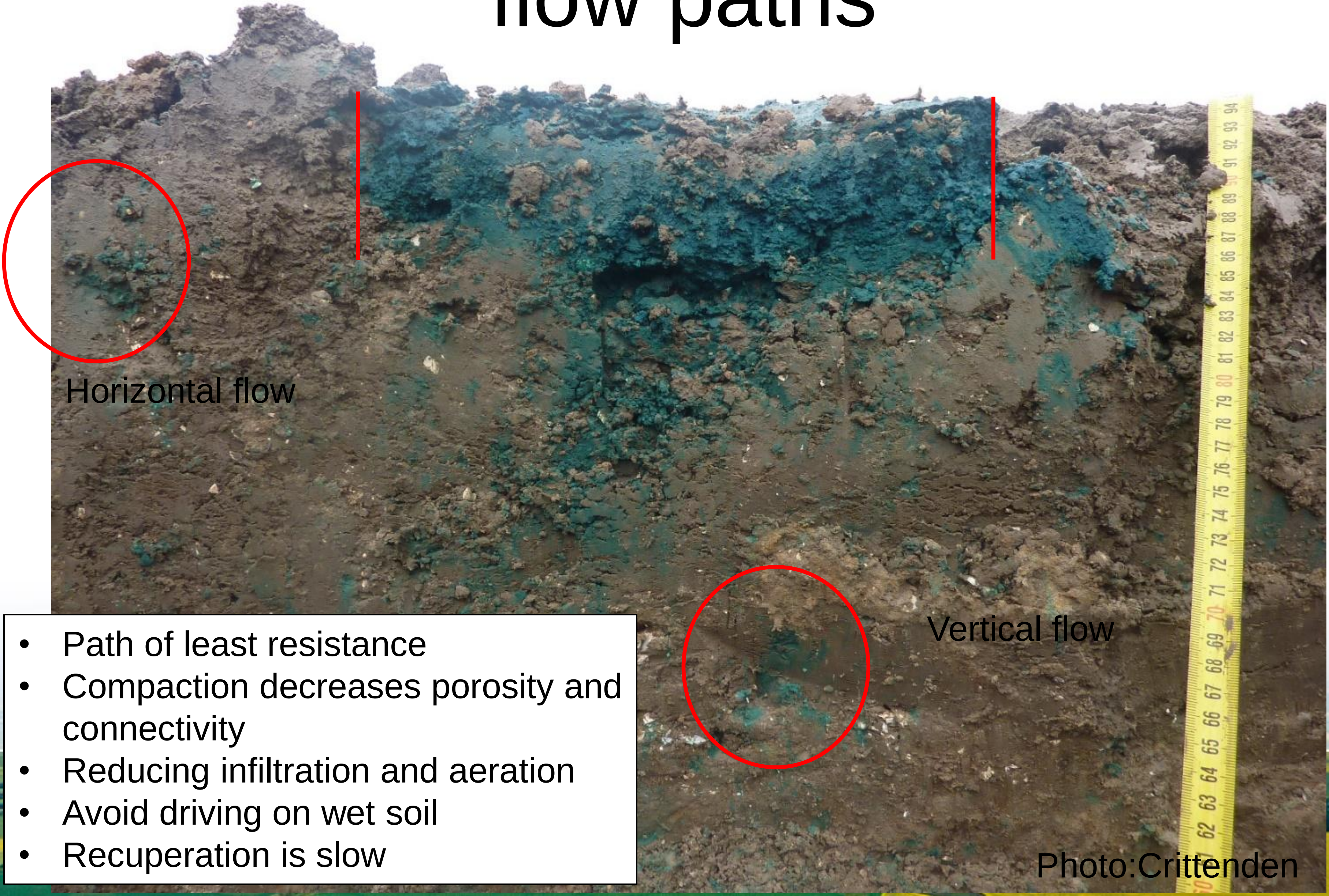


Figure 4. 3. A. Pie chart showing the average relative abundance of fungal phyla across all soil samples (n= 271) from Portage la Prairie (2021). B. Pie chart showing the average relative abundance of fungal phyla across all soil samples (n= 144) from Portage la Prairie (2022). Each segment of the graph corresponds to a specific fungal phylum, and th size of each segment represents the proportion or relative abundance of that phylum within the overall fungal community.

Soil Physics

Soil water infiltration: complex flow paths

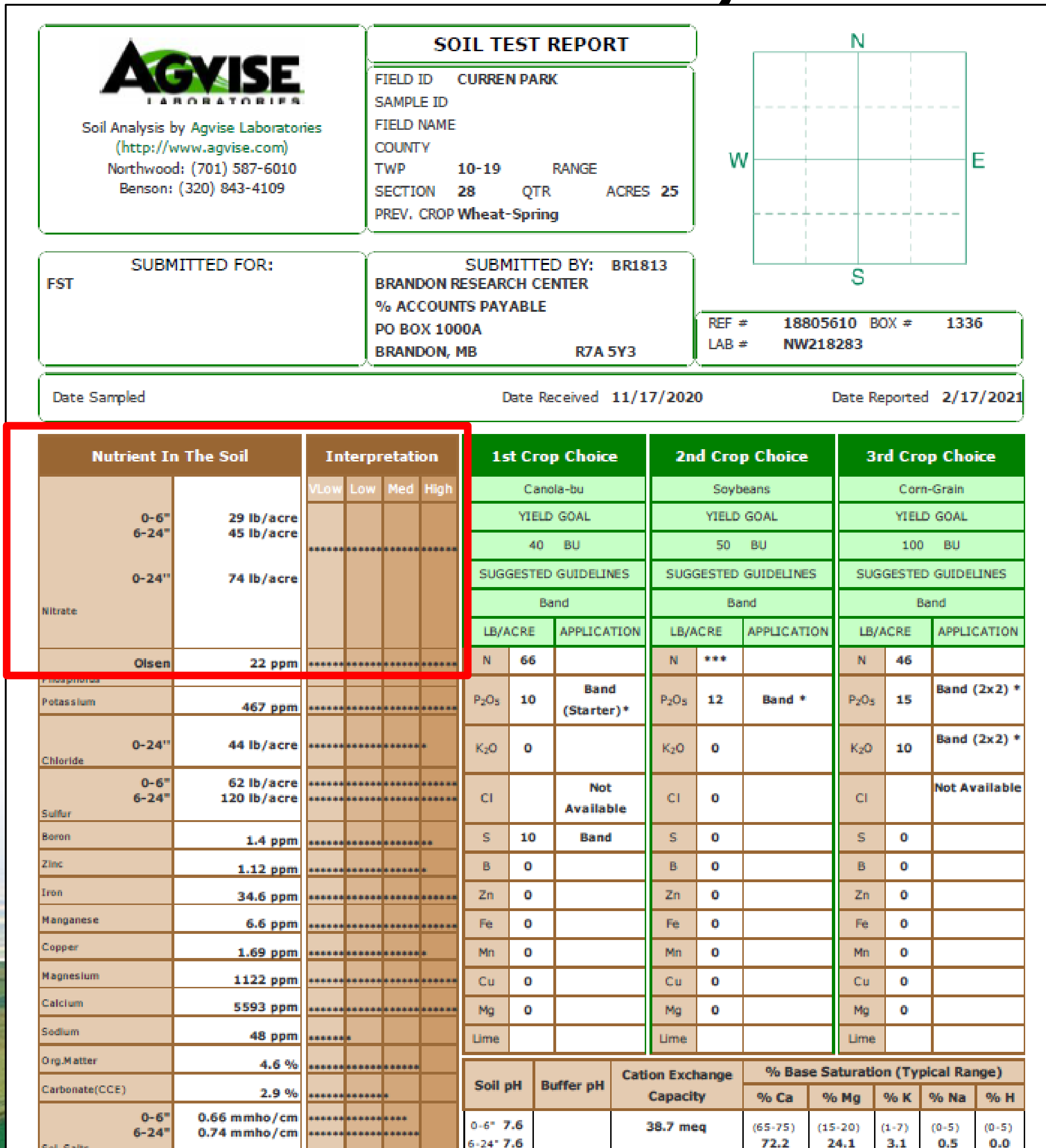


- Path of least resistance
- Compaction decreases porosity and connectivity
- Reducing infiltration and aeration
- Avoid driving on wet soil
- Recuperation is slow

Soil Chemistry

Farmers soil test for appropriate fertilizer application rates

Nitrate
Phosphorus (Olsen)
Potassium
Org. matter
Salts
pH
Soil texture


AGVISE LABORATORIES

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID CURREN PARK
SAMPLE ID
FIELD NAME
COUNTY
TWP 10-19 RANGE
SECTION 28 QTR ACRES 25
PREV. CROP Wheat-Spring

N W E S

SUBMITTED FOR:
FST

SUBMITTED BY: BR1813
BRANDON RESEARCH CENTER
% ACCOUNTS PAYABLE
PO BOX 1000A
BRANDON, MB R7A 5Y3

REF # 18805610 BOX # 1336
LAB # NW218283

Date Sampled Date Received 11/17/2020 Date Reported 2/17/2021

Nutrient In The Soil		Interpretation (VLow, Low, Med, High)
Nitrate	0-6" 29 lb/acre 6-24" 45 lb/acre 0-24" 74 lb/acre	
Phosphorus Olsen	22 ppm	
Potassium	467 ppm	
Chloride 0-24"	44 lb/acre	
Sulfur	0-6" 62 lb/acre 6-24" 120 lb/acre	
Boron	1.4 ppm	
Zinc	1.12 ppm	
Iron	34.6 ppm	
Manganese	6.6 ppm	
Copper	1.69 ppm	
Magnesium	1122 ppm	
Calcium	5593 ppm	
Sodium	48 ppm	
Org.Matter	4.6 %	
Carbonate(CCE)	2.9 %	
Sol. Salts	0-6" 0.66 mmho/cm 6-24" 0.74 mmho/cm	

	1st Crop Choice		2nd Crop Choice		3rd Crop Choice	
	Canola-bu		Soybeans		Corn-Grain	
	YIELD GOAL 40 BU		YIELD GOAL 50 BU		YIELD GOAL 100 BU	
	SUGGESTED GUIDELINES Band		SUGGESTED GUIDELINES Band		SUGGESTED GUIDELINES Band	
	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION
N	66		***		46	
P_2O_5	10	Band (Starter)*	12	Band *	15	Band (2x2) *
K_2O	0		0		10	Band (2x2) *
Cl		Not Available	0			Not Available
S	10	Band	0		0	
B	0		0		0	
Zn	0		0		0	
Fe	0		0		0	
Mn	0		0		0	
Cu	0		0		0	
Mg	0		0		0	
Lime						

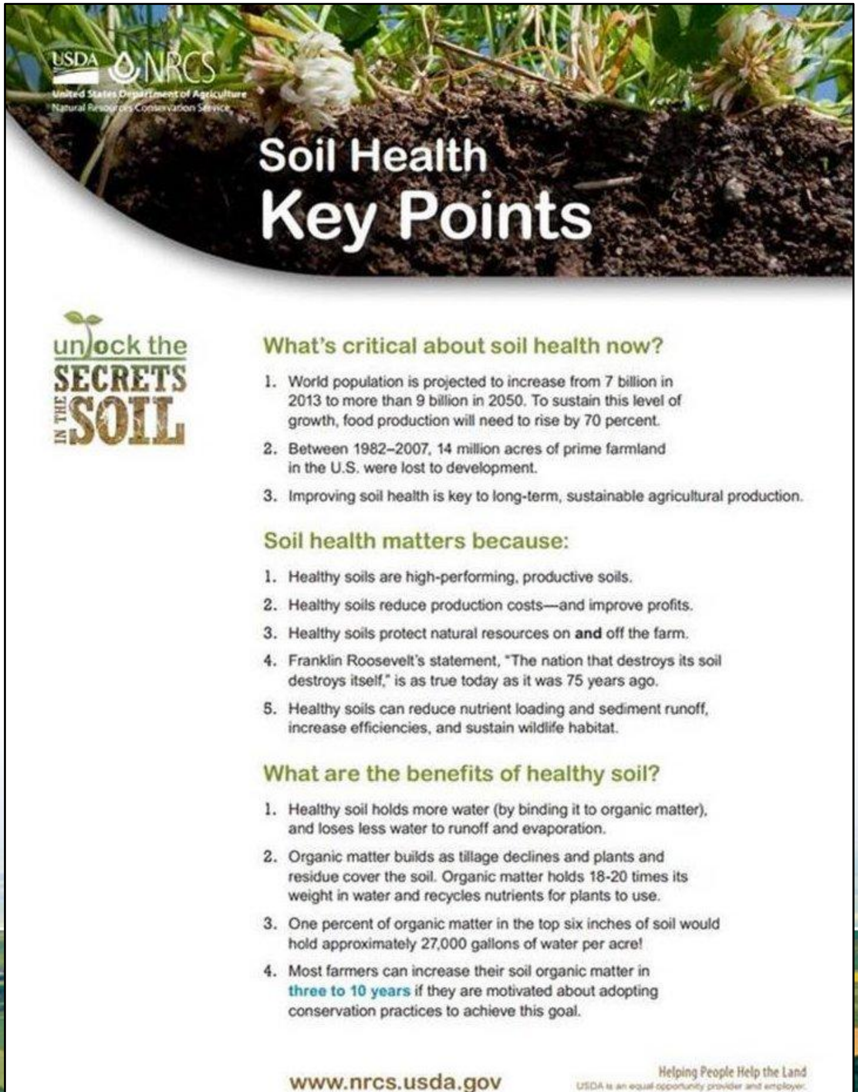
Soil pH	Buffer pH	Cation Exchange Capacity	% Ca	% Mg	% K	% Na	% H
0-6" 7.6 6-24" 7.6		38.7 meq	(65-75) 72.2	(15-20) 24.1	(1-7) 3.1	(0-5) 0.5	(0-5) 0.0

% Base Saturation (Typical Range)

Media Headlines

- Soil’s complexity must be understood (McCain, soil biodiversity, DNA barcoding)
- To manage your fields for optimum yields, start with soil health (“Decisive Farming by TELUS Agriculture agronomists review soil tests and develop specific recommendations”

Lofty Claims



USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Soil Health
Key Points

unlock the SECRETS IN THE SOIL

What's critical about soil health now?

1. World population is projected to increase from 7 billion in 2013 to more than 9 billion in 2050. To sustain this level of growth, food production will need to rise by 70 percent.
2. Between 1982–2007, 14 million acres of prime farmland in the U.S. were lost to development.
3. Improving soil health is key to long-term, sustainable agricultural production.

Soil health matters because:

1. Healthy soils are high-performing, productive soils.
2. Healthy soils reduce production costs—and improve profits.
3. Healthy soils protect natural resources on **and** off the farm.
4. Franklin Roosevelt's statement, "The nation that destroys its soil destroys itself," is as true today as it was 75 years ago.
5. Healthy soils can reduce nutrient loading and sediment runoff, increase efficiencies, and sustain wildlife habitat.

What are the benefits of healthy soil?

1. Healthy soil holds more water (by binding it to organic matter), and loses less water to runoff and evaporation.
2. Organic matter builds as tillage declines and plants and residue cover the soil. Organic matter holds 18-20 times its weight in water and recycles nutrients for plants to use.
3. One percent of organic matter in the top six inches of soil would hold approximately 27,000 gallons of water per acre!
4. Most farmers can increase their soil organic matter in three to 10 years if they are motivated about adopting conservation practices to achieve this goal.

www.nrcs.usda.gov

Helping People Help the Land
USDA is an equal opportunity provider and employer.

Healthy soils are high-performing, productive soils

Healthy soils reduce productions costs – and improve profits

Healthy soils protect natural resources on and off the farm

Cornell Assessment of Soil Health

Test Report

Measured Soil Textural Class: **sandy loam**

Sand: **59%** - Silt: **36%** - Clay: **5%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.09	28	
physical	Surface Hardness	255	14	Rooting, Water Transmission
physical	Subsurface Hardness	400	18	Subsurface Pan/Deep Compaction, Deep Rooting, Water and Nutrient Access
physical	Aggregate Stability	56.4	76	
biological	Organic Matter	2.1	54	
biological	ACE Soil Protein Index	6.9	44	
biological	Soil Respiration	0.6	55	
biological	Active Carbon	359	32	
chemical	Soil pH	5.9	54	
chemical	Extractable Phosphorus	2.3	66	
chemical	Extractable Potassium	175.3	100	
chemical	Minor Elements Mg: 134.0 / Fe: 3.4 / Mn: 2.7 / Zn: 1.3		100	

Overall Quality Score: **53** / Medium

Example soil health report

Solvita Soil Health Factors		RANKING:
Solvita - CO2 Burst	90	Medium
Solvita - SLAN, amino-N	48	Low
Aggregate Stability	35	Medium
Organic Matter	3.2	Medium

Nutrients Value per hectare available			
N + P2O5 + K2O hectare =			$221.78
Nutrients Available kg/ha			
N	P2O5	K2O	
115	229	210	

NUTRIENT FERTILITY

Analysis	Units	Level Found
itrate-N 0-6"	ppm	10
dditonal Nitrate-N	ppm	nt
mmonium-N 0-6"	ppm	nt
rofile Avail-N	ppm	10
iological N-Min	kg/ha	97
-Estimated For Crops		103
hosphate as P	ppm	45
otassium as K	ppm	78
alcium	ppm	480
agnesium	ppm	153
odium	ppm	37
H	Units	6.3
C	dS M	nt
utrient Index	Rating	1.00
ost Limiting Factor		None
Other factors		
Water Soluble Carbon	ppm	204
Water Soluble-N	ppm	16
Soluble C:N Ratio	Unit	12.8
Aluminum, Extractable	ppm	135
P-Saturation	ratio	14%
Iron, Extractable	ppm	186

Notes and Recommendations

USDA Cover Crop Recommendations

Types of Cover Crop Blends Suggested:

20% Legume 80% Grass/Non-legume

Nutrient Limitations/Recommendations

Nutrient Required (estimated) per hectare kg

56	17	84	(N - P - K)

Nutrient Deficit (by difference)

0	0	0	(N - P - K)

Notes on the Report: Soil Health Score integrates: Respiration, Amino-N, Aggregate Stability and Organic Matter
Overall Fertility integrates Health Score and N-min + relative P & K

More questions than answers?

- Unsure how to interpret soil health indicators
- How to go from soil health data to management

ABSTRACT

Soil health has become an emergent focus of contemporary agricultural research, yet little work has addressed how soil health data – and biological indicators in particular – are interpreted by farmers and potentially incorporated into their decision-making. To address this gap, in-depth interviews were conducted with 20 Ohio farmers after sharing a soil health report that detailed physical, chemical, and biological indicators from at least two sampled fields from their farms. Research findings demonstrate that while farmers expressed strong interest in soil biological health indicators specifically, the data often raised more questions than answers for participants. Specifically, three main themes emerged in the interviews: 1) uncertainties in interpreting the soil health indicators, 2) questions regarding translation of soil health data into management, and 3) affirmation of existing management choices. The first two response themes point to a need for scientists to develop greater access and exposure to soil health data to facilitate interpretation. Furthermore, researchers and extension agents can play a critical role in guiding recommendations for potential application of soil health data in on-farm management. While research on soil health has widely expanded in recent years, this study highlights the need for greater attention to its translational science and the co-production of knowledge.

AGROECOLOGY AND SUSTAINABLE FOOD SYSTEMS
https://doi.org/10.1080/21683565.2023.2270928

Taylor & Francis
Taylor & Francis Group

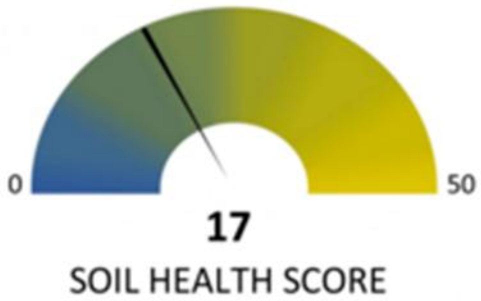
Check for updates

"More questions than answers": Ohio farmers' perceptions of novel soil health data and their utility for on-farm management

Prabhjot Singh[a,b], Nicholas C. Kawa[b,c], and Christine D. Sprunger[a,d,e]

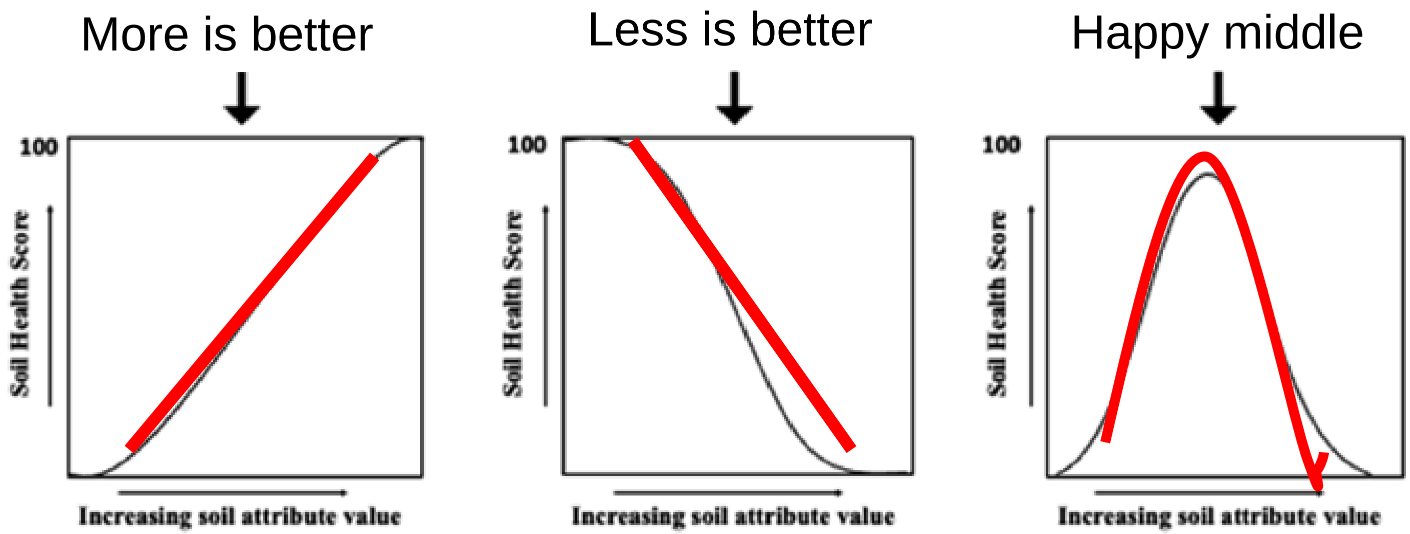
Our objectives

- Understand the utility of soil health indicators for producers
  - Correlate soil health indicators to agronomic outcomes (i.e., crop yield, seed protein content, and seed oil content)
  - How soil health indicators inter-relate with each other



Soil Health Index

Step 3) Model the relationship between the soil attribute value and the Soil Health Score, based on the *type of scoring function*



$$\text{SASH score} = \frac{\sum_1^k (s_k \times w_k)}{\sum_1^k (w_k)} \qquad (2)$$

where *s* represents the soil health score (0–100) for each individual soil attribute and *w* is the corresponding weighting factor. Then, the score for the three depth increments was averaged for a single, overall Saskatchewan Assessment of Soil Health (SASH)

A soil health scoring framework for arable cropping systems in Saskatchewan, Canada[1]
Qianyi Wu and Kate A. Congreves

Can. J. Soil Sci. **102**: 341–358 (2022) dx.doi.org/10.1139/cjss-2021-0045

Soil Health in SK

Table 3. The correlation between the Saskatchewan Assessment of Soil Health (SASH) score and average cereal crop yields obtained from rural municipalities from 2009 to 2019.

Year	Correlation between cereal crop yield and soil health (Pearson's coefficient)		Crop yields ($Mg \cdot ha^{-1}$) (min, median, max)	Precipitation (mm) (annual, April–June)
	SASH score (0–15 cm)	SASH score (0–60 cm)		
2009	**0.64***	**0.63***	1.7, 2.4, 3.0	389.6, 108.6
2010	0.09	0.13	2.1, 2.3, 2.7	550.3, 242.0
2011	−0.28	−0.08	2.0, 2.7, 3.3	409.7, 162.7
2012	0.22	0.21	1.8, 2.4, 3.5	446.6, 207.8
2013	0.24	0.26	2.6, 3.6, 3.8	372.8, 139.9
2014	0.37	0.34	2.1, 2.7, 3.2	443.9, 205.4
2015	**0.47**†	**0.65***	2.0, 2.6, 3.2	373.7, 69.0
2016	0.34	0.29	2.3, 3.3, 4.0	478.6, 144.8
2017	0.28	0.21	2.4, 2.9, 3.9	310.0, 108.5
2018	**0.43**‡	0.32	1.7, 2.8, 3.9	319.0, 104.7
5 year (2014–2018)	**0.47**†	**0.44**‡	2.4, 2.7, 3.4	385.2, 126.5
10 year (2009–2018)	**0.41**‡	**0.41**‡	2.2, 2.8, 3.1	409.5, 149.3

Note: Significant correlations are bolded and indicated at $p < 0.05$ (*), $p < 0.1$ (†), and $p < 0.15$ (‡). Cereal crop yield and precipitation data are included for each year.

A soil health scoring framework for arable cropping systems in Saskatchewan, Canada[1]
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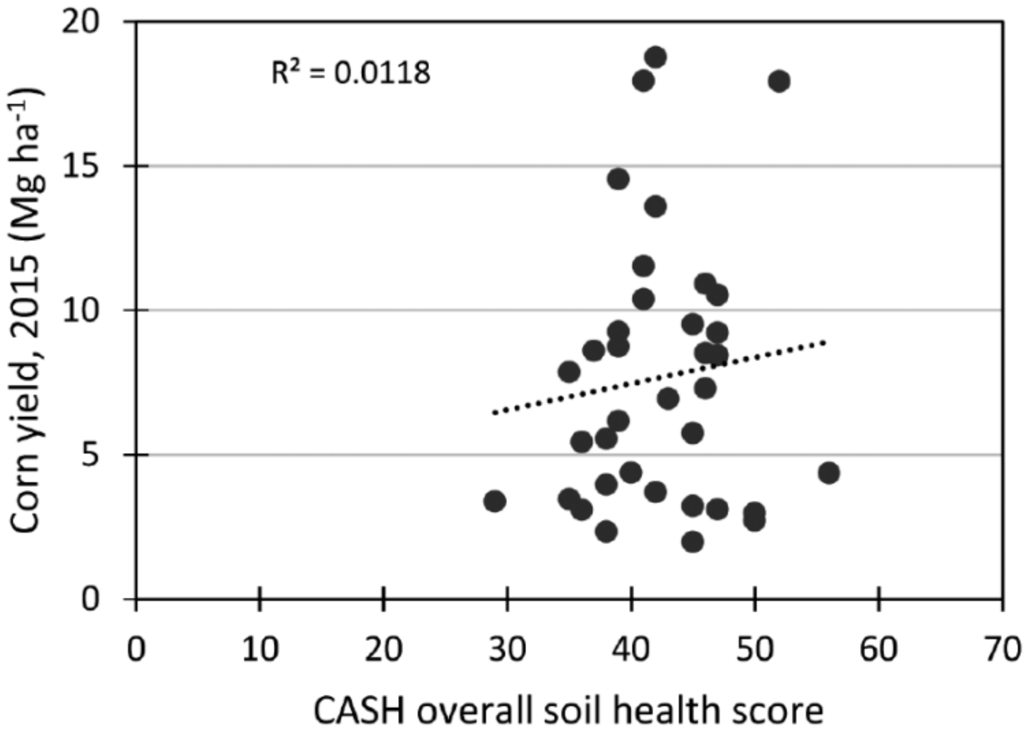
Soil Health and Yield Don’t Always Match

b

a



Soil health did not increase corn yield

b

Fig. 2. Correlation between the Cornell comprehensive assessment of soil health (CASH) overall soil health scores and recent crop yields (Mg ha^{-1}) for soils of the piedmont (a) and mountain (b) trials. Each solid circle on the graph represents an individual research plot.

Roper, W.R., Osmond, D.L., Heitman, J.L., Wagger, M.G. and Reberg-Horton, S.C. (2017). Soil Health Indicators Do Not Differentiate among Agronomic Management Systems in North Carolina Soils. Soil Science Society of America Journal, 81: 828-843. https://doi.org/10.2136/sssaj2016.12.040

What components of soil health impact on agronomy?

- Two field experiments in MB
- Tillage experiment at Portage la Prairie
- Crop sequence experiment at Morden
- Which of 20 soil health indicators related to crop yield, seed protein, and seed oil?

Tillage is still a question in MB

Table 1. Percentage of land prepared for seeding using various tillage systems in the Canadian prairie provinces from 1991 to 2016. Adapted from Statistics Canada (2019b).

Province	Tillage system†	Percentage of land prepared for seeding			
		1991	2006	2011	2016
Manitoba	Conventional	66	43	38	41
	Conservation	29	35	38	39
	No-till	5	21	24	$\boxed{20}$
Saskatchewan	Conventional	64	18	10	7
	Conservation	26	22	20	19
	No-till	10	60	70	$\boxed{74}$
Alberta	Conventional	73	25	13	12
	Conservation	24	28	22	19
	No-till	3	48	65	$\boxed{69}$

† Tillage systems in the Statistics Canada census questionnaires were defined for conventional, conservation, and no-till, respectively, as tillage that incorporates most of the crop residue into the soil, no-till or zero-till seeding (including direct seeding into undisturbed stubble or sod), and tillage that retains most of the crop residue on the surface (including minimum tillage) Statistics Canada (2019b).

Grant and Flaten, 2019

Tillage systems

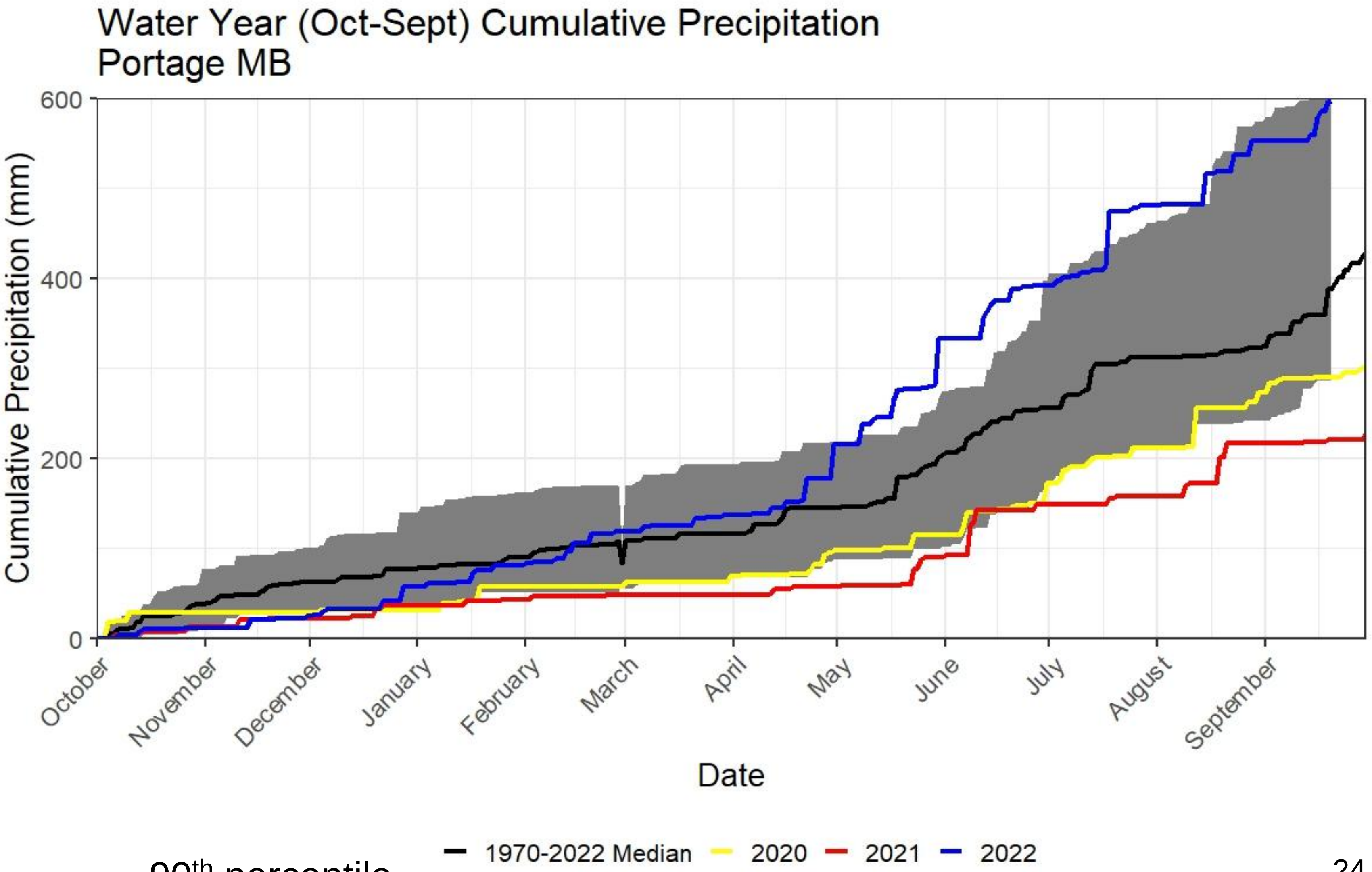
Cultivator

Deep

Vertical

Raised beds subsoiled, rototilled, and then shaped

Precip. outside normal



90th percentile

Code from Dr. Alex Koiter

What did we measure?

- pH, soil organic matter, nitrate, ammonium, Olsen-P, K, S, CO2, texture, total C, CCE, TOC, POXC, ACE protein, water extractable (total N, ammonium, organic N, organic C)

Tillage on crop yield

In a dry year, lower disturbance tillage gave a yield bump for soybean but not corn. Soil nitrate was most sensitive to tillage management and related to corn yield. Soybean yield related to soil S, K, Olsen P, and water extractable NH4 and OC.

	2020				2021				2022			
	CT	DT	RB	VT	CT	DT	RB	VT	CT	DT	RB	VT
Canola	26	23	18	23	5	7	6	4	43	51	46	47
Corn	124	131	126	124	137b	167a	168a	143ab	166	141	158	150
Soybean	48	45	46	49	59a	51ab	47b	56ab	80	78	76	74

Table 1: Crop yields (bu/ac) for conventional tillage (CT), deep tillage (DT), raised bed (RB), and vertical tillage (VT) at AAFC Portage la Prairie. Letters beside values indicate statistical significance between tillage systems within each crop and year

Tillage on protein

In a wet year, protein was lower in vertical tillage for soybean and canola. Protein and oil most related to soil pH, SOC/SOM, CCE, ACE protein, and K.

	2020				2021				2022			
	CT	DT	RB	VT	CT	DT	RB	VT	CT	DT	RB	VT
Ca	21.8ab	21.7ab	22.8a	21.4b	23.9a	23.3ab	22.9b	24.0a	21.8	21.6	21.7	21.3
Co	9.3	9.1	9.4	9.1	9.3	9.2	9.4	9.2	8.5	8.3	8.6	8.4
So	39.8a	39.9a	39.6ab	39.0b	38.5ab	38.8ab	39.3a	38.0b	38.0	37.9	37.9	37.8

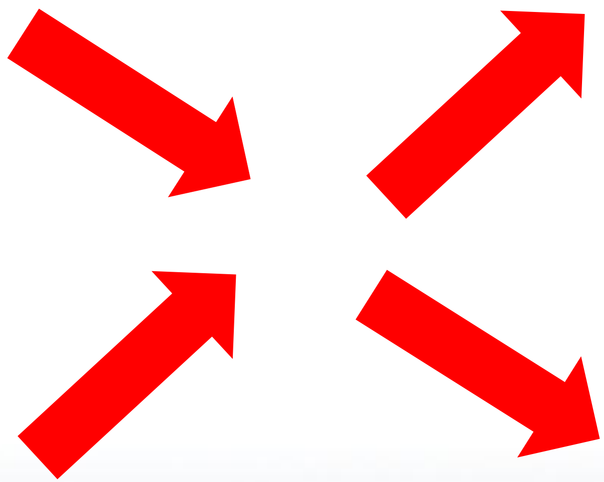
Table 2: Seed protein levels (%) for conventional tillage (CT), deep tillage (DT), raised bed (RB), and vertical tillage (VT) at AAFC Portage la Prairie. Letters beside values indicate statistical significance between tillage systems within each crop and year.

Soil organic carbon

2021 2022

Protein

Oil



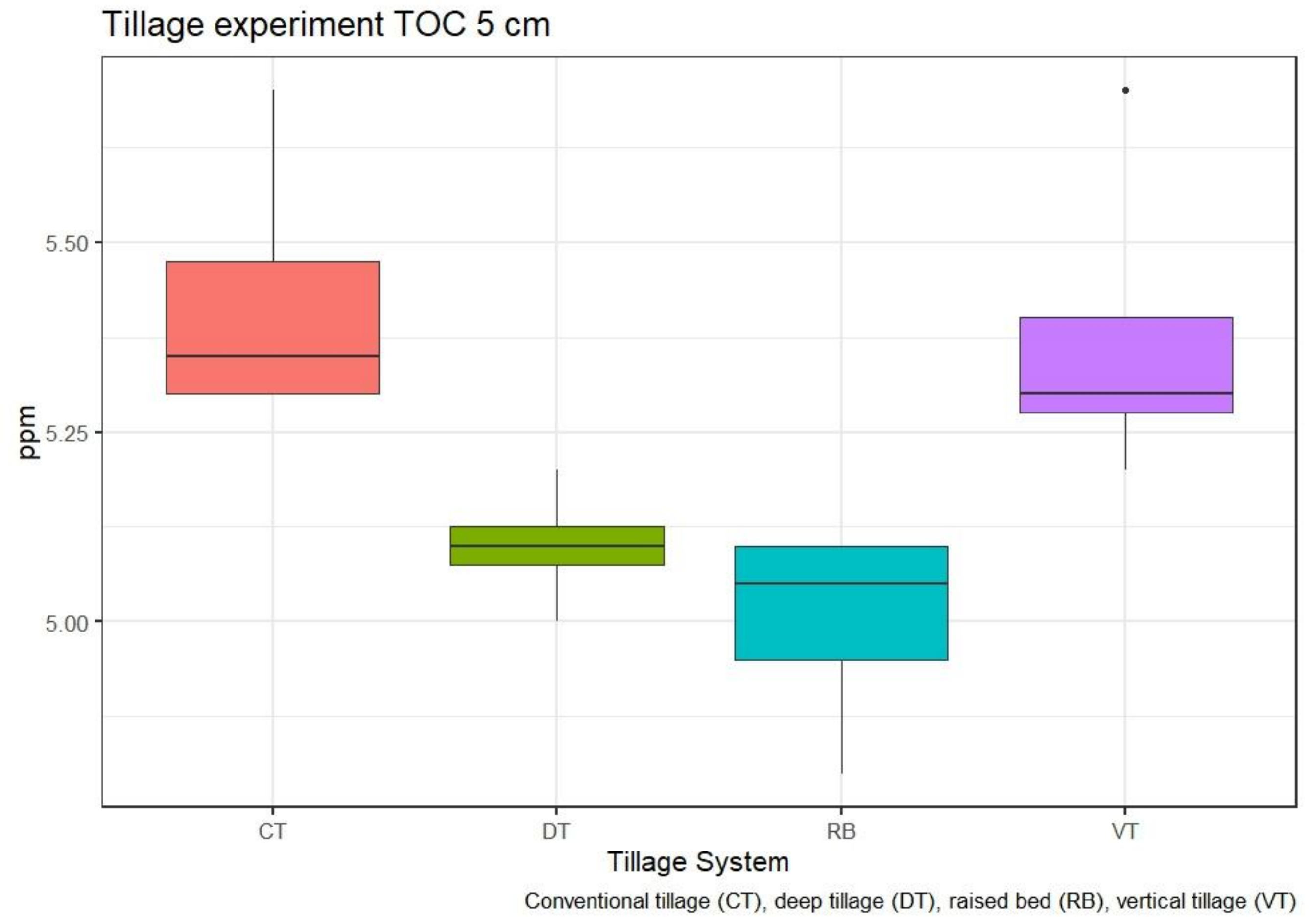
Soybean

	2021	2022
Yield (bu/ac)	53	77
Protein (%)	39.6	37.9

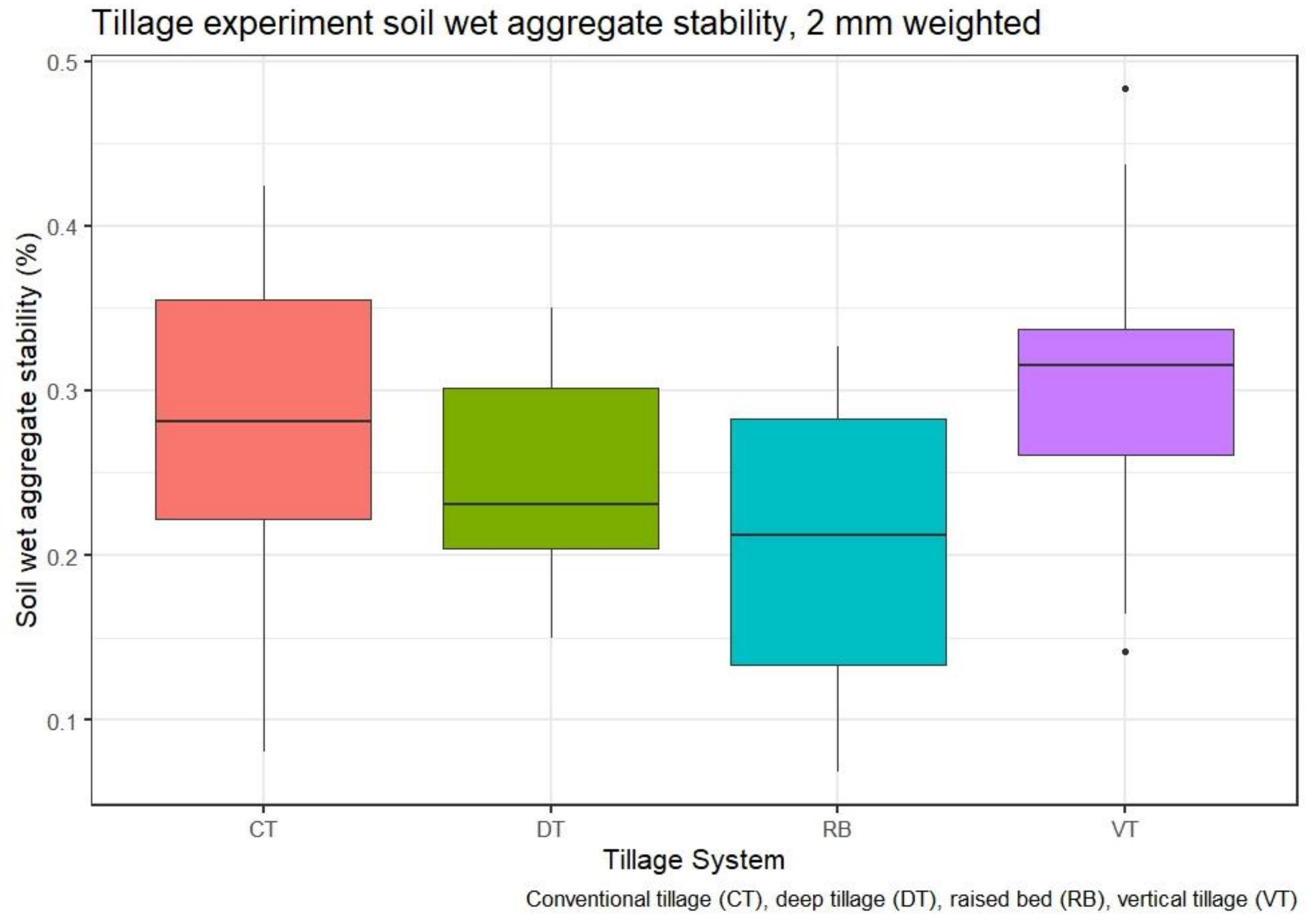
Same pattern as POXC and ACE protein, Solvita CO2 no relation

Stephen Crittenden, Curtis Cavers, and Zisheng Xing. 2024. The effect of four tillage systems on agronomic properties and soil health indicators in southern Manitoba. Canadian Journal of Soil Science. 104(3): 273-282. https://doi.org/10.1139/cjss-2023-0100

Organic Carbon



Aggregation and tillage



Conclusions from tillage

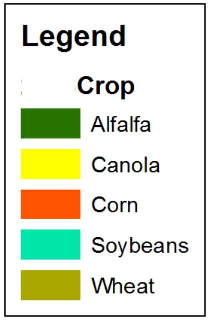
- Tillage system effected soil nitrate more than other indicators
- Soil health indicators meant to describe soil C and N pools were not strongly positively associated
- Soil health indicators correlated with agronomic responses in soybean more than canola and corn

https://cdnsciencepub.com/doi/pdf/10.1139/cjss-2023-0100

Soil Fertility and Crop Rotation Planning

- Crop rotation as a disease management tool
- Rotation effects on insects
- Crop rotation on soil moisture availability and nutrient supplies
- Integrated weed management (seeding rates, spacing, depth)

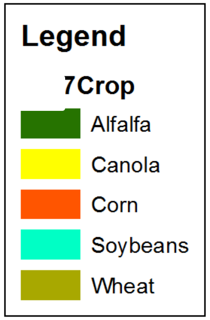
Year 1



Morden Research and Development Centre Matrix Project

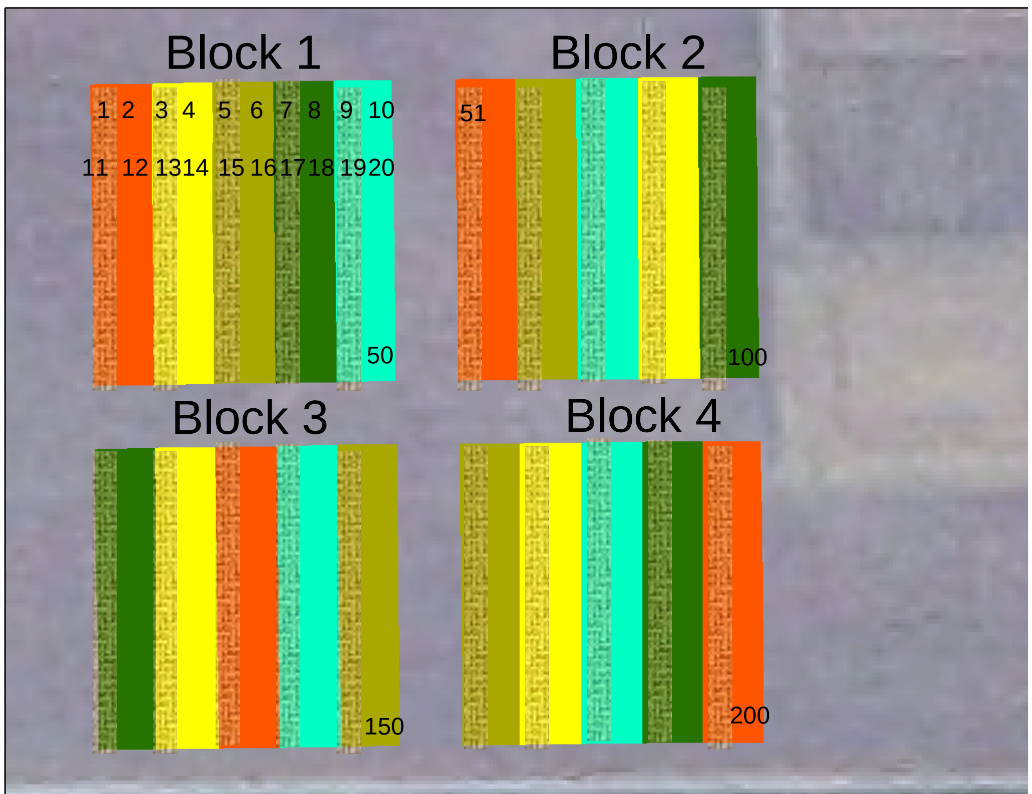
In Yr 0 everything is wheat. In Yr 1 crops were seeded west/east and tillage is north/south. Soil properties and agronomy (yield etc…) were sampled by plot (i.e., the 25 plots that were created in yr 2) as per the little black numbers

Year 2



Morden Research and Development Centre Matrix Project

Tillage

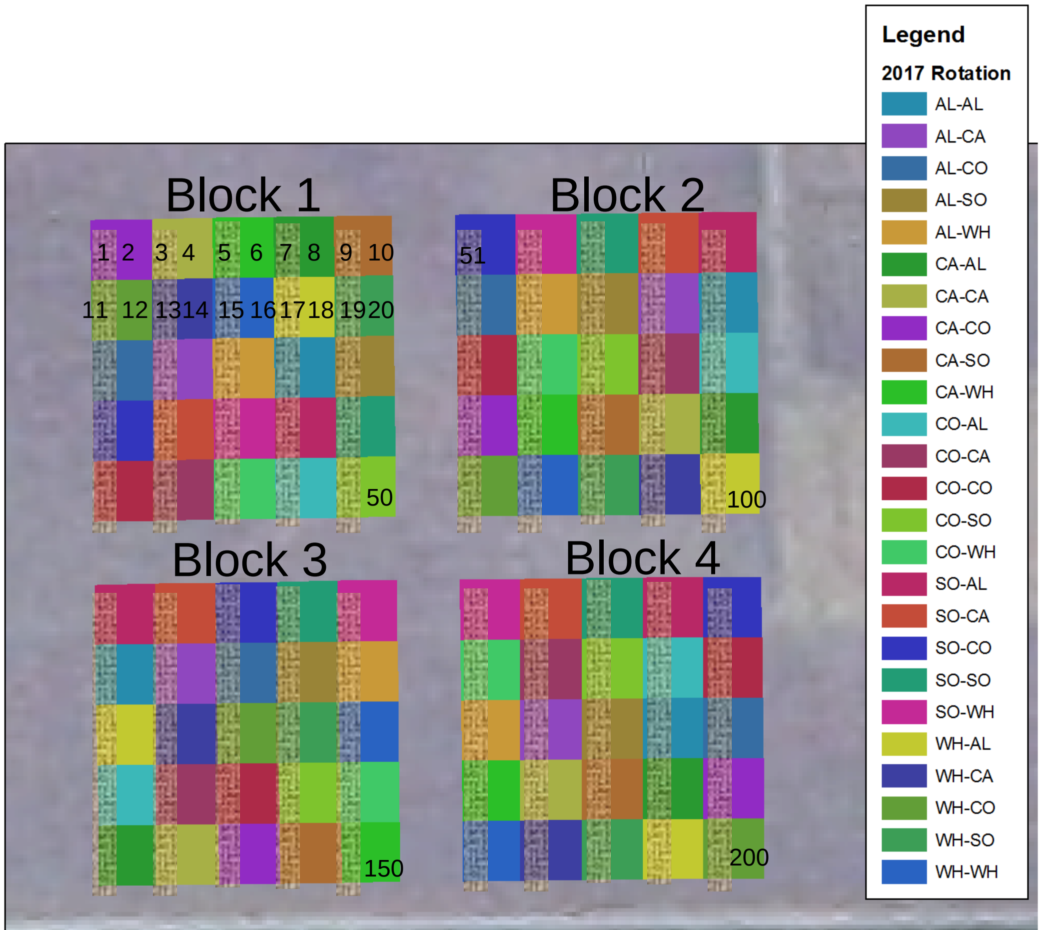


In yr 2 crops were seeded north to south

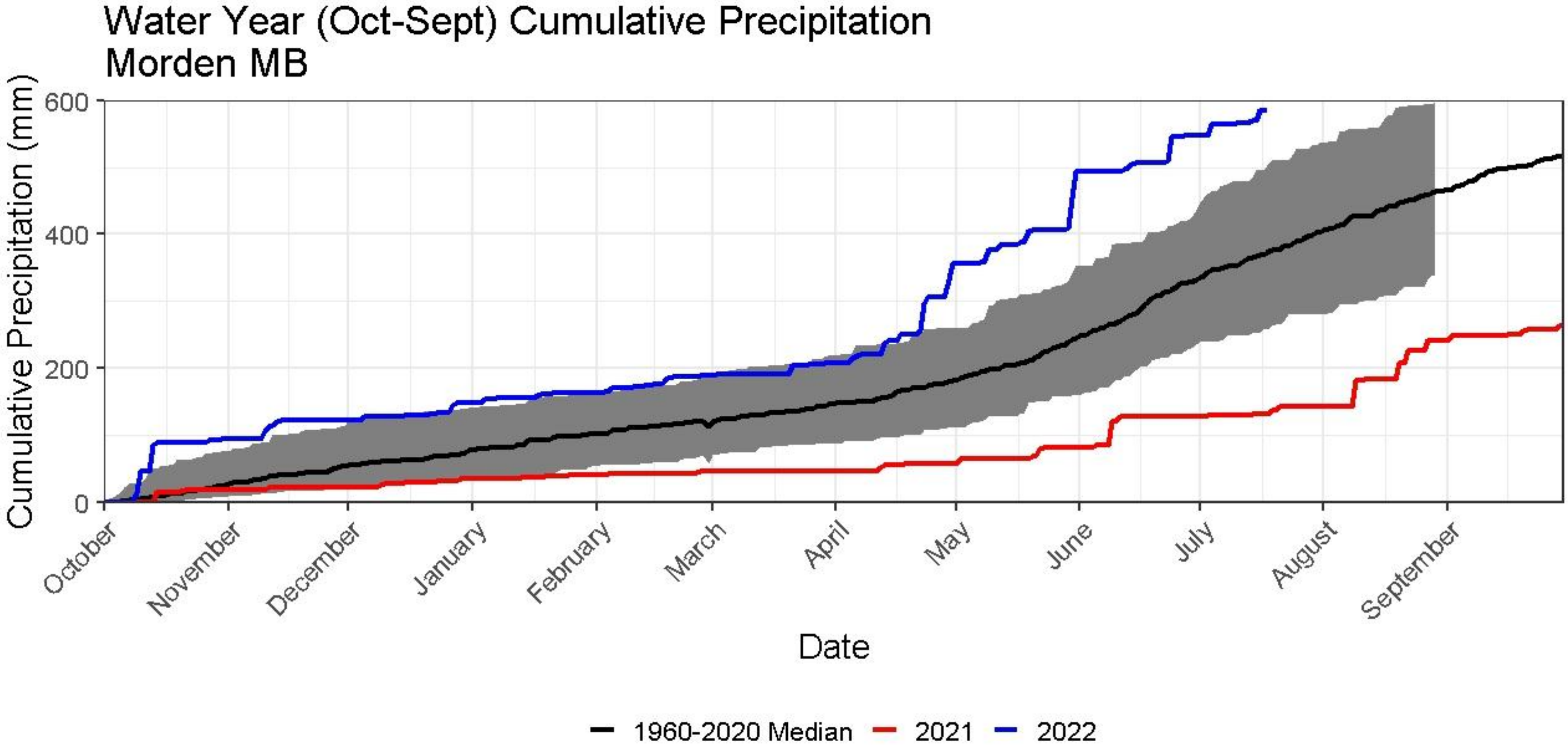
Yr 2 Crop Sequence combinations plus tillage 5 crops x 5 crops x 2 tillage systems by 4 blocks

Morden Research and Development Centre

Matrix Project



In Yr 1 soil health can be compared but agronomic properties not.
In Yr 2, we should have repeated measures for the agronomy and soil. In Yr 2 the agronomic comparisons should be within each crop,



Code from Dr. Alex Koiter

Table 1. Yield response of Manitoba crops sown on large (>120 acre) fields of various previous crops (stubble) in rotation (% of 2011-2020 average relative yields).

Previous Crop	Crop Planted											
	Spring Wheat	Winter Wheat	Oat	Barley	Canola	Flax	Pea	Soybean	Navy Bean	Sunflower	Corn	Potato
Spring Wheat	85	95	93	95	101	102	101	101	111	102	96	100
Winter Wheat	76	66	90	100	94	95	99	104	104	103	87	73
Oat	90	93	77	75	98	98	91	99	86	99	95	98
Barley	86	100	90	79	99	103	87	98	103	98	91	100
Canola	100	103	100	102	93	93	104	100	89	87	98	103
Flax	95	107	91	102	100	81	90	100	NSD	89	97	NSD
Pea	104	86	106	104	107	126	NSD	99	NSD	74	99	NSD
Soybean	107	100	109	110	102	106	106	95	NSD	108	102	89
Navy Bean	111	NSD	114	112	101	NSD	NSD	113	91	NSD	110	96
Sunflower	94	NSD	101	104	91	95	NSD	91	NSD	NSD	87	NSD
Corn	99	NSD	109	93	108	114	96	98	111	112	90	118
Potato	100	NSD	85	103	105	NSD	NSD	97	126	NSD	107	96

NSD = Not sufficient data to provide analysis.
Source: Manitoba Agricultural Services Corporation (MASC) Harvest Production Reports

Preceding crop on yield

Soybean bumped yield of canola and wheat compared to alfalfa. Yield related to SOM, P, CCE, and water extractable total N.

Crop in 2022→	Alfalfa[1]	Canola	Corn	Soybean		Wheat
Tillage→				Conv	Zero*	
Preceding crop ↓						
Alfalfa	0.94 a	29b	72b	45	31	23b
Canola	0.60 bc	38a	93ab	41	38	36a
Corn	0.77 b	37a	75ab	40	43	33ab
Soybean	0.55 bc	39a	93ab	38	51	38a
Wheat	0.54 c	38a	97a	41	47	34ab

Table 3. Preceding crop and tillage effects on crop yields at AAFC Morden. Letters beside values indicate statistical significance between preceding crop. Tillage was conventional (conv) or zero-till (zero).

*Soybean had significantly greater crop yield in zero-till (42%) compared to conventional (41%), but no effect of preceding crop.

[1] ton/acre

Preceding crop on protein

No difference in protein of crop following soybean.
Soil nitrate and CO_2 related to soybean seed protein.

Crop in 2022→	Canola	Corn	Soybean	Wheat
Preceding crop ↓				
Alfalfa	20.6ab	7.5	37.8ab	13.7ab
Canola	20.8ab	7.1	37.6a	13.7ab
Corn	20.3b	6.6	36.8b	13.2b
Soybean	21.4ab	6.8	37.1b	13.8ab
Wheat	21.9a	7.1	37.2ab	14.5a

Table 4. Preceding crop and tillage effects on seed protein at AAFC Morden. Letters beside values indicate statistical significance between preceding crop.*

Conclusions from crop sequence

- Nitrate strongest with crop yield, then pH, P, and S, then ACE Protein, Solvita, POXC, and K
- Nitrate, SOC, ACE protein, Solvita strongest with seed protein, then SOM and pH

Take aways from experimental data on soil health

- The direction and magnitude of the interactions of soil health with crop agronomic properties is crop and weather dependent.
- Soil health scoring functions may not apply in all growing conditions and crops consistently from year to year

Active Carbon

"The active soil C measured by the new procedure was more sensitive to management effects than total organic C, and more closely related to biologically mediated soil properties, such as respiration, microbial biomass and aggregation, than several other measures of soil organic C"

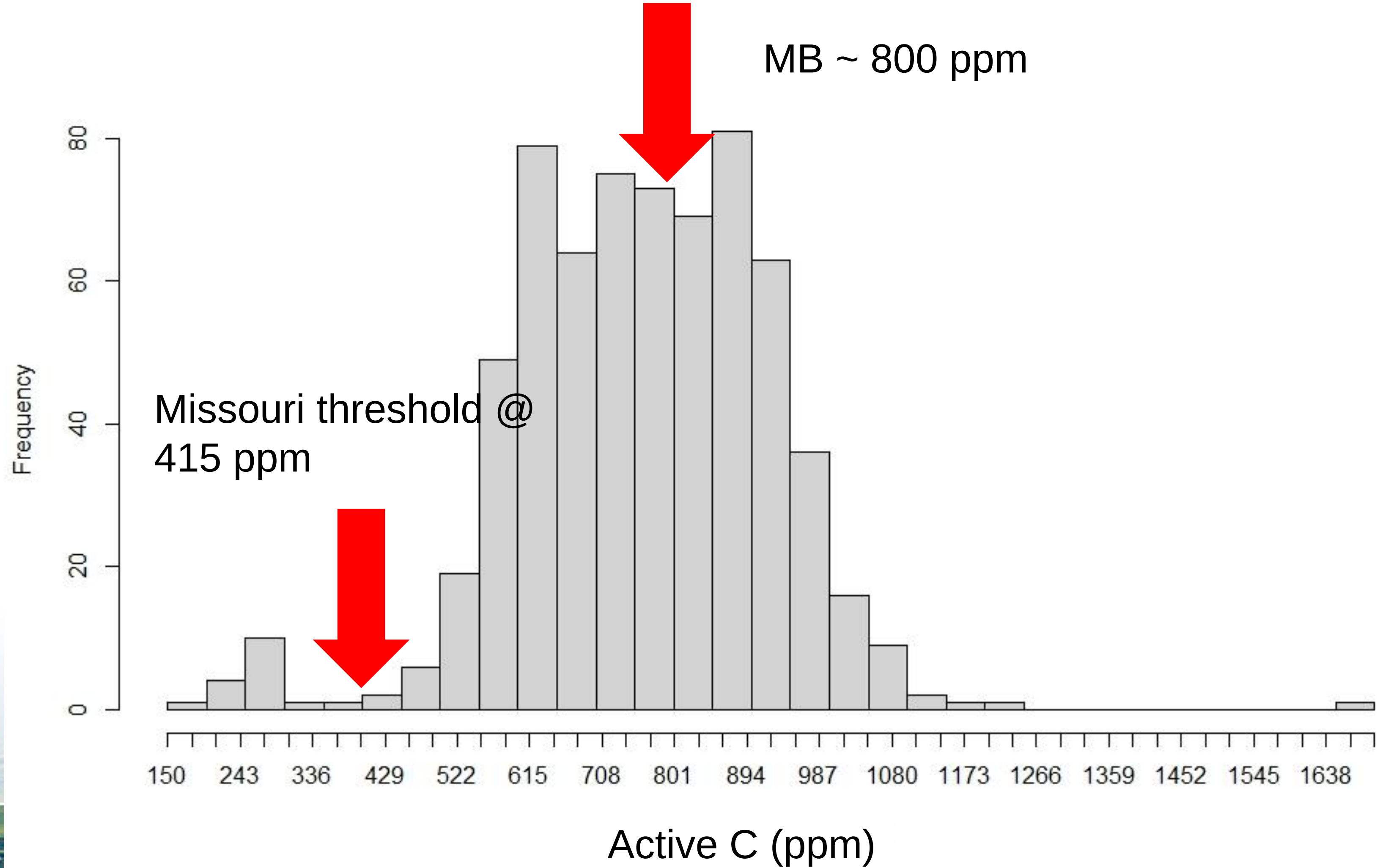
Weil, R., Islam, K., Stine, M., Gruver, J., & Samson-Liebig, S. (2003). Estimating active carbon for soil quality assessment: A simplified method for laboratory and field use. American Journal of Alternative Agriculture, 18(1), 3-17. doi:10.1079/AJAA200228

Agronomic interpretation of active carbon

- Active carbon a factor influencing grain productivity
- Corn grain yield at 446 sites in Missouri
- 415 mg POXC kg-1, threshold for maximum grain productivity
- Neither ACE protein nor CO2 burst related to productivity

Svedin, J. D., Veum, K. S., Ransom, C. J., Kitchen, N. R., & Anderson, S. H. (2023). An identified agronomic interpretation for potassium permanganate oxidizable carbon. Soil Science Society of America Journal, 87, 291–308. https://doi.org/10.1002/saj2.20499

Active C in MB



Active carbon in region

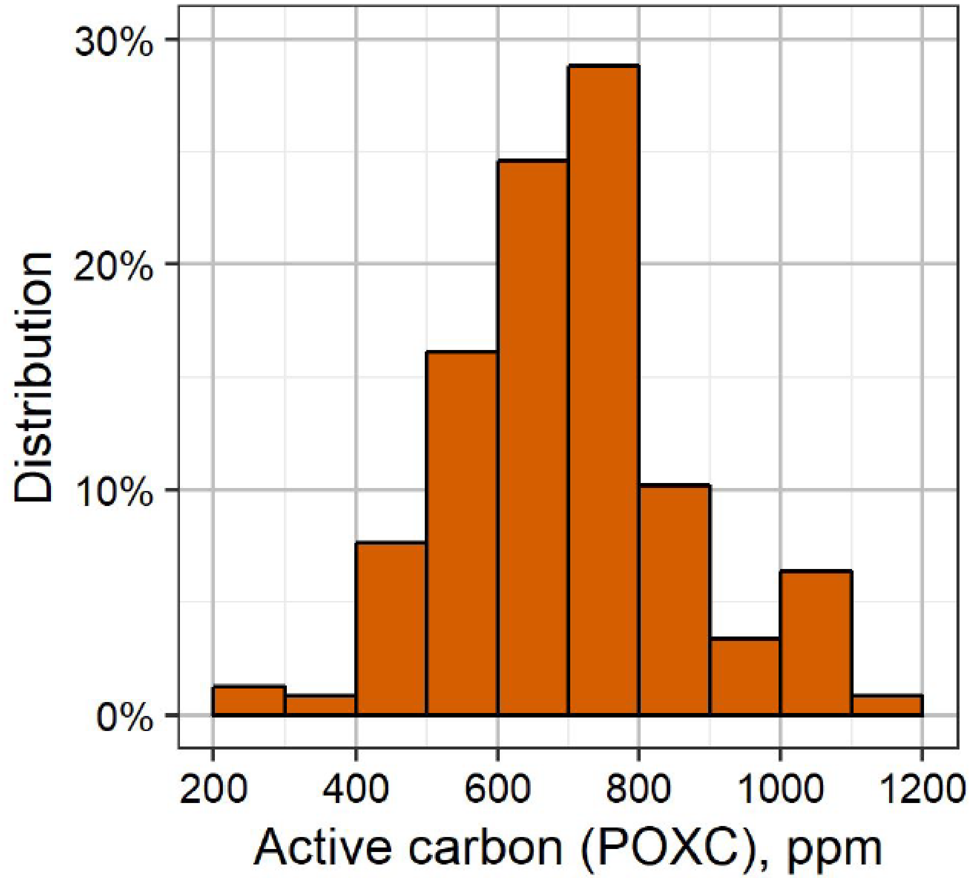
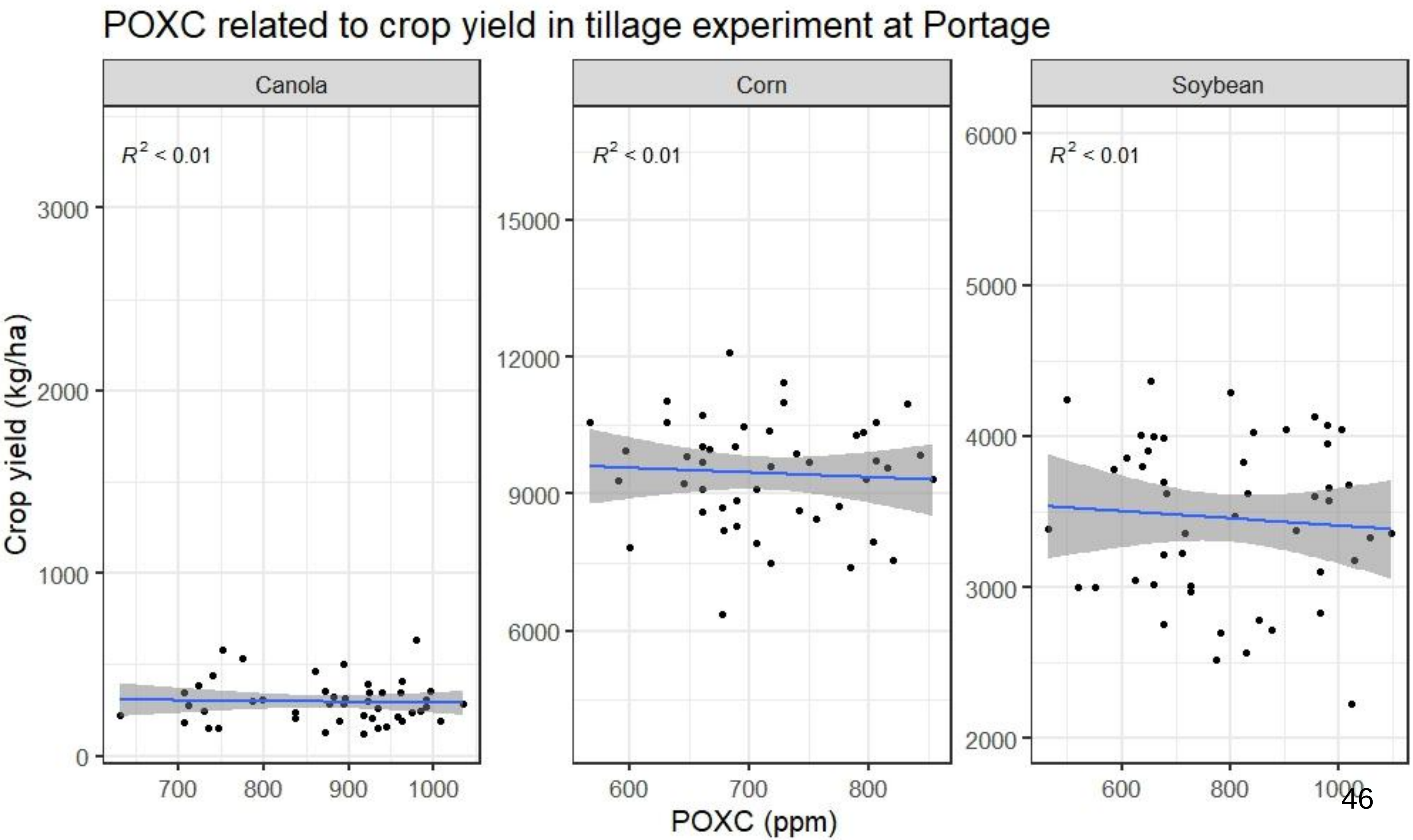


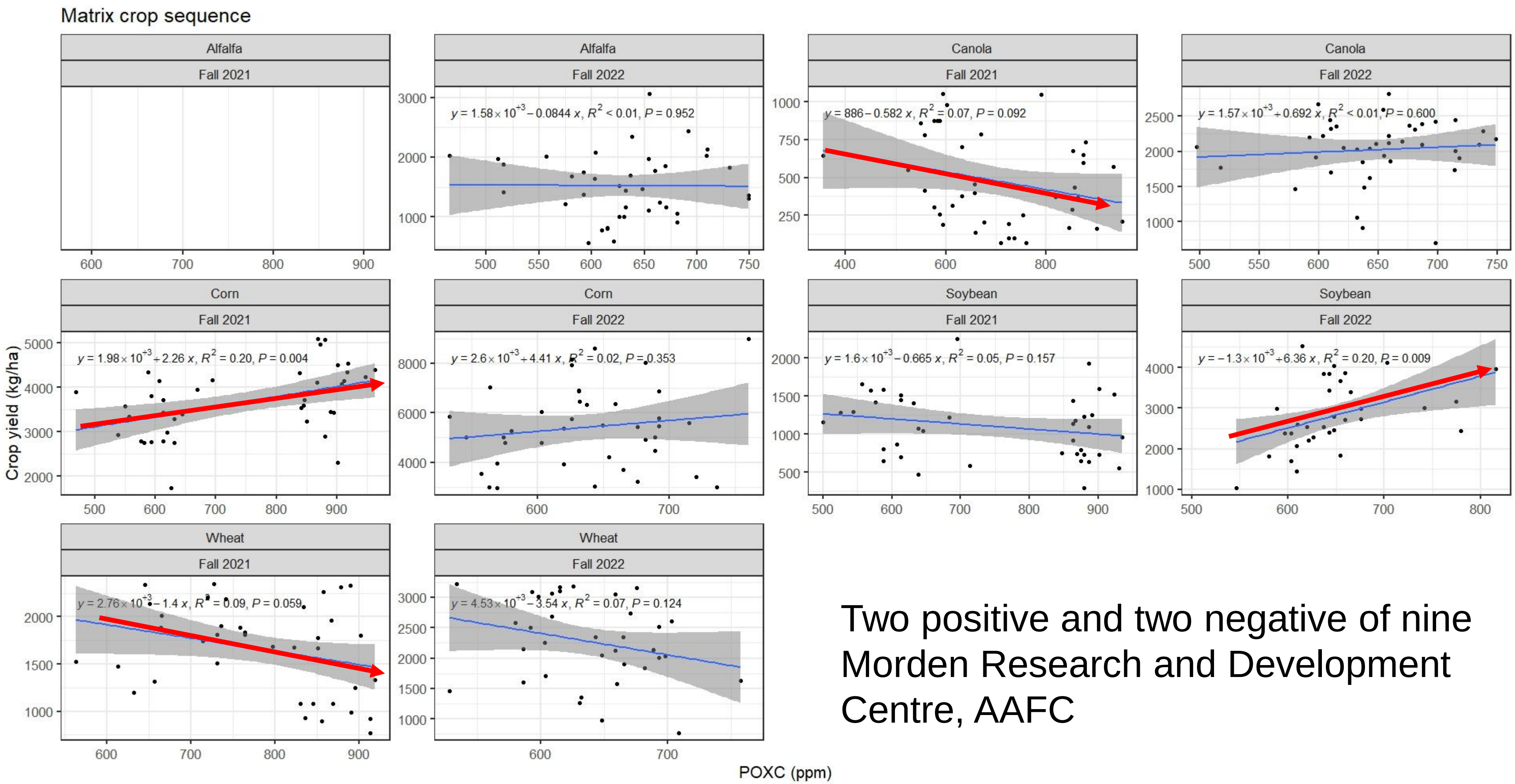
Figure 2. Active carbon distribution among agricultural soils of the upper Midwest and northern Great Plains.

https://www.agvise.com/active-carbon-poxc-what-does-it-measure/

Active C did not relate to crop yield



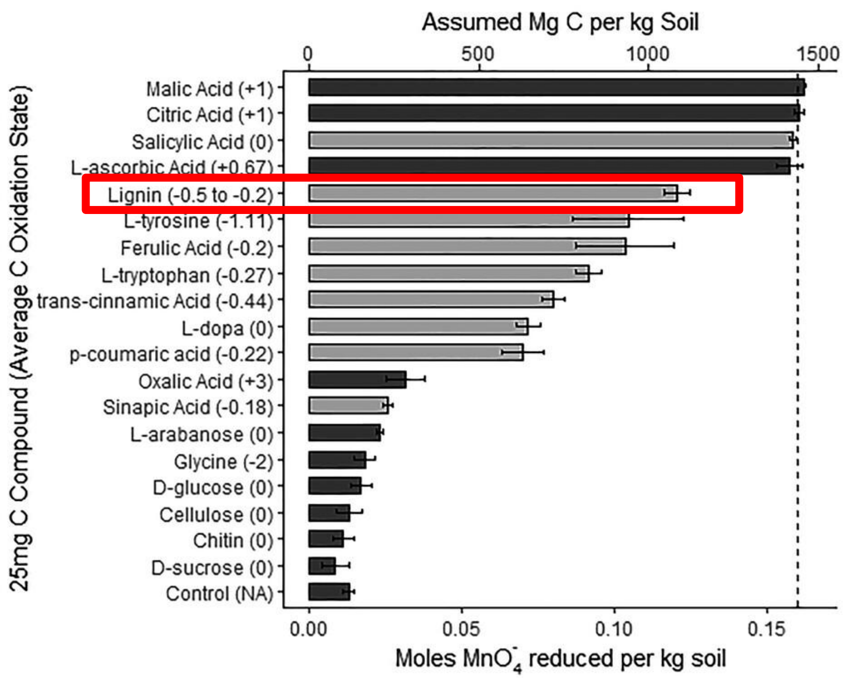
POXC v yield



Two positive and two negative of nine Morden Research and Development Centre, AAFC

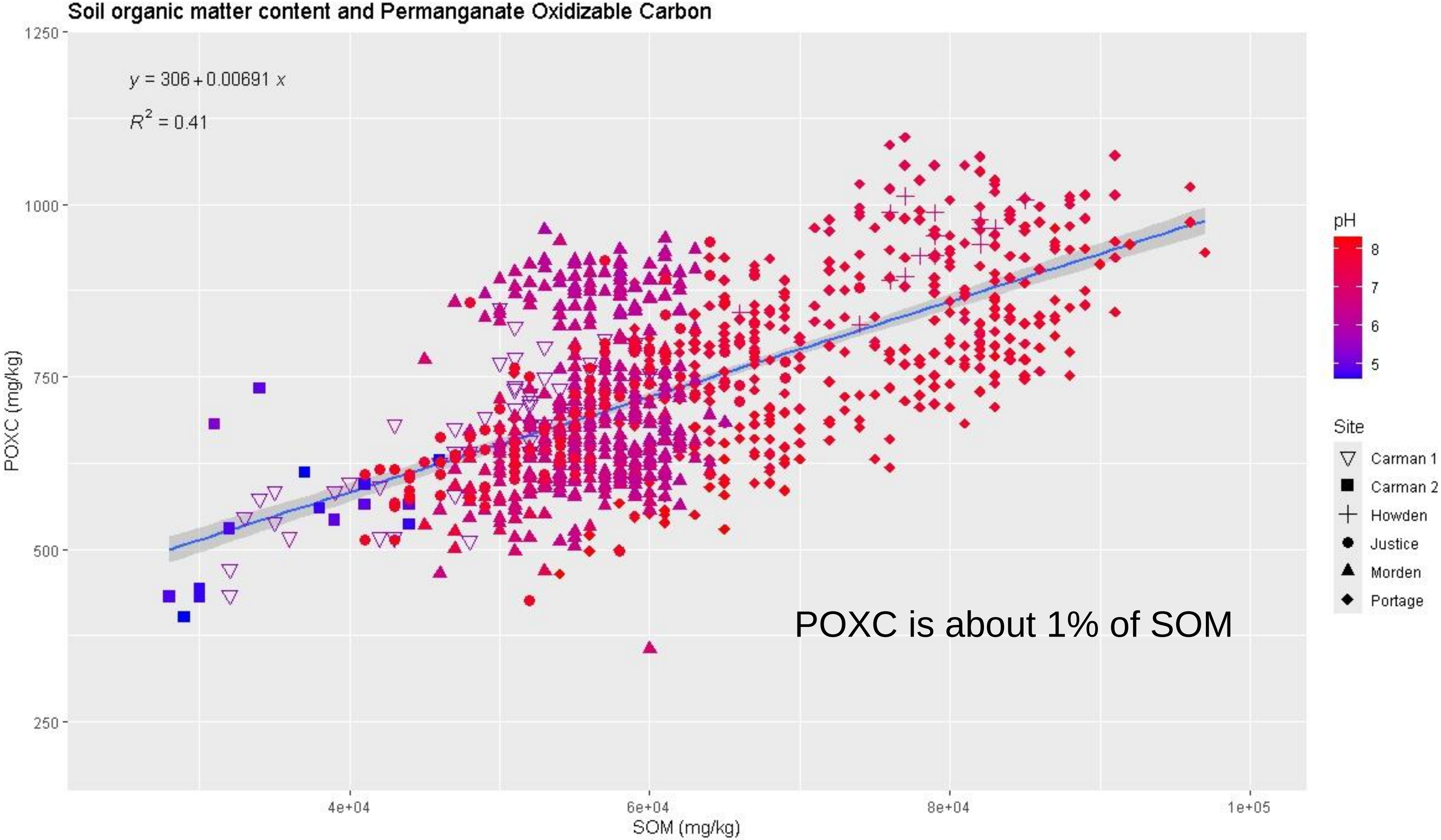
Revisiting Active C

- "POXC (Active C) does not measure the labile SOC pool the POXC assay was developed to quantify"
- Measures chemical lability not biological
- Recalcitrant material like lignin are oxidized



Woodings, F. S., & Margenot, A. J. (2023). Revisiting the permanganate oxidizable carbon (POXC) assay assumptions: POXC is lignin sensitive. *Agricultural & Environmental Letters*, 8, e20108. https://doi.org/10.1002/ael2.20108

Active Carbon vs. SOM



POXC is about 1% of SOM

Is it worth it?

POXC $22.55 US / SOM (LOI) $4.45 US

Across both experiments, soil organic matter (SOM) significantly related to agronomic properties 15 times whereas POXC 13 times.

50

Where is soil health?

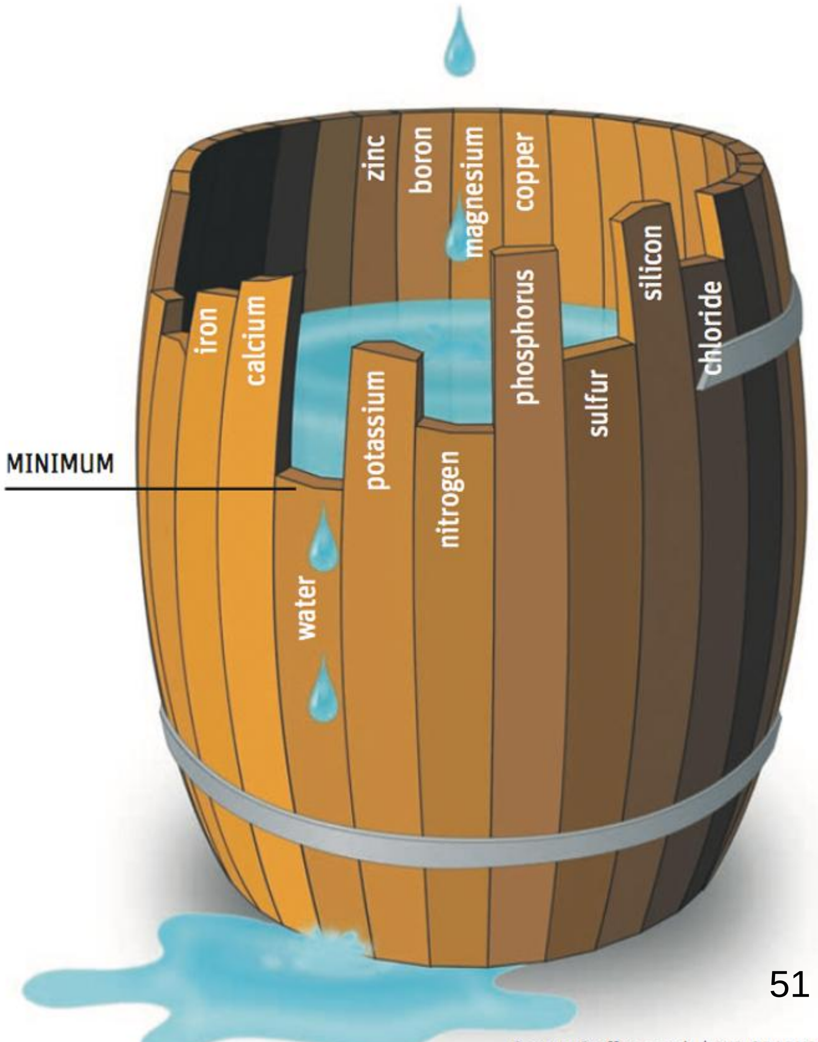
This is all soil health. Additional indicators can be useful but probably shouldn't replace NPKS, pH, EC, SOM.

For example, soil health indicators related to nitrogen fit into the stave of the barrel.

LAW OF THE MINIMUM – LIEBIG'S LAW

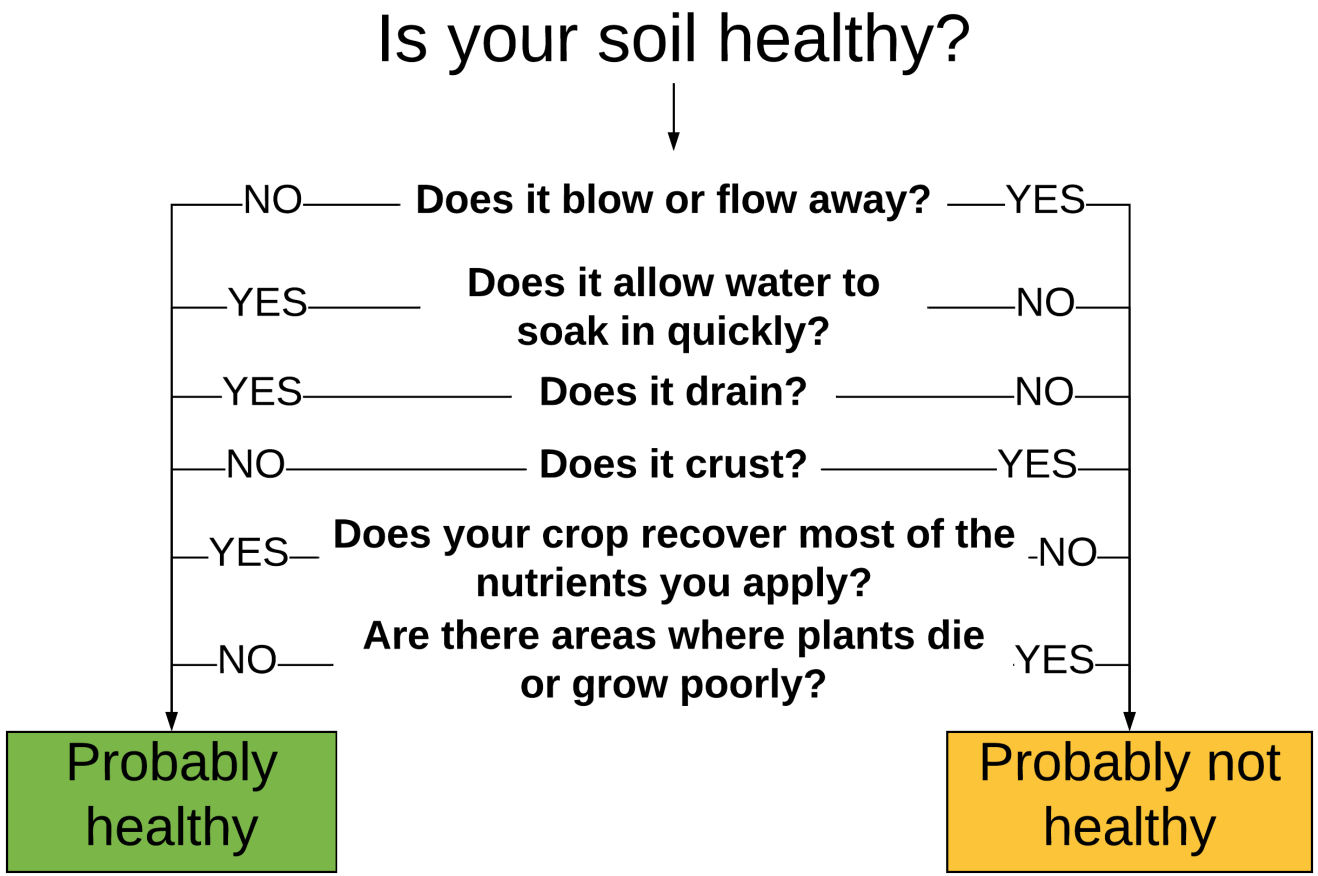
Justus von Liebig formulated the law of the minimum: if one crop nutrient is missing or deficient, plant growth will be poor, even if the other elements are abundant.

The analogy for the potential of a crop is a barrel with staves of unequal lengths. The capacity of the barrel, a crop's yield, is limited by the length of the shortest stave and can be increased only by lengthening that stave. When that stave is lengthened, another one becomes the limiting factor.



Source: Staff research | WP GRAPHIC

Remove major threats first



Soil (health) evaluation begins by asking "What's the problem with my soil?" | CSANR | Washington State University (wsu.edu)

Why pay attention to soil health?

- To help you make decisions
  - Benchmarking
    - Track with time
    - Shift in management
  - Spatial variability
    - Topography
    - Salinity
    - Potholes

Conclusion

- Soil test don’t guess
- Oldies are still goodies, use other soil tests for specific questions

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

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- MB Ag Action
- MPSG
- MCGA

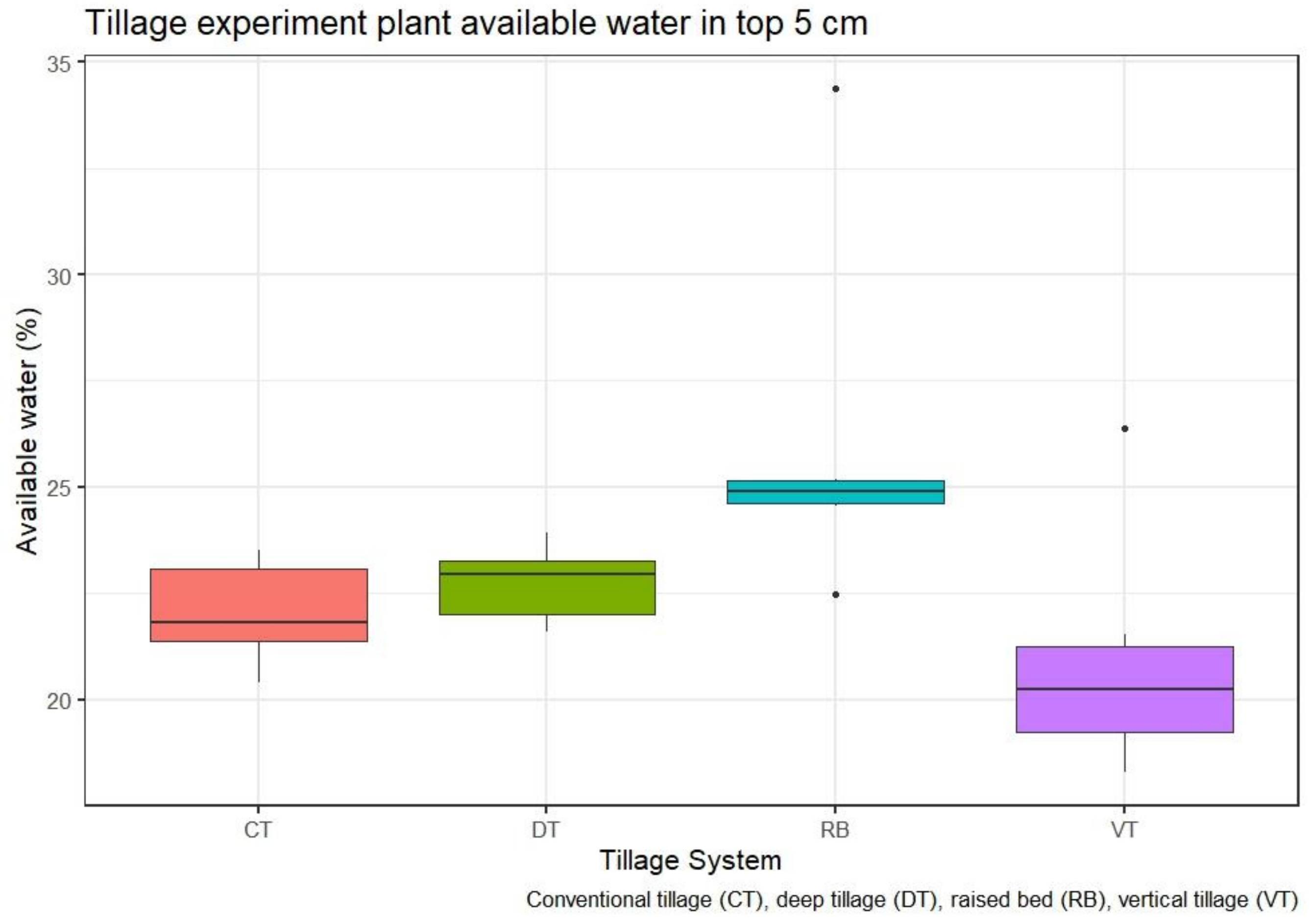
Thank you!

For more information, please contact:

Stephen.Crittenden@agr.gc.ca

Canada

Plant available water



Raised beds had significantly greater plant available water than vertical tillage