Liming for crop production and soil health

Presented by

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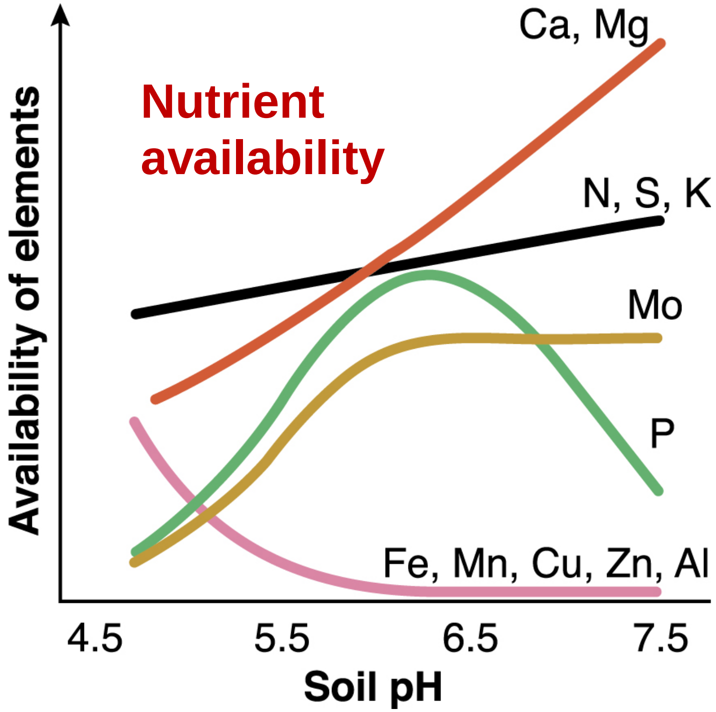
Introduction

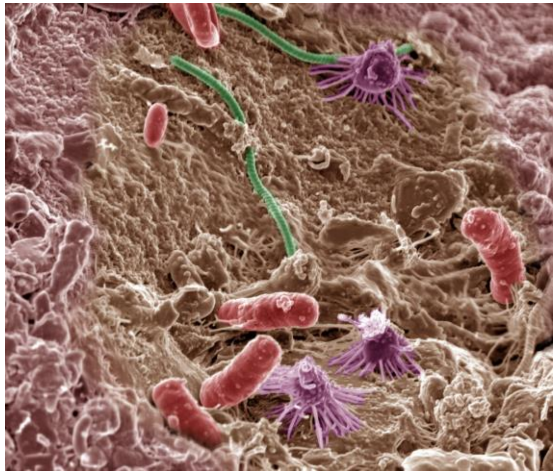
- Soil pH is a measure of the acidity and alkalinity of soil. It is regarded as one of the most informative measurements of soil characteristics as it directly affects:



Department of Agriculture and Food Australia, 2018

Plant growth

Microbial activity



Introduction

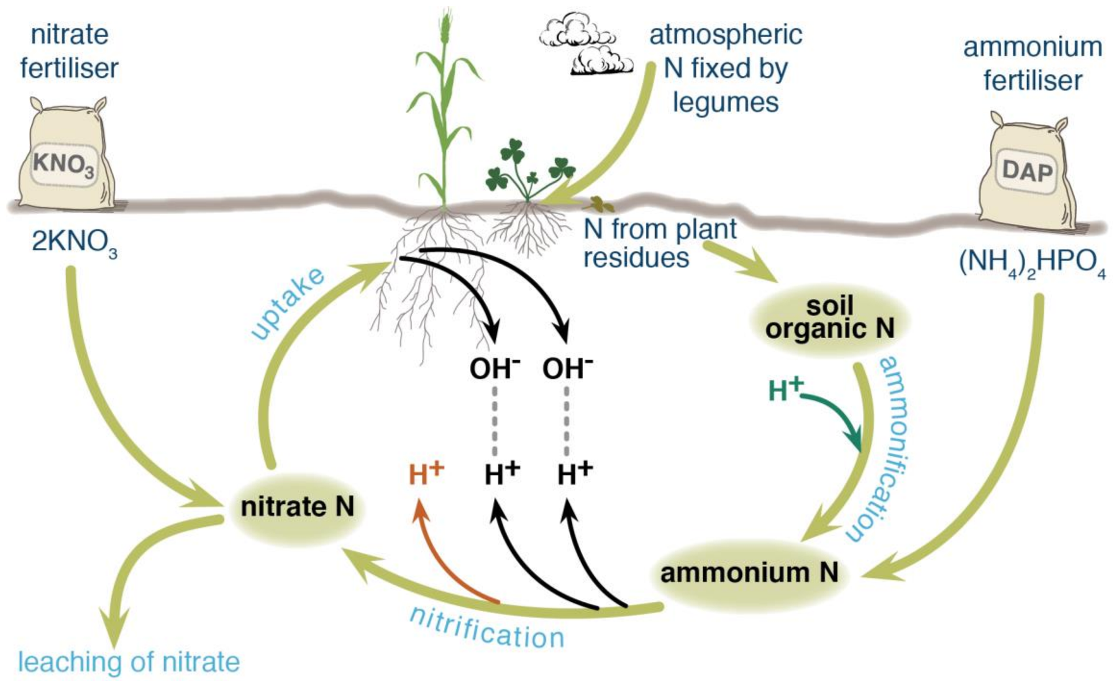
➢ Like other soil characteristics, soil pH is influenced by various factors

Natural factors

❿Parent material
❿Climate
❿Decomposition of organic matter
❿Topography
❿Microbial activities
❿Mineral weathering

Anthropogenic factors

❿Fertilizer use
❿Land use changes
❿Pollution and emissions
❿Removal of harvested material



Source: Msimbira, L. A., & Smith, D. L. (2020).

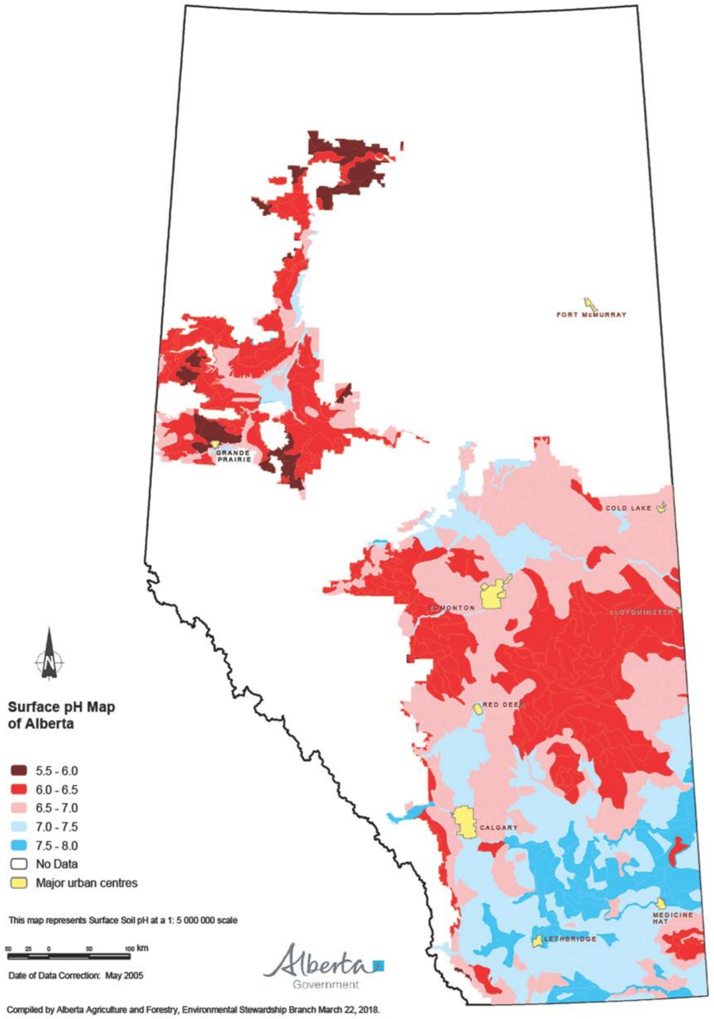
Introduction

- Decline in soil pH can lead to soil acidification and jeopardize the sustainability of agriculture and food security worldwide

- About 30–40% of the world’s arable land is acidic (i.e., pH <5.5)

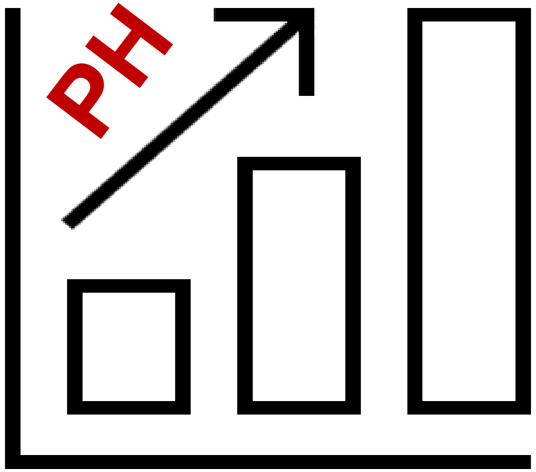
- In Canada, soil acidity has been a notable challenge since the 1960s, particularly in western Canada, where approximately 6.3 million acres of arable land have reported pH levels below 6.0

- With agricultural intensification, the potential for soil acidification to rise persists. Acidic soils are known to cause nutrient imbalances, impair microbial activity, and reduce crop yield thus impacting sustainable food production



Introduction

- Lime application is commonly used as a strategy to mitigate soil acidification and raise soil pH
- Liming is the process of adding lime to soil (i.e., materials with neutralizing effect) to reduce acidity or increase soil pH



How does soil liming work ?

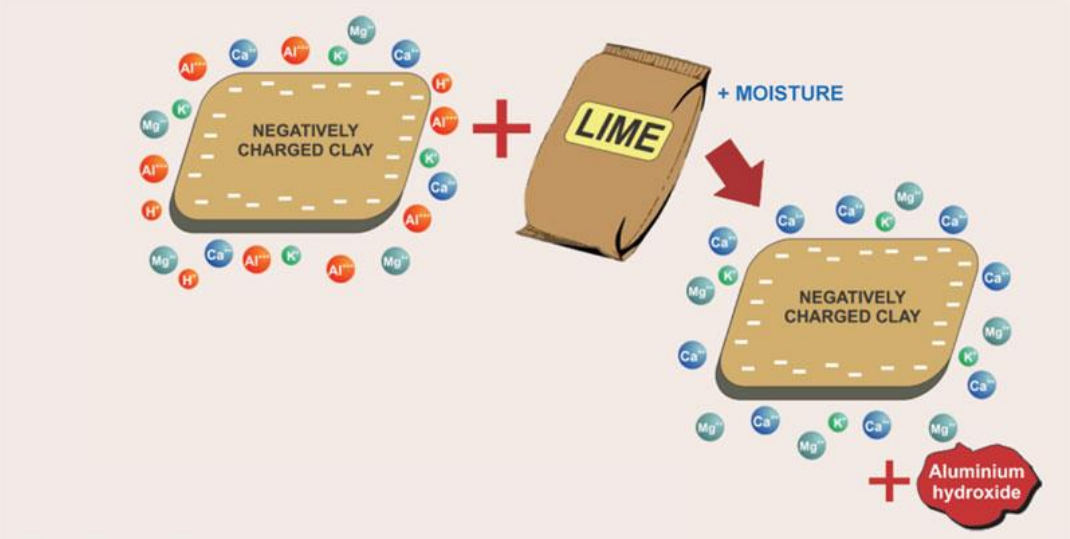
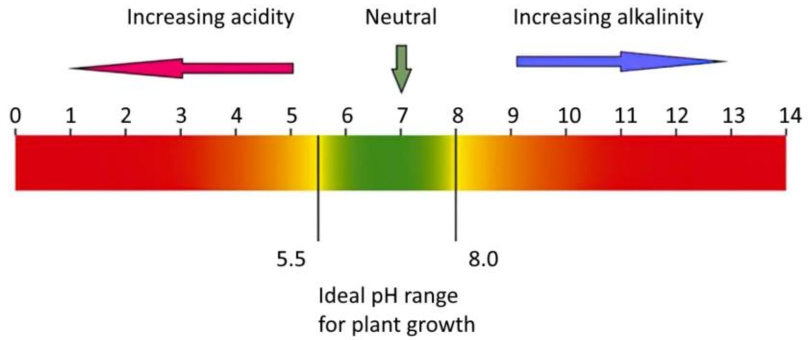


Figure 1: Illustration of the neutralising role of lime on soil acidity.



Introduction

Different types of lime materials to address soil acidity

- Calcium carbonate ($CaCO_3$)
- Dolomitic lime ($MgCO_3$)
- Hydrated lime ($Ca(OH)_2$)
- Quick lime (CaO)
- Cement Kiln Dust (CKD)
- Wood ash

Lime materials exist in different forms

Fine particles

Pelletized form

Incorporated into soils
Applied on soil surfaces

Introduction

Although various sources of lime are available in the Canadian Prairies, The practice of liming is not widespread due to:

- High cost
- Lack of information on application timing and frequency,
- Lack of information of appropriate sources
- Effect on crop productivity
- Effect on soil health

Given that most research on liming for crop production in Alberta dates back 40 years, there is an urgent need for new information to adapt current realities

RESEARCH ARTICLE

Effect of long-term tillage on soil aggregates and aggregate-associated carbon in black soil of Northeast China

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The Influence of Applying Lime and NPK Fertilizers on Yield of Maize and Soil Properties on Acid Soil of Areka, Southern Region of Ethiopia

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Effects of Lime Type on Yields and Leaf Concentrations of Several Vegetable Crops as Related to Soil Test Levels

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Additional index words. calcitic lime, dolomitic lime, nutrient uptake, *Lycopersicon esculentum, Zea mays, Phaseolus vulgaris, Brassica oleracea*

Key components of the project

Soil health objectives

- **Objective 1**: To measure any shift in soil microbial community structure and function over time in lime (cement kiln dust) versus no lime treatments
- **Objective 2:** To evaluate the effects of liming on selected soil health parameters: wet aggregate stability, pH, CEC, exchangeable cations, readily soluble Al and Mn, available NPKS, organic C, total C and total N

Agronomic objectives

- **Objective 1:** To evaluate the effect of liming (Cement Kiln Dust) on agronomic parameters and crop yields across different on-farm field sites
- **Objective 2:** To evaluate the effect of different lime sources agronomic parameters and crop yields
- **Objective 3:** To evaluate the profitability of lime application

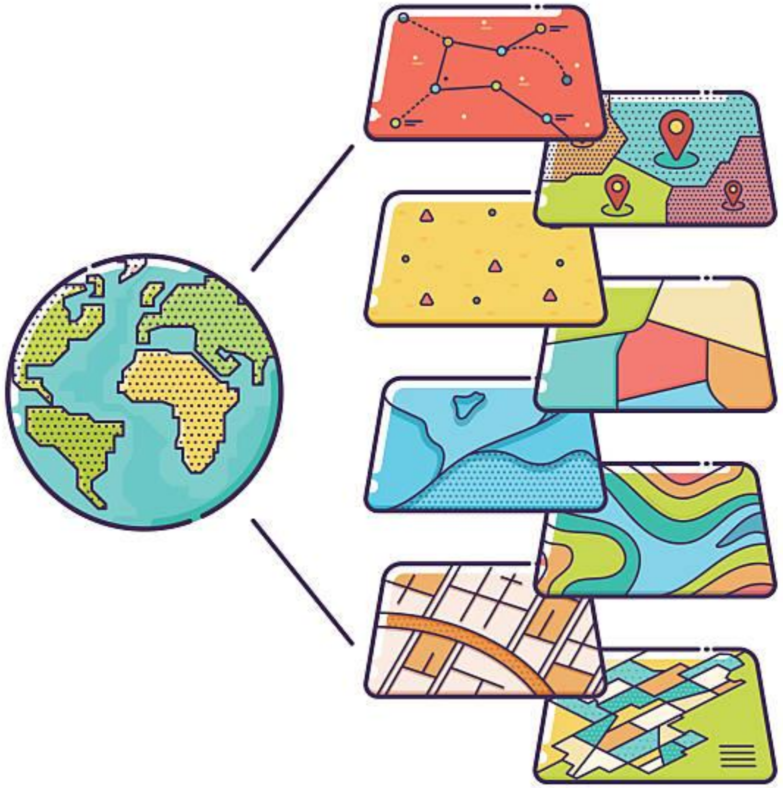
Key components of the project

Geospatial component

1. The spatial pattern of soil pH measured by soil optix sensors under field conditions

2. The effect of soil pH variability on soil organic matter (SOM), cation exchange capacity (CEC)

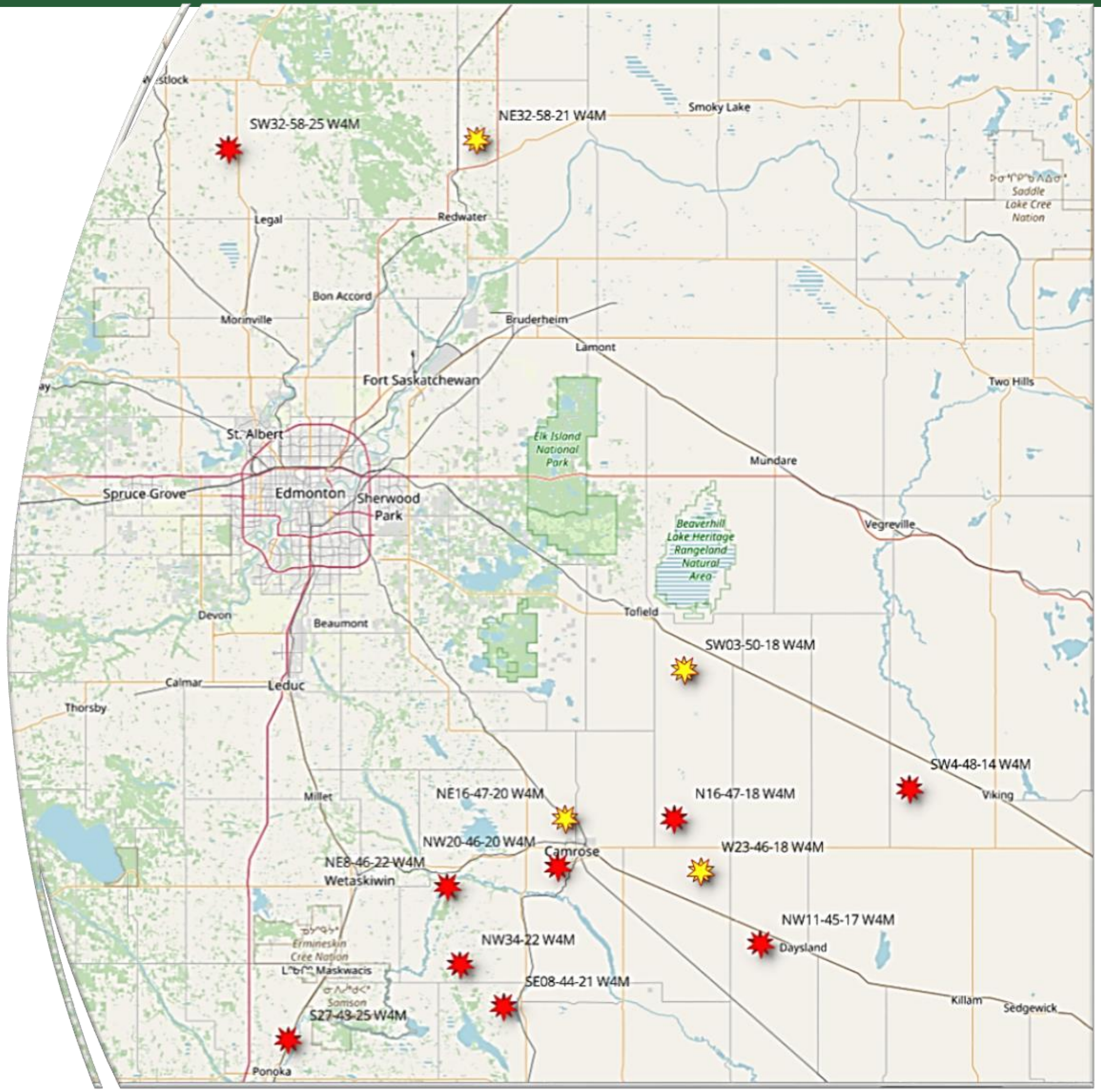
3. The effect of soil pH variability on crop yields across different field



Methodology and approach

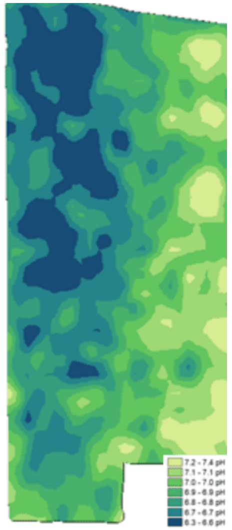
2022-2023 Study sites

Field sites: (*n=12*)
•4 fields in 2022
•8 fields in 2023
•Fields located in central Alberta



Methodology and approach

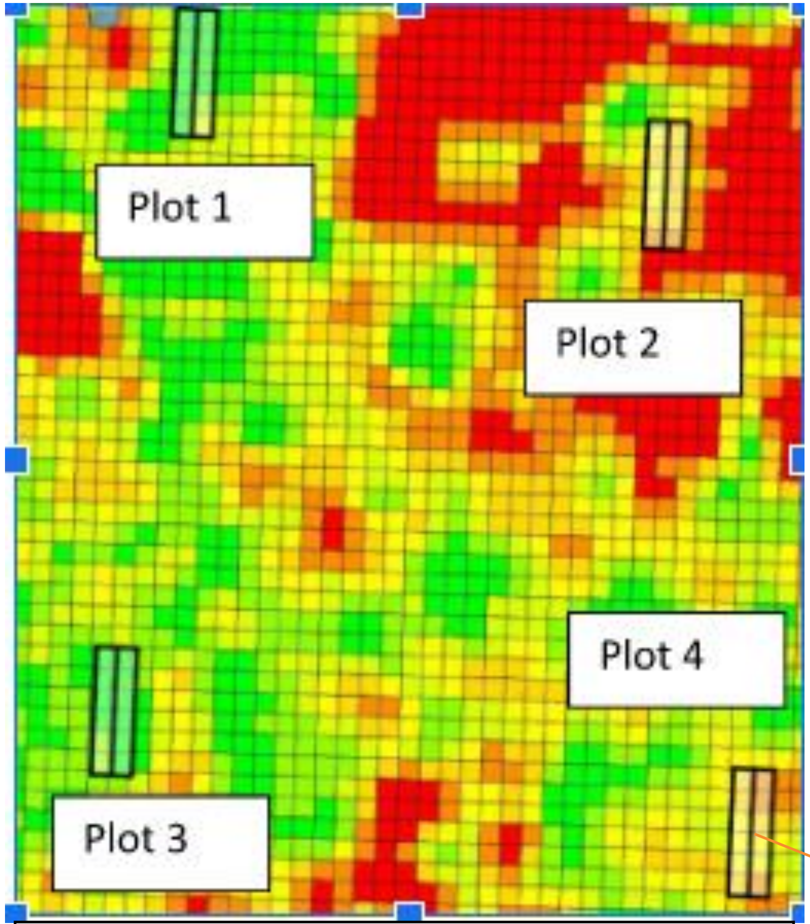
Soil mapping → Soil sample collection for calibration → Data processing and generation of maps



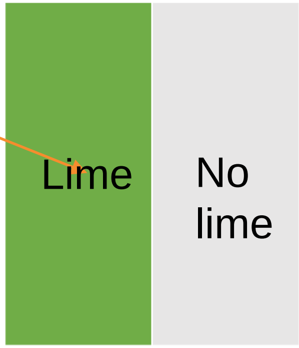
- ❑ Using soil optics technology, 12 grower fields with low soil pH were identified within the black and gray soils in Edmonton
- ❑ Precision lime application was done by soil optics exempting the no-lime plots

Methodology and approach

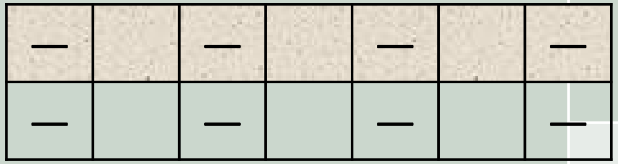
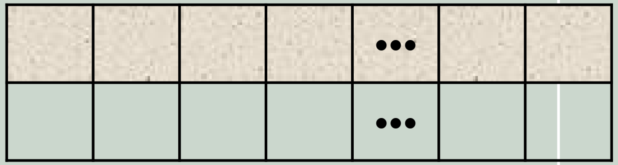
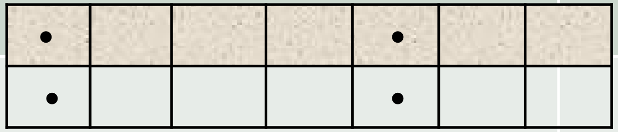
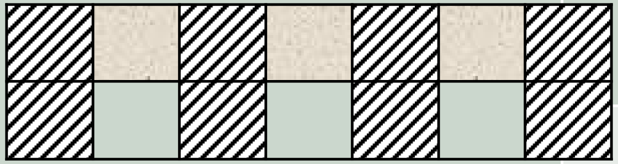
Research design: Before after control impact (BACI)
Treatments: 2 lime treatments* 12 farms *4 replicates



Representation of the field layout of each farm having Limed and the no-lime plots replicated 4 times



Agronomic data collected

Type of data to be collected	Stage of crop development	Number of samples/representative sections	Pseudo-replicates (sectional data collection)	Sampling frequency	Tools for data collection
Soil samples (Nutrient analysis)	**Before planting** **At flowering** **After harvesting**	8*4*13= 416 samples (0-15,16-30cm)		3	Track mount auger
Plant count	**Emergence** Canola (7-10 days) Wheat (7-10 days)	8*4*13=416 sections		1	Ruler
Plant height	**Flowering** Canola (50-60 days) Wheat (80-100 days)	3*2*4*13= 312 sections		1	Ruler
SPAD measurement	**Flowering**	3*2*4*13= 312 sections		1	SPAD meter
Above ground Biomass	**Flowering**	4*4*13=208 samples		1	Quadrat (0.25*0.25)cm
Days to flowering	**Pre-flowering**	8*4*13=416 sections		1	Visual assessment
Days to Maturity	**Hardening** Canola (90-120 days) Wheat (100-120 days)	8*4*13=416 sections			

Methodology and approach

Soil health parameters measured:

- pH,
- EC,
- CEC,
- exchangeable cations,
- readily soluble Al and Mn,
- available NPKS,
- organic C,
- total C and N
- Soil organic matter (SOM)
- Wet aggregate stability
- Microbial communities

Soil sampling collection time and depth

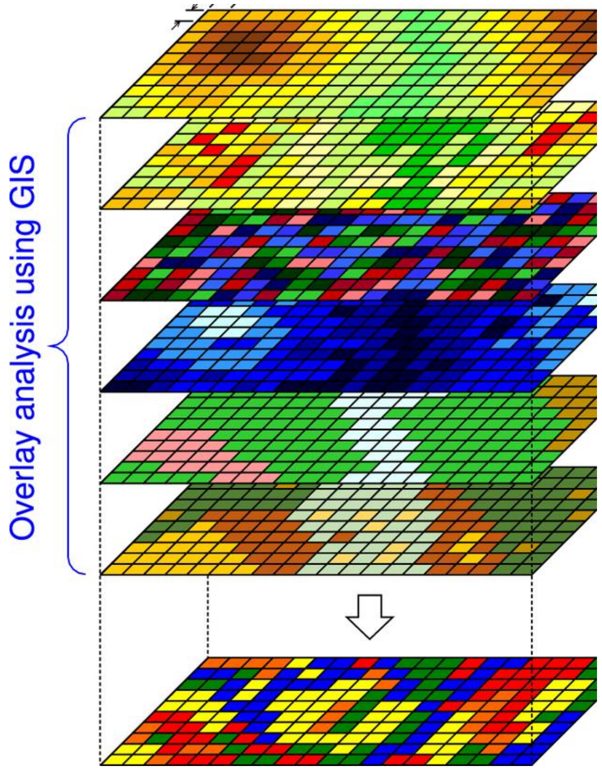
Depths of sampling: 0-15, 15-30 and 30-60 cm

Time of soil sampling:

- pre-planting
- mid-season
- post-harvest

Methodology and approach

- Spatial fusion of soil maps and yield maps using GIS



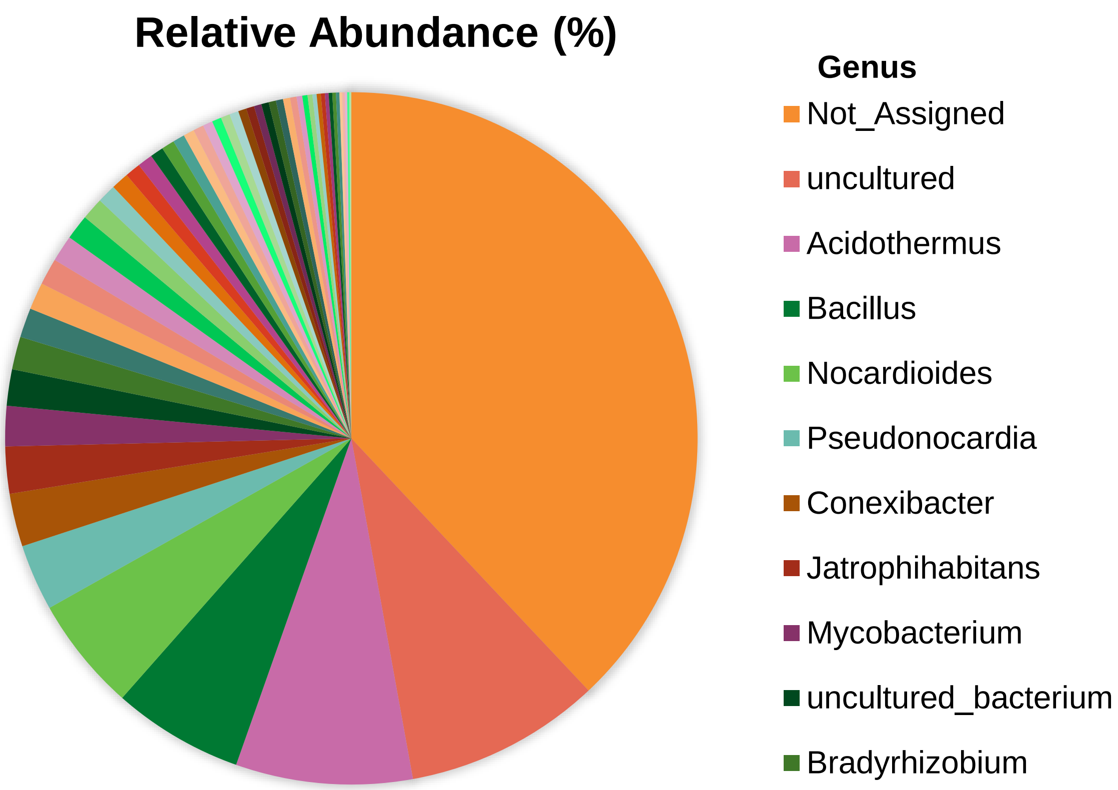
- Yield maps

- pH
- CEC
- SOM
- Sand
- Silt
- clay

- Delineation based on soil pH levels (i.e., <5.5, 5.5-6.0, 6.0-6.5 and 6.5-7.0

- Basic statistics parameters i.e. the mean value and standard deviation

Preliminary results from microbial studies



Relative abundance (%) of bacterial genera observed in limed and unlimed plots

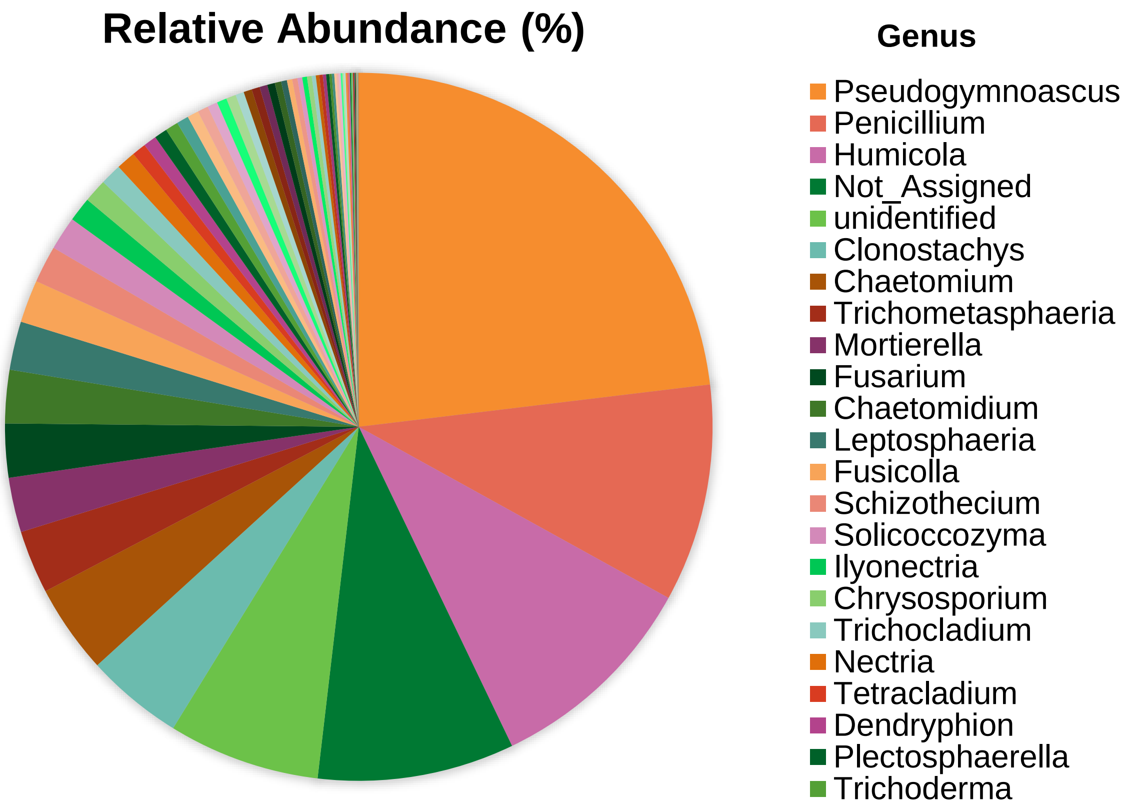
Most abundant genera:

Acidothermus, Bacillus, Nocardiodes, Pseudonocardia, Conexibacter. Jatrophihabitants, Mycobacterium, Bradyrhizobium

Beneficial roles: breakdown of cellulose and OM, nutrient cycling, improving soil fertility, protection of plant from pathogens and conferring stress tolerance

Preliminary results from microbial studies

Relative abundance: Fungal Genus



***Most abundant genera:** Pseudogymnoascus, Peniccillium, Humicola, Clonostachys, Chaeotomium, Mortierella, Trichometasphaeria, Chaetomidium, Leptosphaeria, Fusicolla

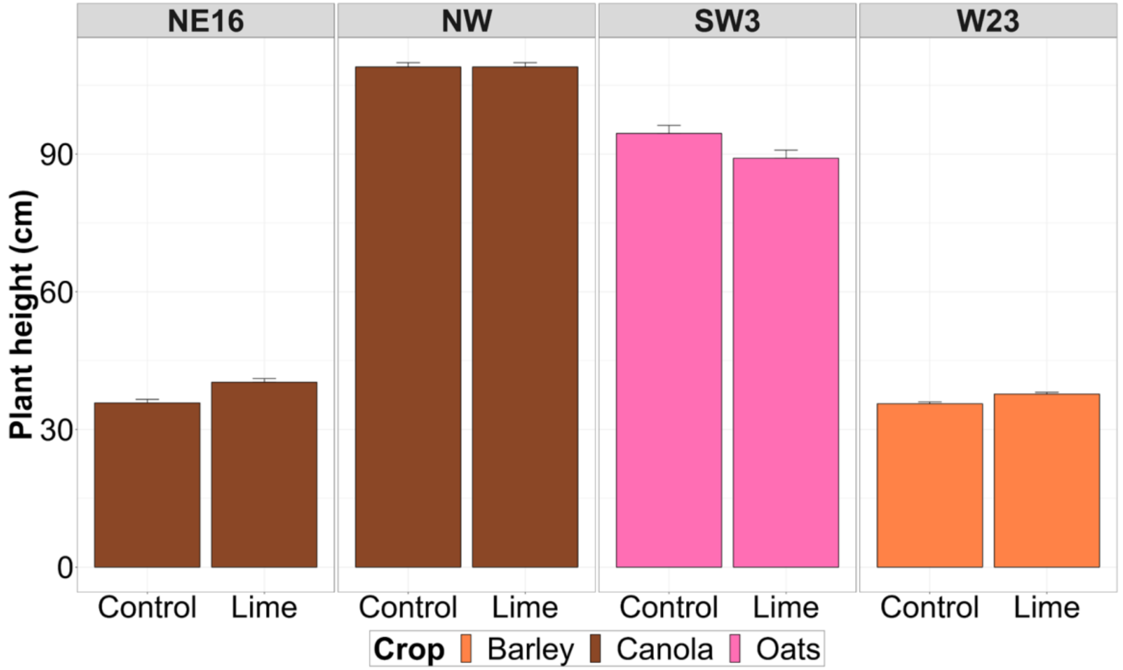
Beneficial roles: biocontrol of fungal pathogens, OM decomposition, bioremediation, production of solubilized P, production of plant growth hormones, increase nutrient availability

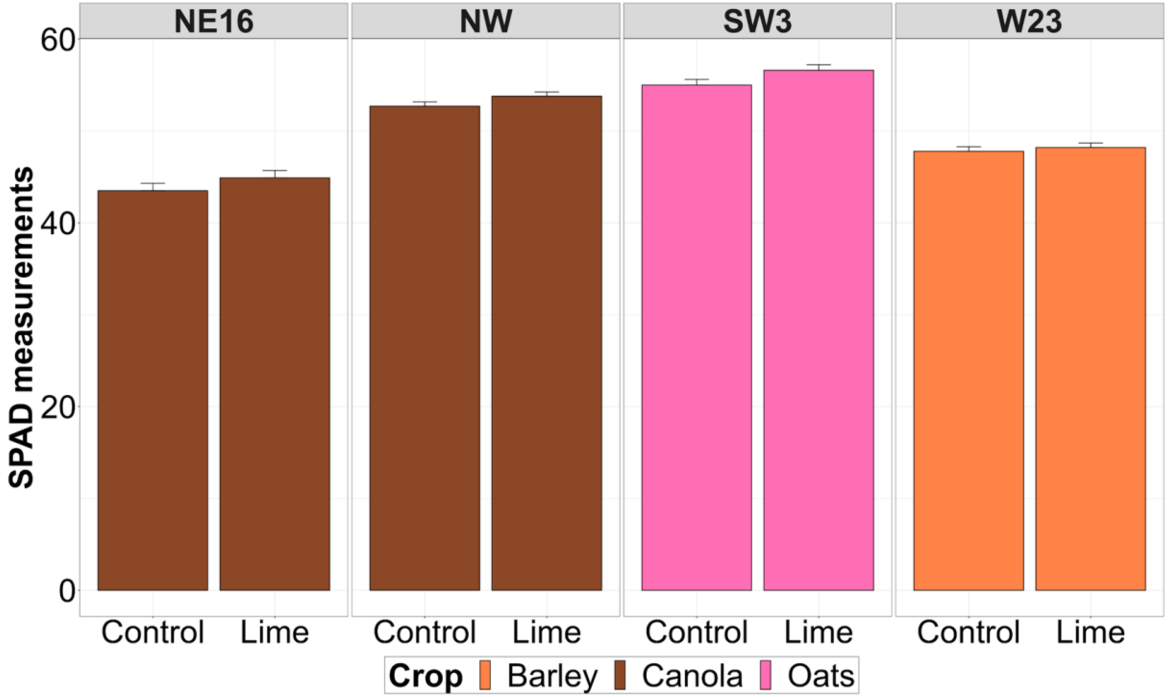
Fusarium: pathogenic, can cause wilt diseases

Preliminary conclusions

- Overall, liming had no significant effects on abundance of bacterial and fungal communities.
- Liming effects on soil microbes may not be evident over short-term periods.
- Shifts in microbial structure and function due to liming have implications on OM decomposition, nutrient cycling, mycorrhizal associations etc.
- Microbial community composition can vary from field to field.

Preliminary agronomic results

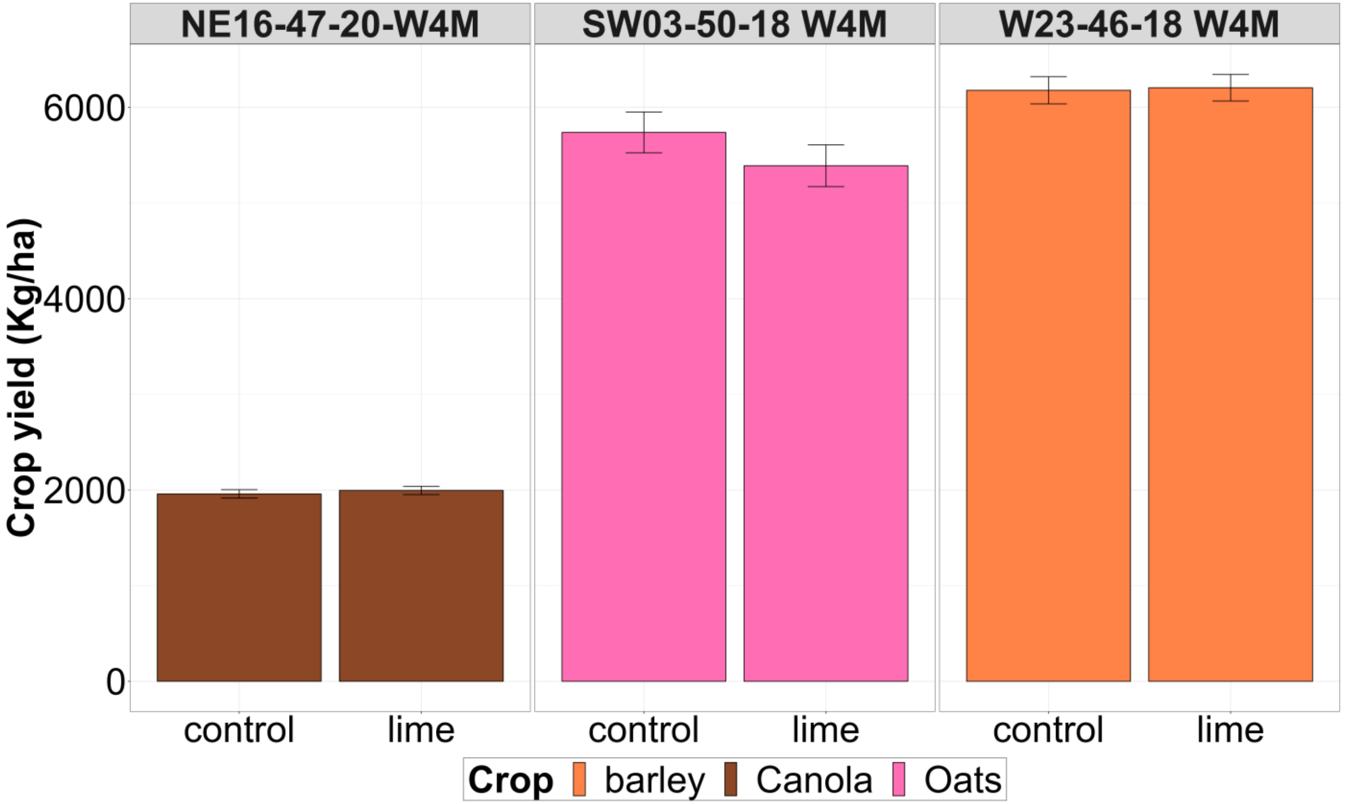




The effect of CKD lime on plant height (cm) of Canola, Oats and Barley across different sites

The effect of CKD lime on the chlorophyll content of Canola, Oats and Barley across different sites

Preliminary agronomic results

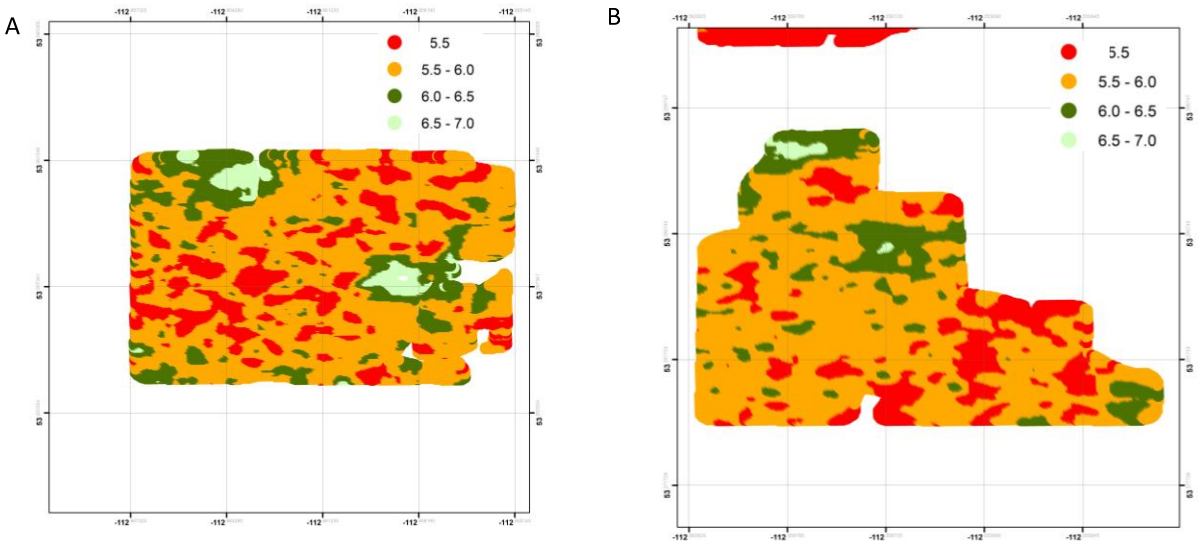


The effect of CKD lime on yields of Canola, Oats and Barley across different sites

Liming did not increase yields of canola and barley.

Negative response to lime application was observed for oats

Results from geospatial analysis

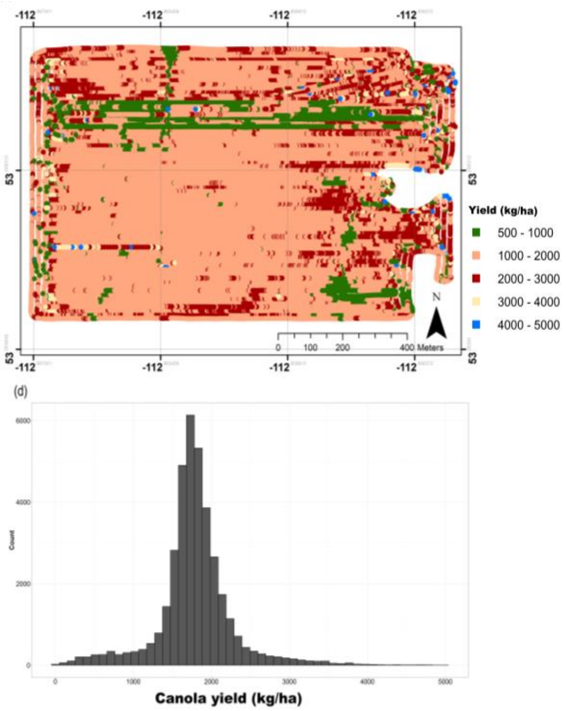


Maps of soil pH across two different field sites in Camrose. A) Field 1 and B) Field 2

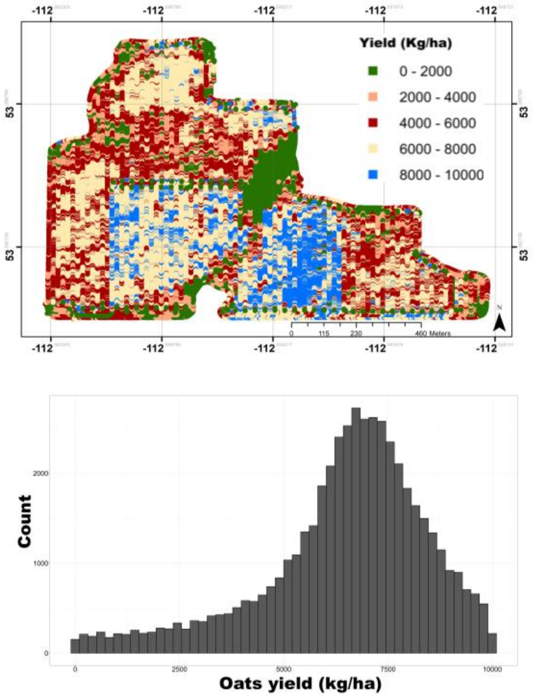
- Soil pH varied across Field 1 and Field 2 and ranged from 5.5 to 7.0
- A greater portion of each field site has a pH ranging between 5.5 - 6.0

Results from geospatial analysis

A



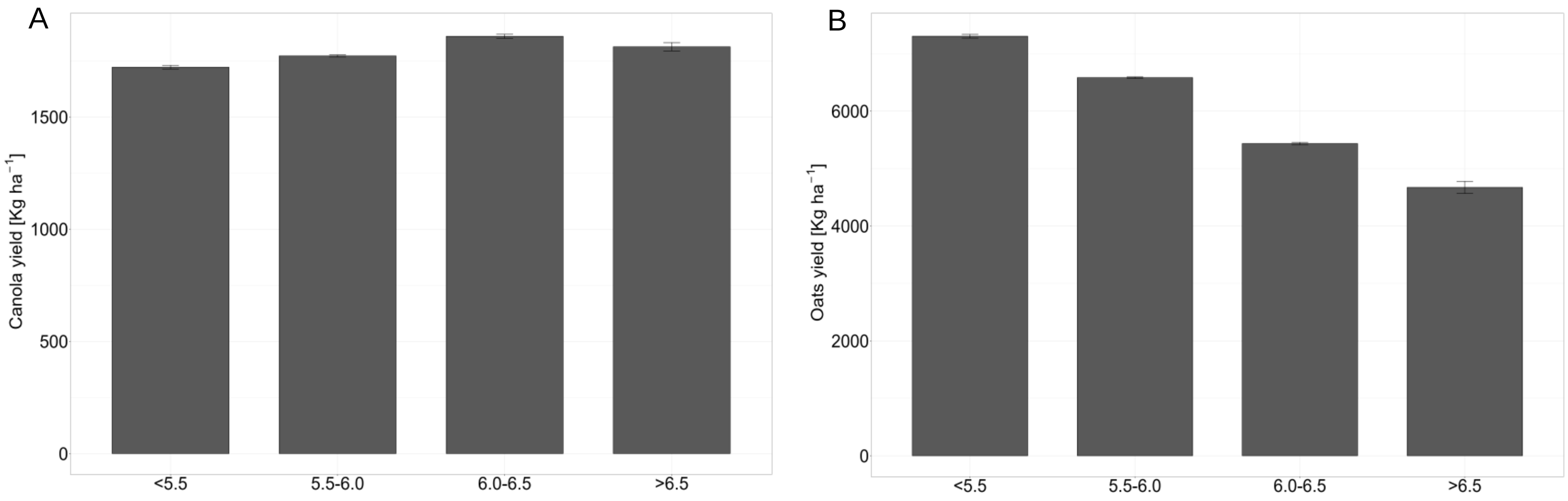
B



Maps of crop yields across three different field sites in Camrose. A) Field 1 B) Field 2 and C) Field 3

- Canola (A) and oats (B) yield varied spatially across all fields
- Canola yields varied from 500 – 4000 kg/ha in Field 1
- Oats varied from 2000 – 8000 kg/ha in Field 2

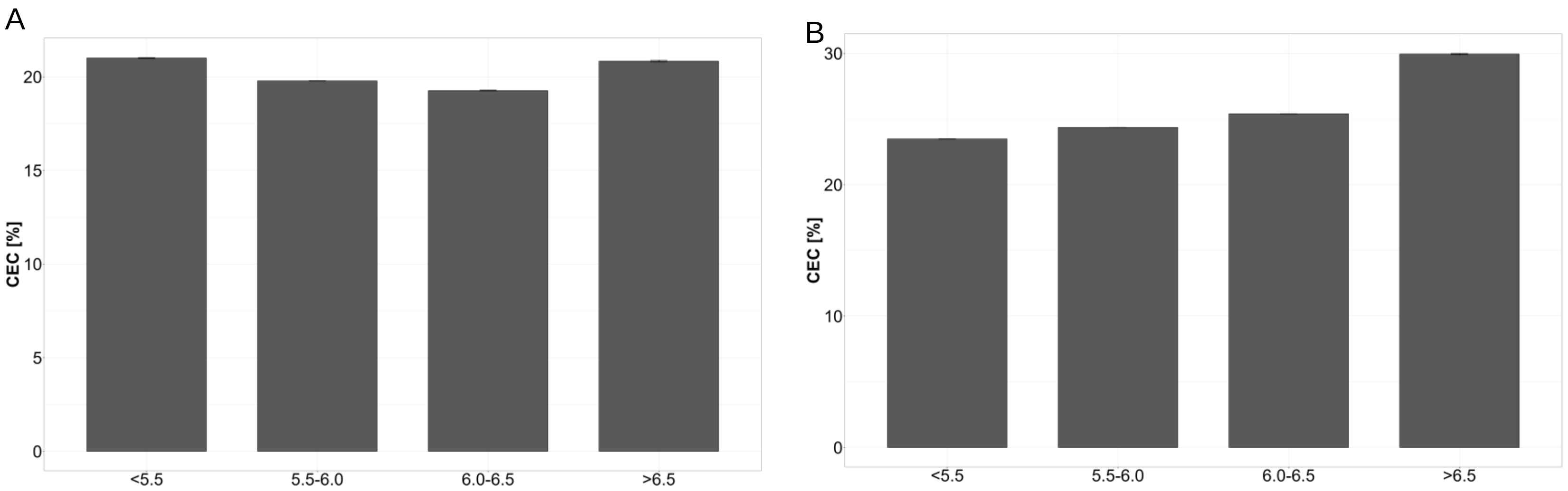
Results from geospatial analysis



- Canola and oats showed distinct responses to soil pH
- Canola yields increased with higher soil pH
- Significant decrease in oats yields with increasing soil pH

The effects of soil pH on canola (Field 1 A) and oats (Field 2 B)

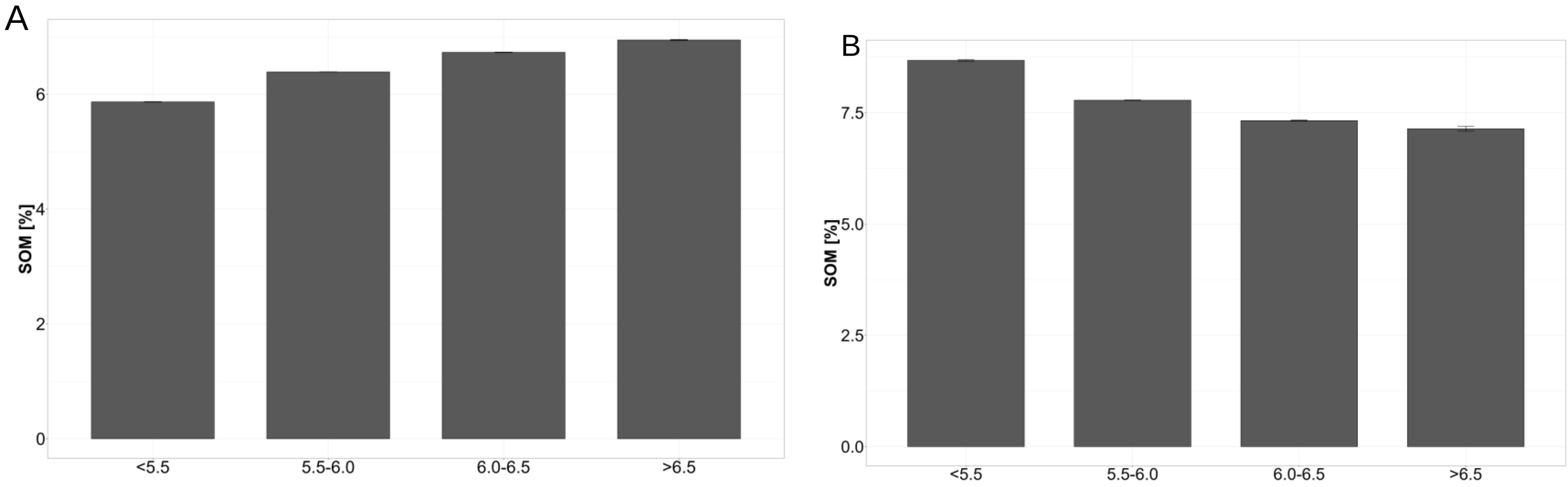
Results from geospatial analysis



The effects of soil pH on CEC Field 1 (A) and Field 2 (B)

- Inconsistent trends in the effect of pH on CEC were observed in Field 1
- A consistent increase in CEC with higher soil pH in Field 2
- Generally, the highest CEC was observed with pH >6.5

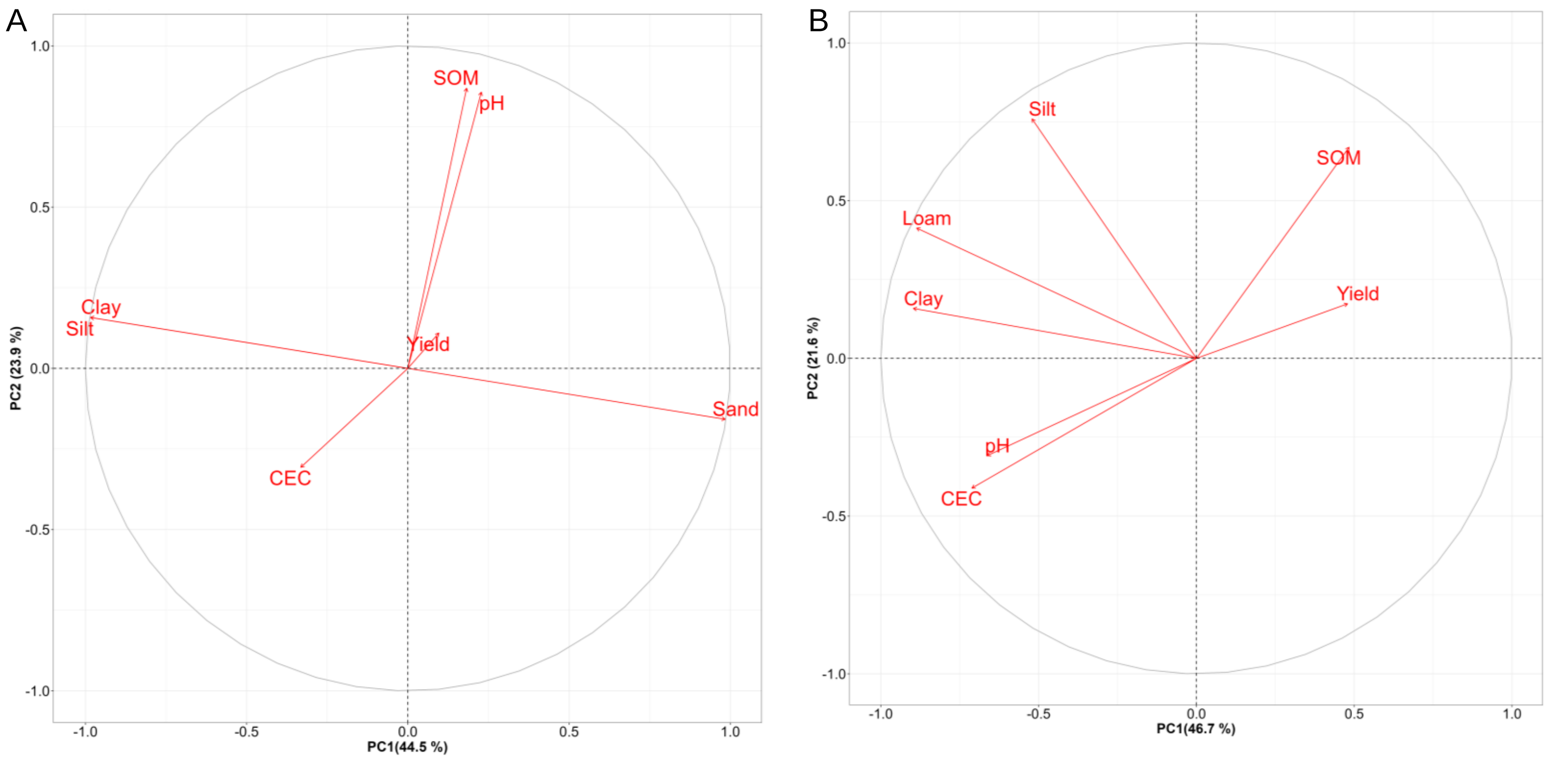
Results from geospatial analysis



The effects of soil pH on SOM Field 1 (A) and Field 2 (B)

- SOM consistently increased with higher soil pH in Field 1
- SOM consistently decreased with higher soil pH in Field 2

Results from geospatial analysis



Principal component analysis of the relationship between some soil properties and yields in Field 1 (A) and Field 2 (B)

- Strong positive relationship between SOM and yields across all Fields
- Inverse relationship between pH and yields in Field 2
- Inverse relationship between CEC and yields across all Fields

Conclusions

1. Crop responses to soil pH differed, with canola showing higher sensitivity to lower pH levels, while oats demonstrated higher tolerance to low soil pH

2. CEC showed variability with soil pH across different fields; however, the highest CEC was observed in regions characterized by higher soil pH.

3. Similar patterns were observed with SOM and yields across different pH levels in all fields. Higher SOM levels were associated with increased crop yields, even in the presence of low soil pH.

4. The variability observed in the dataset was largely contributed by SOM, pH and CEC.

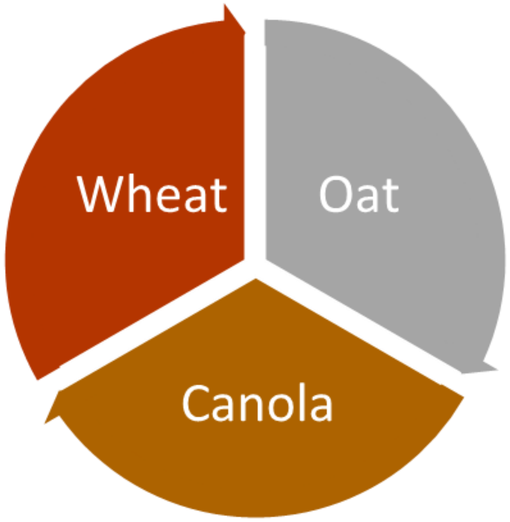
Current and future work

- ❑Factorial experiment

Treatments

- ❑2 soil types: Grey (Breton plots) and black (CDC North) soils
- ❑3 Crops: Wheat, canola and oat
- ❑5 lime sources

T0: No lime Control, T1: Agricultural lime, T2: Cement Kiln Dust,T3: Hydrated Lime, T4: Sugar beet lime



	Wheat					Canola					Oat				
Rep 1	T1	T4	T0	T3	T2	T1	T3	T2	T4	T0	T4	T0	T2	T3	T1
Rep 2	T4	T0	T2	T1	T3	T0	T4	T3	T2	T1	T2	T1	T3	T4	T0
Rep 3	T1	T4	T2	T3	T0	T2	T0	T4	T1	T3	T0	T3	T1	T2	T4
Rep 4	T3	T1	T2	T0	T4	T1	T3	T0	T2	T4	T2	T4	T0	T1	T3

Experiment layout per research site

Current and future work

- Soil sampling at producer's fields (n=12)
- DNA extraction for soil microbes (bacteria and fungi)
- Nematode analyses: nematode extraction, morphological and molecular identification
- Assess aggregate stability on limed vs unlimed soils
- Soil processing for analysis of chemical properties
- Development of questionnaires for farmers surveys
- High precision analysis of remotely sensed images to understand the drivers of soil pH variability and implications on crop yields

Acknowledgement

Results Driven Agriculture Research

Advancing Agriculture through Research

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