Evaluation of various strategies for the integrated management of clubroot of canola

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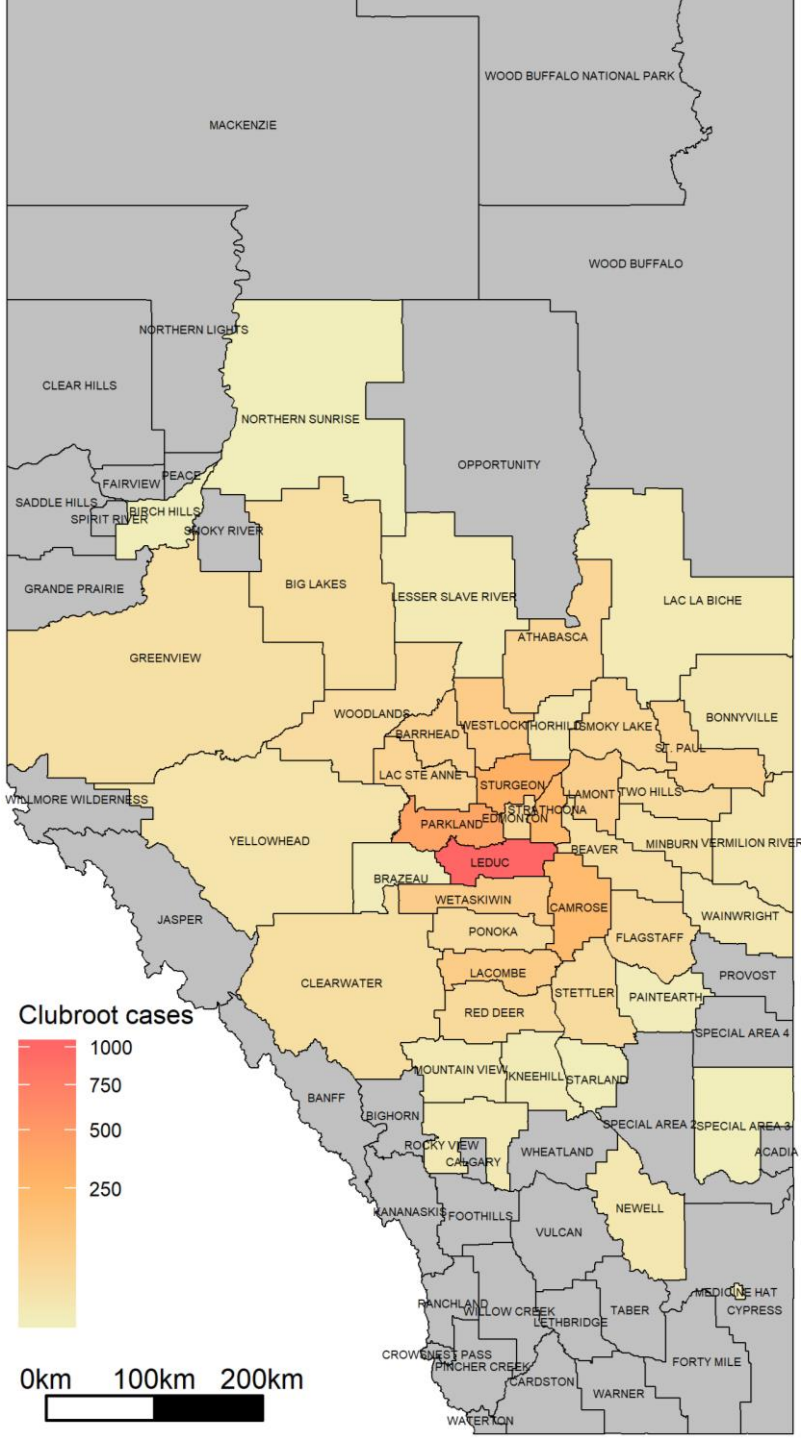
2019 Survey

- 3,353 fields with confirmed clubroot infestations as of 2019, **but it is assumed to be much higher**.

- Starland and Kneehill municipalities have **confirmed clubroot infestations in 2019.**

- Some of the most severely infested fields were planted to clubroot resistant canola

Strelkov et al. (2020), *Canadian Plant Disease Survey* (In Press)



Aigu & Strelkov, 2019

Clubroot Resistance Breakdown

- Clubroot was first discovered in Alberta on canola in **2003**
- First CR variety commercially available in **2009**

2 fields (2013) → **204** (2018) → **>320** (cumulative, 2019)

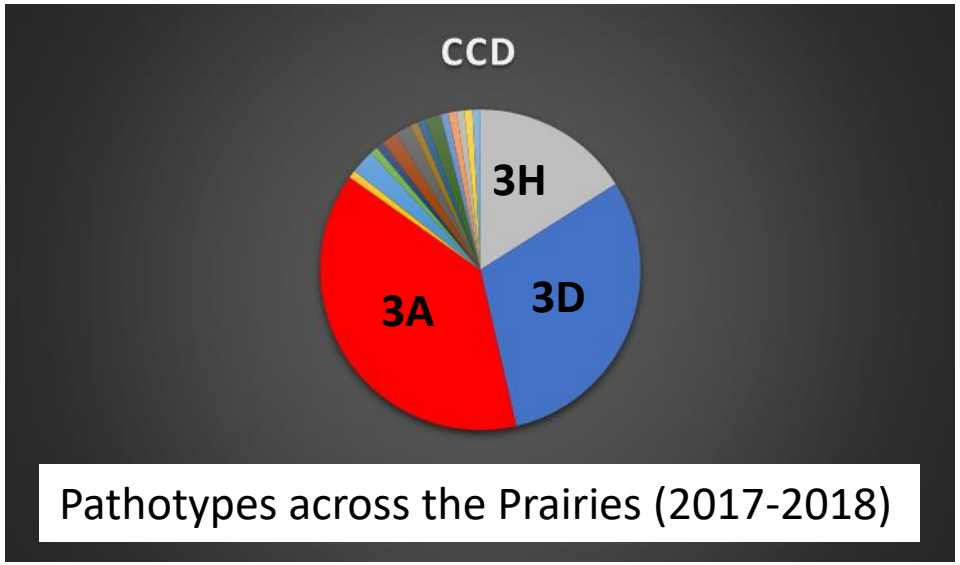
- Resistance has been overcome in AB + MB, but not yet SK

There are currently **36** pathotypes across the Canadian Prairies.

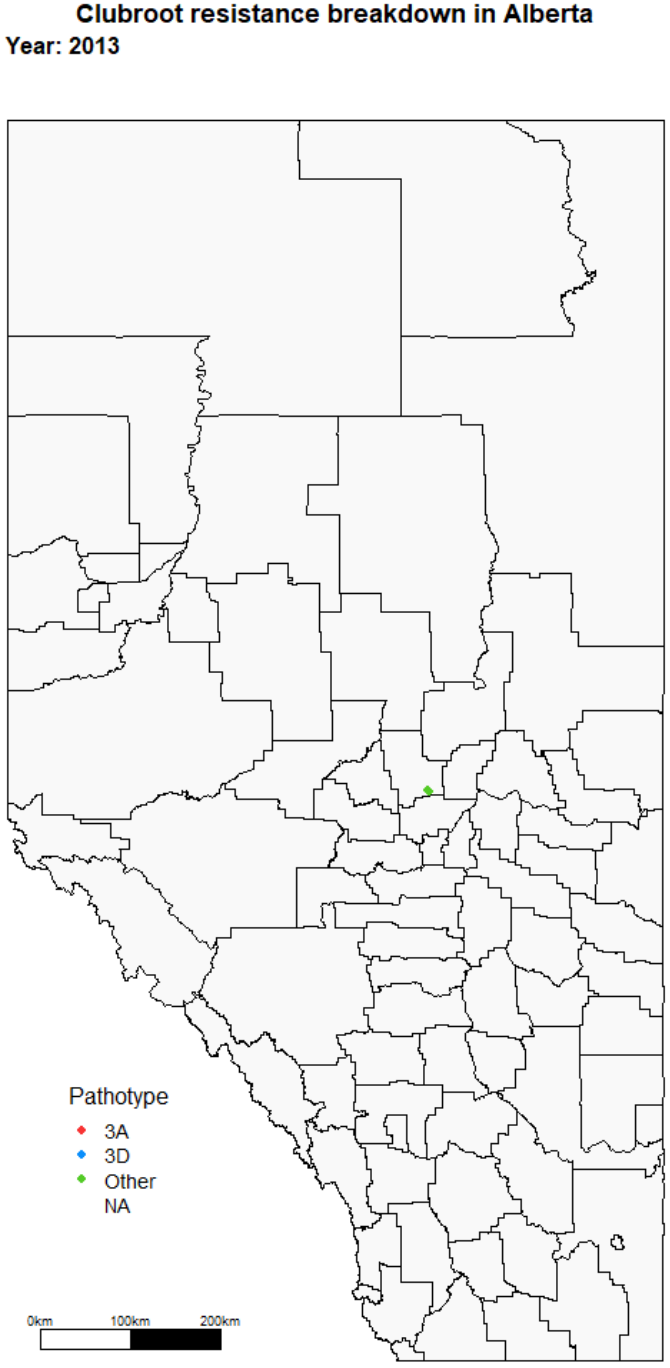
19 of these pathotypes can overcome 'first generation' resistance.

Predominant Pathotypes

- Predominant pathotypes continue to be 3A, 3D (and the 'old' pathotype 3H)
- Many of the 'new' pathotypes **confined to a specific area/county**



Pathotypes across the Prairies (2017-2018)



Trials

1. Weed/Pathotype Trial: Are known clubroot susceptible weeds equally susceptible to all pathotypes?

2. Rotational Trial: Is there a detriment to early clubroot resistance deployment?

3. Field Trial: What's the effect on clubroot resting spore load with the collective use of integrated strategies?

Weed/Pathotype Trial

Determine if common weeds found across the prairies are similarly susceptible to the predominant *P. brassicae* pathotypes in Alberta.

6 plant species:

- Susceptible canola var.
- Pepperweed (*Lepidium* spp.)
- Shepherd's purse (*Capsella bursa-pastoris* L.)
- Stinkweed (*Thlaspi arvense* L.)
- Flixweed (*Descurainia sophia* L.)
- Alsike clover (*Trifolium hybridum* L.)

3 pathotypes:

- 3A
- 3H
- 5I

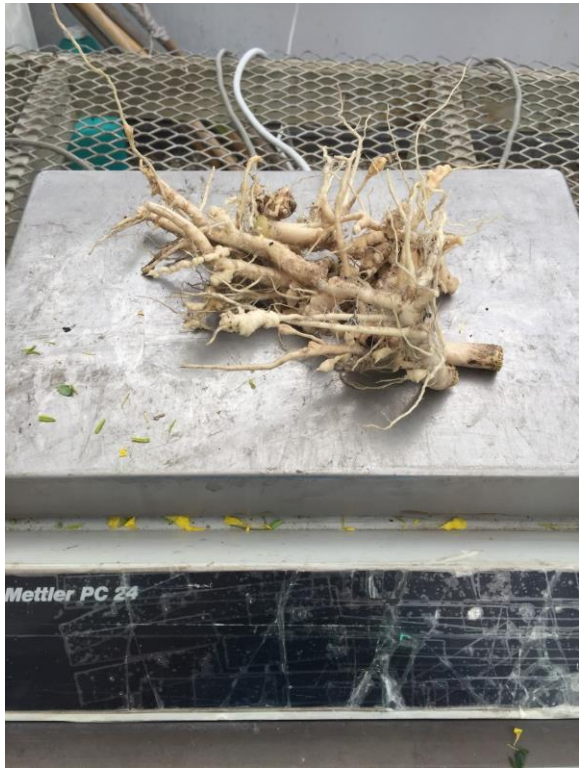
Weed/Pathotype Trial

- Bioassays
- Inoculation *after* germination
- [1 x 10^6]
- 8 wk evaluations
- Other test TBD

Trays 1-4						
3H	*B. napus* (Susceptible control)	*D. sophia* (Flixweed)	*T. arvense* (Stinkweed)	*C. bursa-pastoris* (Shepard's purse)	*L. latifolium* (Pepperweed)	*T. hybridum* (Alsike clover)
Trays 5-8						
3A	*B. napus* (Susceptible control)	*D. sophia* (Flixweed)	*T. arvense* (Stinkweed)	*C. bursa-pastoris* (Shepard's purse)	*L. latifolium* (Pepperweed)	*T. hybridum* (Alsike clover)
Trays 9-12						
5I	*B. napus* (Susceptible control)	*D. sophia* (Flixweed)	*T. arvense* (Stinkweed)	*C. bursa-pastoris* (Shepard's purse)	*L. latifolium* (Pepperweed)	*T. hybridum* (Alsike clover)

8-week Evaluations

Shoot weight, shoot heights, root weight, gall weight, incidence of disease



Index of Disease (ID%)

$$ID(\%) = \frac{\sum(n \times 0 + n \times 1 + n \times 2 + n \times 3)}{N \times 3} \times 100$$

1 2 3

Where:

n = number of plants in a class

N = is the total number of plants

0, 1, 2, 3 = symptom severity classes

Horiuchi & Hori (1980) modified by Strelkov et al. (2006)

Rotational Greenhouse Trial

Twitter Poll

4-crop rotation: **Canola – Wheat – Barley – Canola**

Each crop grown for 8 weeks with a 4 week break between crops

Clubroot Resistant (CR) + Clubroot Susceptible (CS)

4 different rotations:

CR-W-B-CR

CR-W-B-CS

CS-W-B-CR

CS-W-B-CS

5 different concentrations:

0 spores/g of soil

1×10^2 spores/g of soil

1×10^4 spores/g of soil

1×10^6 spores/g of soil

1×10^8 spores/g of soil


Mixture =
2/3 field soil +
1/3 soilless mix

Ground galls, 3H = inoculum, measuring 1,000,000,000 spores/g

* Used a **4mm screen** on grinder and a **hemocytometer** to measure spores

Rotational Greenhouse Trial

Sanitation of tools between each tub is very important to prevent cross-contamination

Rotation: R ⇨ S; check ⇨ 1×10^8

Fertilizer 11-month, 4-crop trial

- Canola: **151 kg/ha** of N, **84 kg/ha** of P, **48 kg/ha** of S
- Wheat: **123 kg/ha** of N, **28 kg/ha** of P, **11 kg/ha** of K, **11 kg/ha** of S

Seeding 40 plants per tub (5 plants x 8 rows)

'Thinned' prior to 1st leaf

Rotational Greenhouse Trial

Canola 8-week evaluations, all root material removed, dried and reincorporated by blender prior to wheat

Wheat & Barley harvested at 8 weeks; growing point removed from soil to ensure death

Soil Samples completed after every crop, with 2 samples after canola (before and after root reincorporation)

Lab Analysis quantitative PCR

Trace or no symptoms at ≤ 10,000 spores/g soil

Preliminary Results

Round #1

	Rotation	ID %	ID %
1,000,000 spores/g of soil	CR-W-B-CR	14.17%	45.83%
	CR-W-B-CS	10.83%	65.83%
	CS-W-B-CR	85.83%	69.99%
	CS-W-B-CS	67.50%	97.50%

	Rotation	ID %	ID %
100,000,000 spores/g of soil	CR-W-B-CR	69.17%	95.83%
	CR-W-B-CS	49.17%	73.33%
	CS-W-B-CR	88.34%	59.16%
	CS-W-B-CS	95.84%	98.34%

Moving forward...

Quantitative PCR in progress: Analyze spore load change over time, >950 samples in total

Duplication in progress: 11-month GH trial

Ideal Conditions for Clubroot

1. High moisture
2. **Warm soil** temperature
3. Acidic soils

Field Trial

3 components: **Genetics, Weed Management, Lime Application**

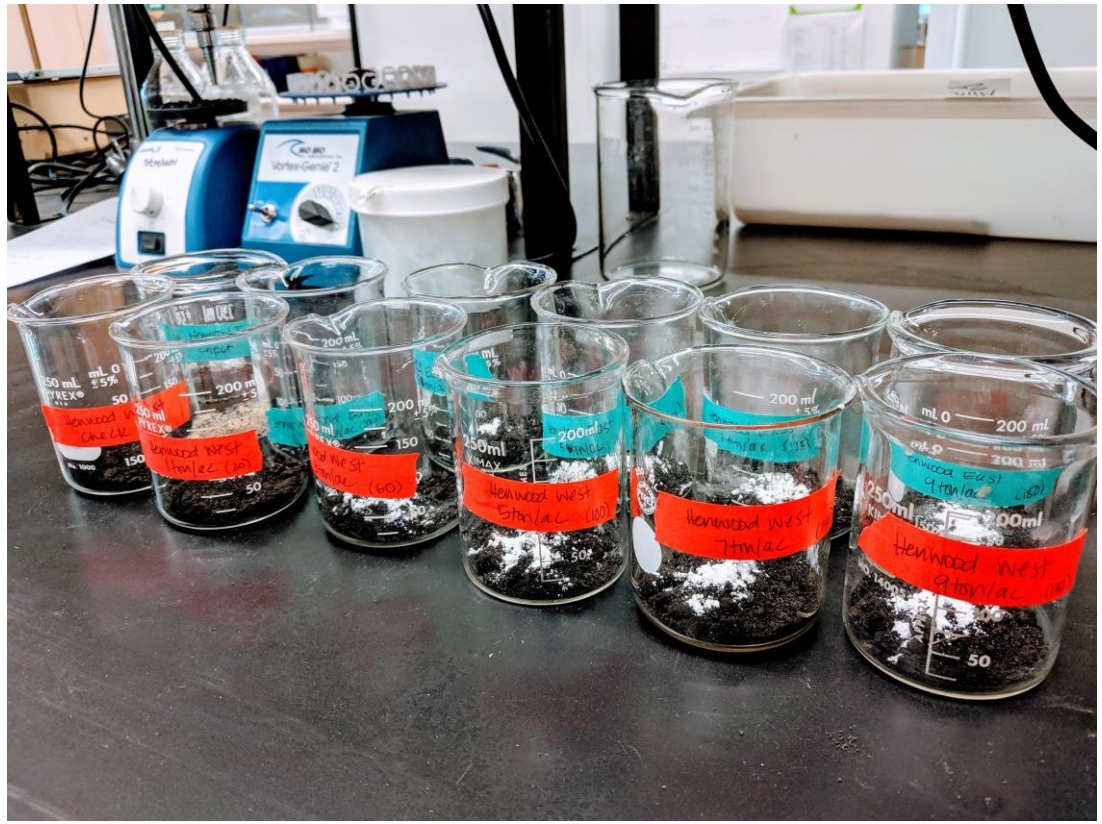
Genetics: CR + CS cultivars

Weeds Management: Hand weeded/Not Weeded

Lime: Application of hydrated lime to a desired pH of 7.2

CR	CR	CR	CR	CS	CS	CS	CS
Lime	Lime	No Lime	No Lime	Lime	Lime	No Lime	No Lime
Weeds	No Weeds	Weeds	No Weeds	Weeds	No Weeds	Weeds	No Weeds

Application Rate of Hydrated Lime $Ca(OH)_2$



0, 1, 3, 5, 7, and 9 ton/ac

0, 2.47, 7.41, 12.36, 17.30, and 22.24 ton/ha

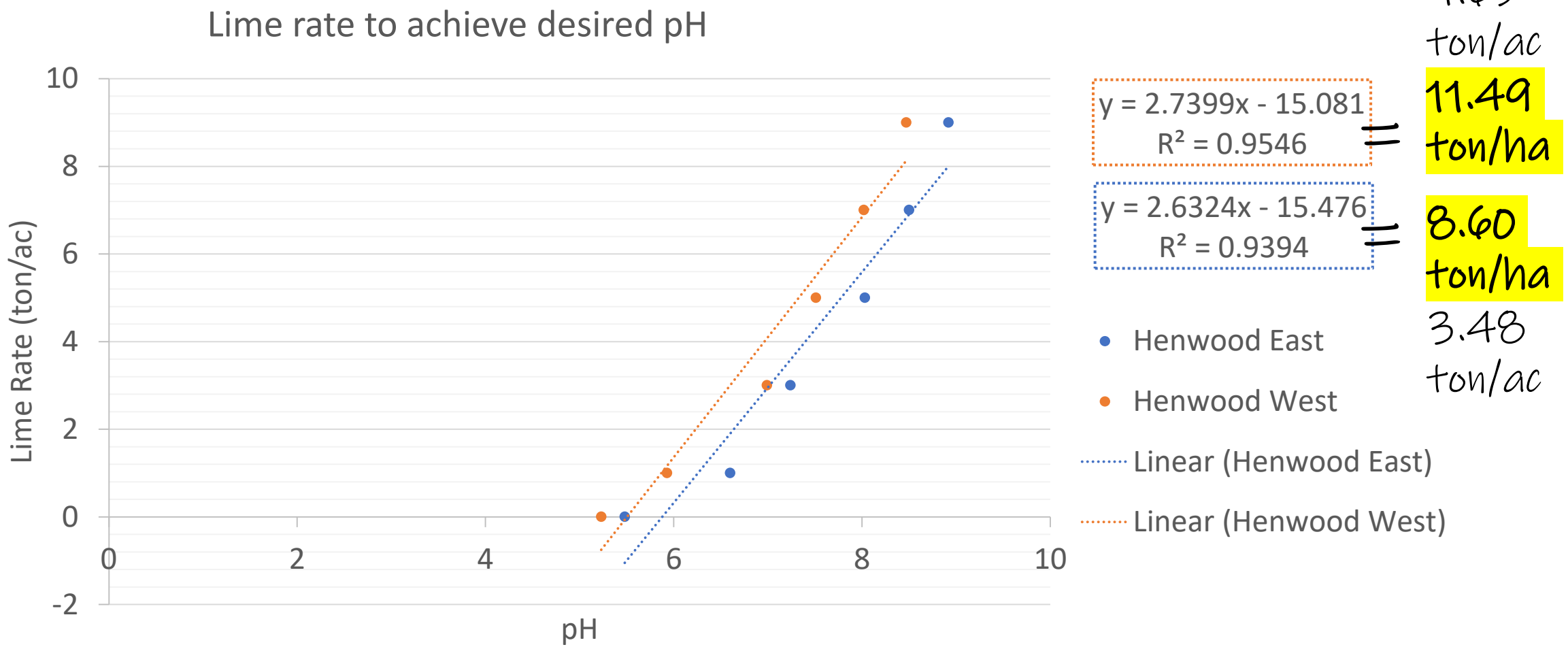
Calcium Carbonate Equivalent (CCE) = quantity of carbonate in the soil, expressed as $CaCO_3$

Soil Sample Recommendation

SMP Method? 6.5 pH using $CaCO_3$ CCE= 100

$Ca(OH)_2$ CCE = 136

Hydrated Lime Regression Lines



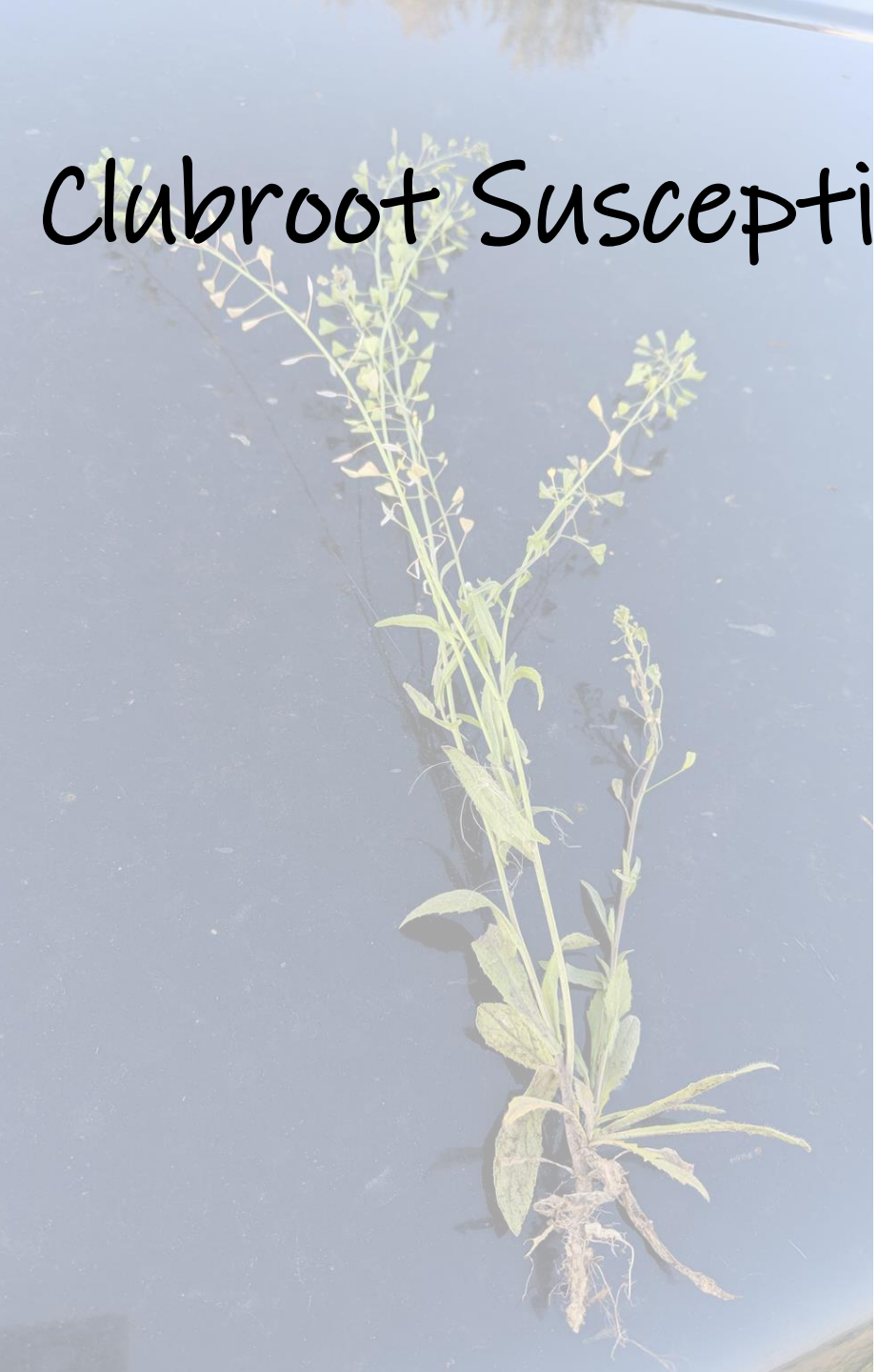
4.65 ton/ac

11.49 ton/ha

8.60 ton/ha

3.48 ton/ac

Clubroot Susceptible Weed: Shepherd's Purse



Clubroot Susceptible Weed: Stinkweed

WEEDS MANAGED

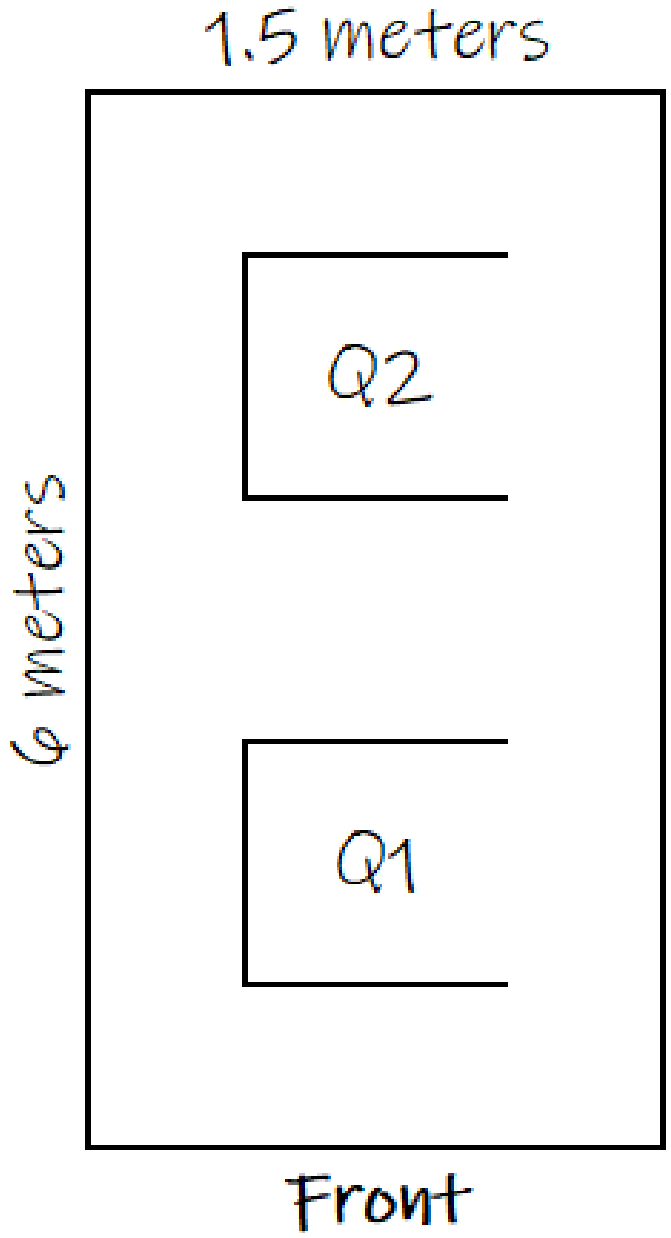
WEEDS UNMANAGED

Weed Counts

Placed a 0.25m^2 quadrat at the front and back of each plot, avoiding the sides because of edge effects.

Counted **total and known clubroot susceptible weeds**.

Counts were combined to get a density per 0.5m^2, then multiplied by two for weeds per m^2.



Index of Disease (%) – both trial sites

	WEEDS	NO WEEDS	WEEDS	NO WEEDS
LIME	R 1.25	R 1.25	S 28.31	S 34.59
NO LIME	R 4.18	R 3.38	S 76.24	S 78.75
L vs NL	2.93	2.13	47.93	44.16
R vs S	27.06	33.34	72.06	75.38

* Weeds are non-significant for the ID% in the canola growing season

Index of Disease (%) – both trial sites

	WEEDS	NO WEEDS	WEEDS	NO WEEDS
	Current typical practice			
NO LIME	R 4.18	R 3.38	S 76.24	S 78.75
R vs S			72.06	75.38

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	WEEDS	NO WEEDS	WEEDS	NO WEEDS
LIME	R	R	S	S
	1.25	1.25	28.31	34.59

Let's add some hydrated lime...

R vs S	27.06	33.34

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Hydrated lime compliments the use of CR genetics

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Moving forward...

Spring soil samples using a Dutch auger to collect top 4" of soil (tomorrow!)

Quantitative PCR

In Conclusion..

I hope to **quantify the consequences of not implementing** an integrated clubroot management plan – and **determine the most effective 'recipe'** for canola growers.

Acknowledgments

Collaborators, colleagues & staff

Industry partners


Thank You