

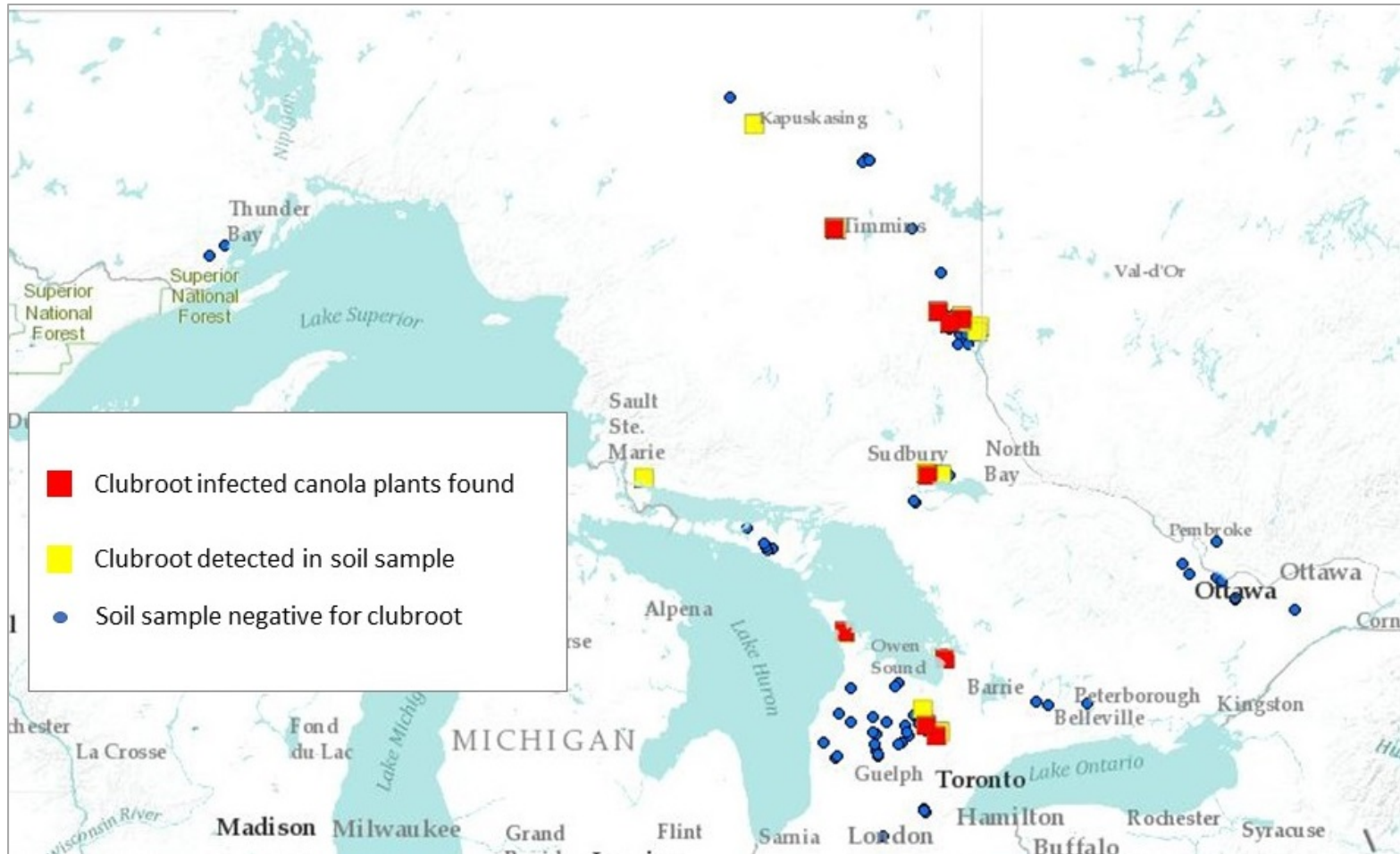
CLUBROOT OF CANOLA

WHAT CAN BE DONE?



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Ontario Clubroot Survey 2016-2018



Goals for Ontario

- Prevent transmission
- Keep spore counts low
- Maintain access to resistant varieties
- Maintain high yielding canola



How to Achieve Goals

- Active management for clubroot by all canola growers in the province
- Grow resistant varieties now!
- Farmers know their risks
- Communication
- Continued research



Clubroot on Brassica crops

- Cause: *Plasmodiophora brassicae* - not a fungus
- Needs a living host to reproduce
- Attacks most plants in the mustard (*Brassicaceae*) family
- Causes stunting, delayed maturity, yield loss, and plant death
- Persistent resting spores, some survive many years in soil
- Many strains (pathotypes) that infect different crops and cultivars

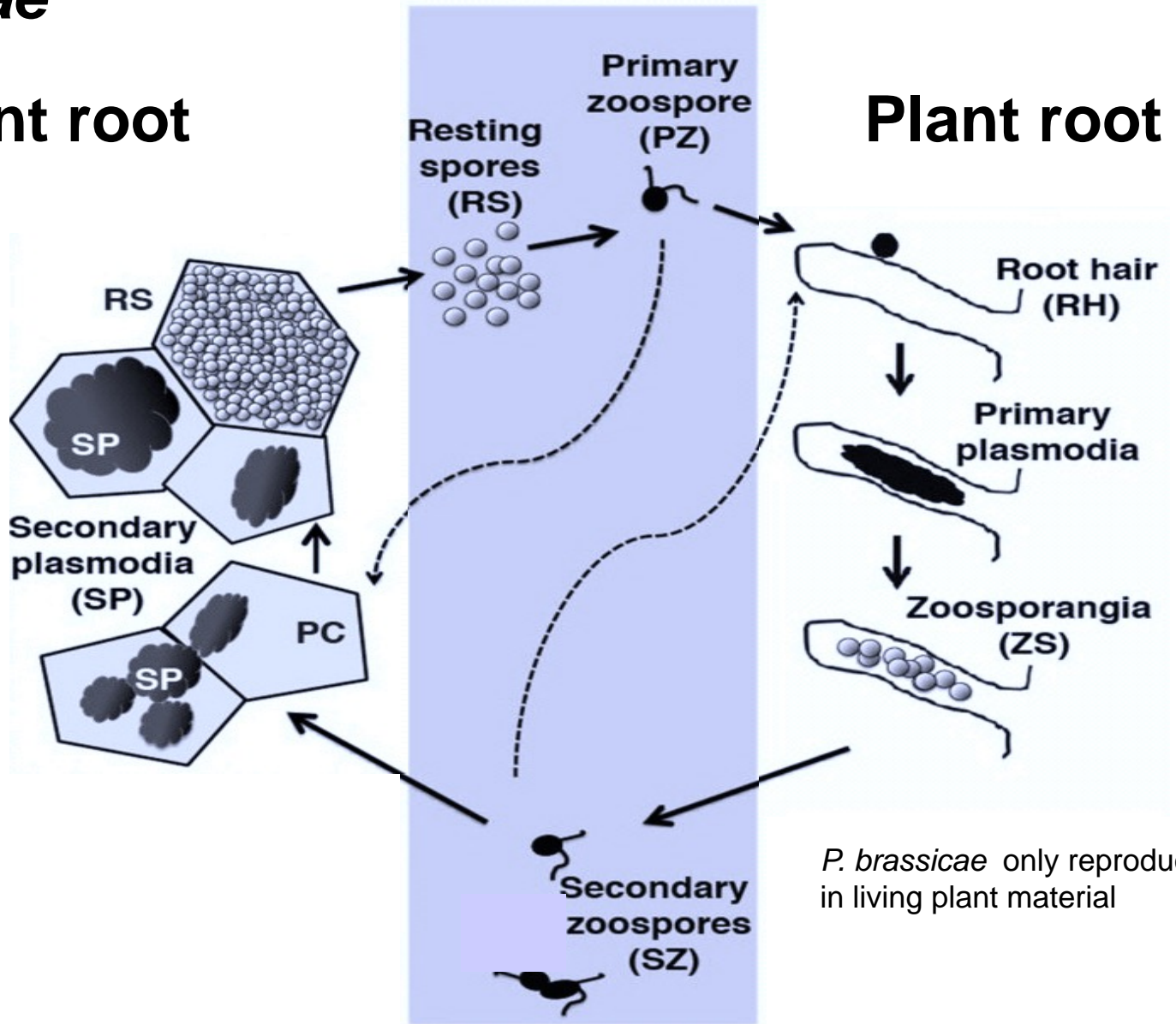


Life cycle of *P. brassicae*

Plant root

Soil

Plant root



P. brassicae only reproduces in living plant material

It 's all about the numbers

- Soils in Alberta can have 10 million or 100 million resting spores per gram, soils in our research plots are at 1 to 10 million spores
- A 90% reduction could still leave a million spores

Keep the numbers as low as possible!

< 1,000

1,000

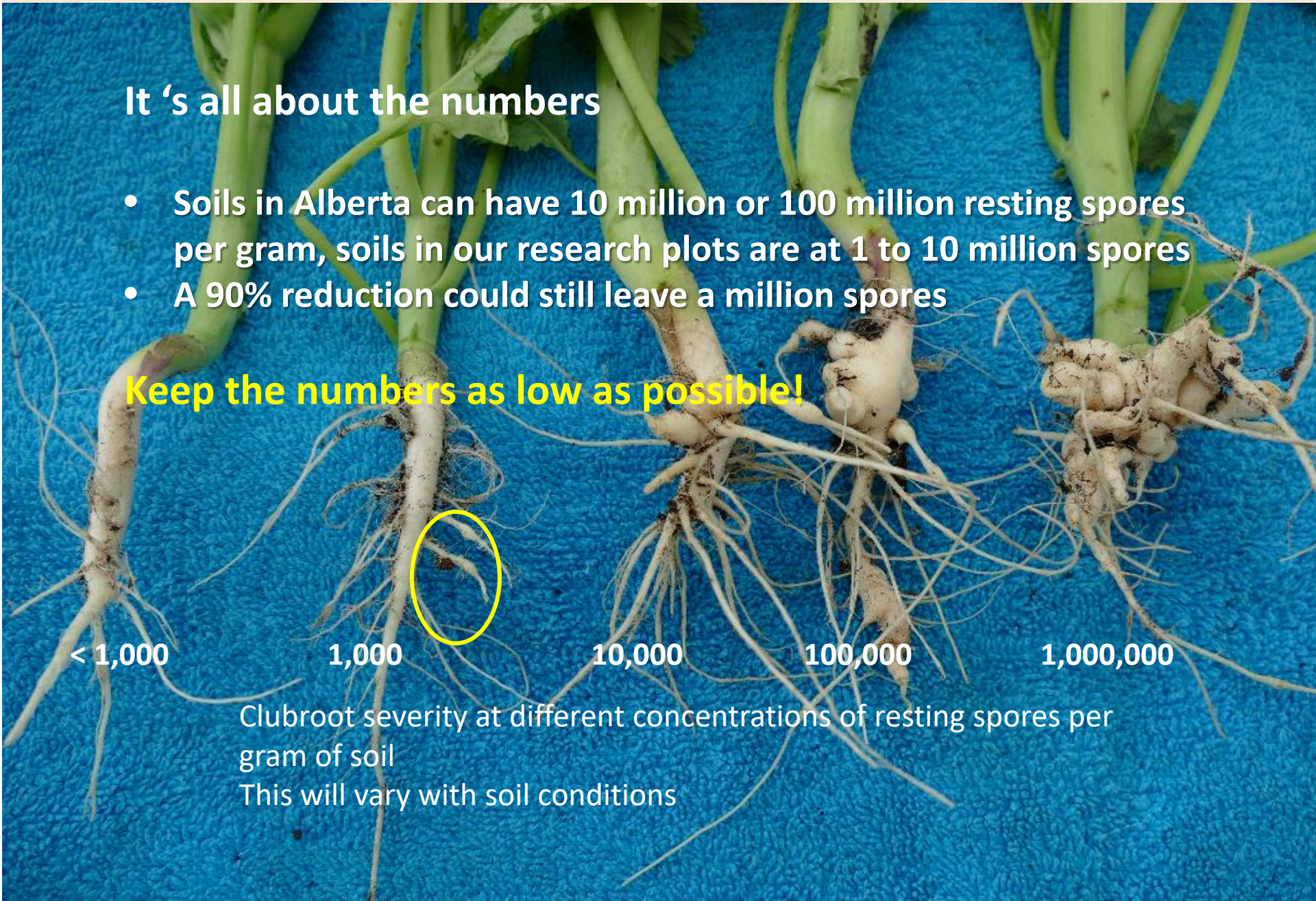
10,000

100,000

1,000,000

Clubroot severity at different concentrations of resting spores per gram of soil

This will vary with soil conditions



Clubroot in Ontario

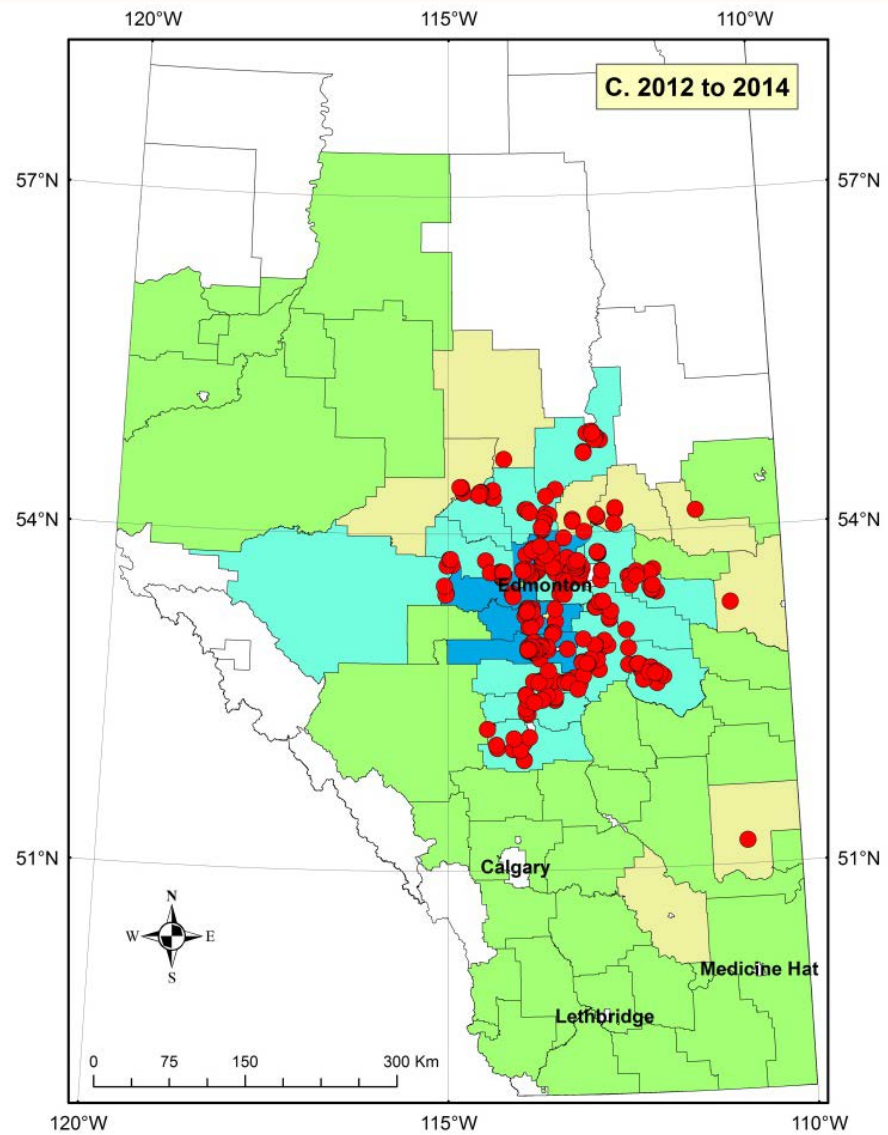
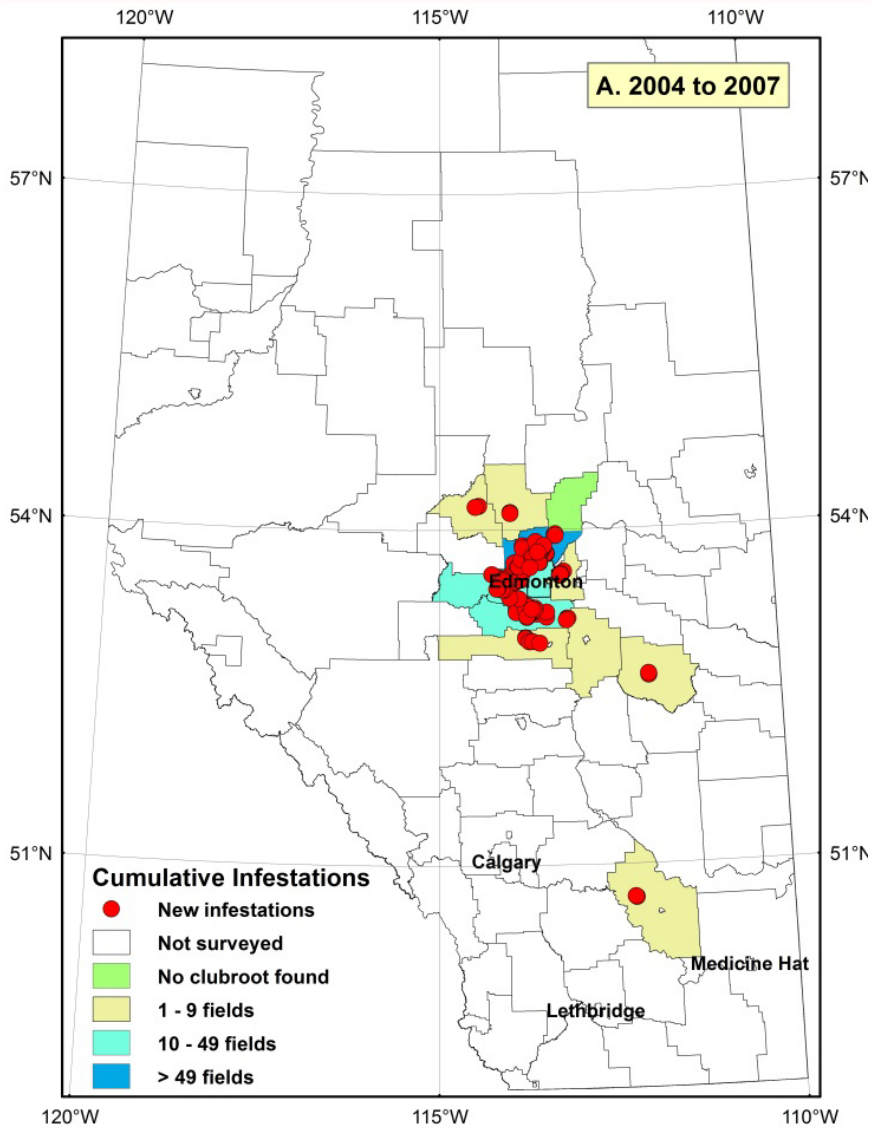
- Clubroot on vegetables since 1920's
- On canola in Ontario in 2016
- Naturally occurring at the Muck Crops Research Station
- We are conducting trials in collaboration with researchers in Western Canada
- Clubroot is not a regulated disease in Ontario



A

How does clubroot spread?





How to prevent or slow the spread of clubroot?

- Grow clubroot resistant canola if clubroot is in your area**
- Prevent the movement of soil from infested fields**
- Keep track of infested fields even when they are not in canola (grass problem areas?)**
- Keep the soil pH above 7.2**
- Crop rotation**



How to reduce resting spores, if clubroot is already in a field?

- **Crop rotation**
 - **2 year break from canola**
- **Grass cover crops?**
- **Lime to increase soil pH to 7.2 or above**
- **In vegetable crops, some growers can apply fungicides or even fumigate the soil (not economical for canola)**

Crop Rotation and resting spore concentration

AAFC Research Farm, Normandin, QC, 48° 51' N – 72° 32' W
Labarre silty clay soil naturally infested with the clubroot organism

Continuous susceptible canola and break intervals of
1, 2, 3, 5, and 6 years following susceptible canola

Rotations during break intervals were barley and field pea and fallow



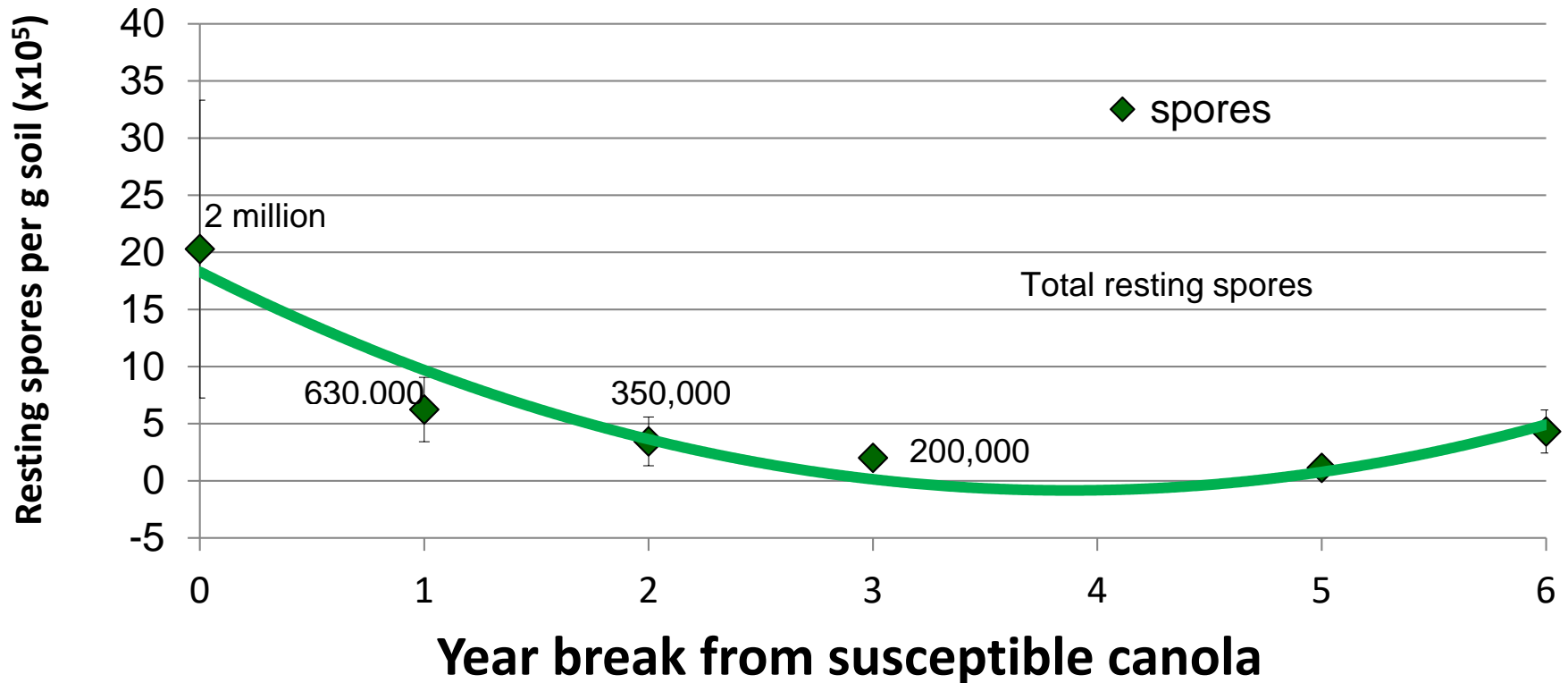
AAFC Research Station



Normandin, QC

How long for rotation or a cover crop?

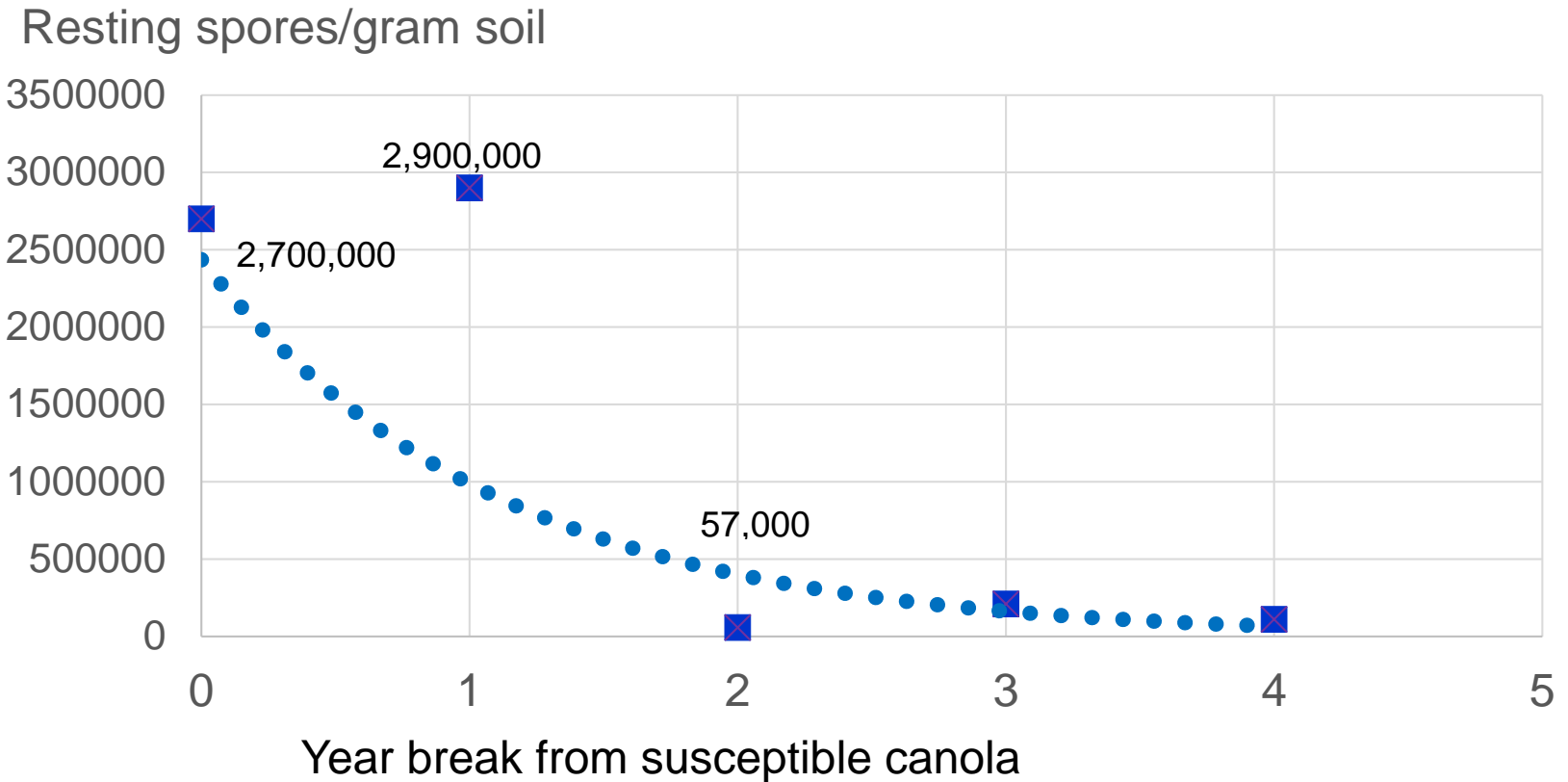
Resting spore counts in relation to crop rotation in soil, Normandin, Que 2015



* Regression lines ($P < 0.05$)

Break from canola: soil samples also from Normandin

Peng et al. 2016



A two year break from canola results in a major drop in resting spore numbers

Crop rotation, canola and clubroot

- ❑ There are many benefits to crop rotation beyond clubroot management
- ❑ Greatest reduction in resting spores in the first year (usually), further decrease in the second year, then very slow decline
- ❑ The spores that survive the first year or two are viable and live for many more years
- ❑ Recommend a two year break from canola – but there could still be high numbers of resting spores in the soil

(current results are from the Quebec site but early results from Alberta show the same trend)

Add Lime: Raising soil pH to suppress clubroot

- Common in Europe
- Common for vegetables



**Apply lime to increase soil pH to 7.2
(sometimes 7.5).
This can require several tonnes/ha**

Several field trials are underway:

Spruce Grove, Alberta – 2018

Field trials in Saskatchewan and Manitoba in 2019

**BUT results can vary depending on how many resting
spores are present AND temperature and other soil
conditions**

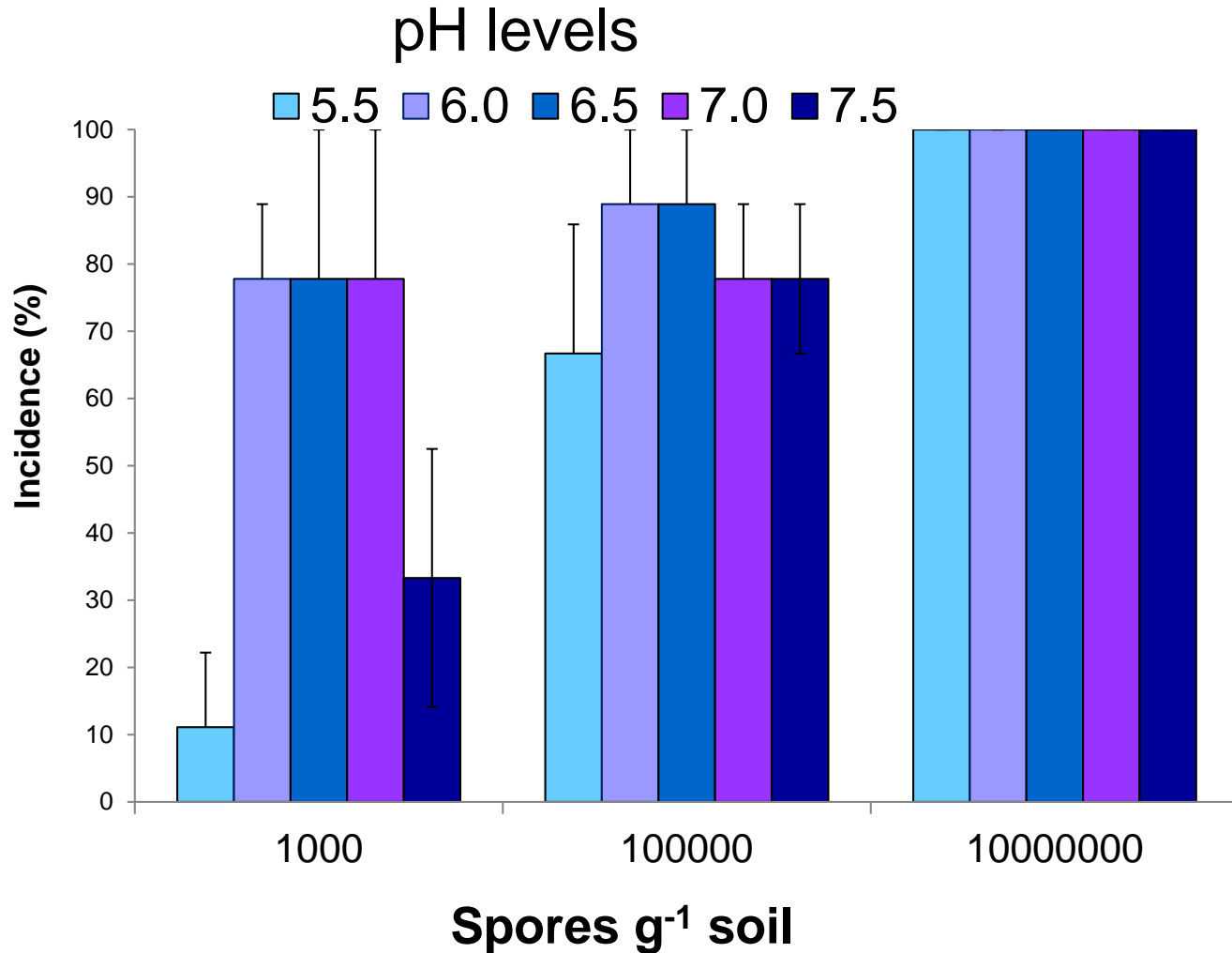
Resting spores, pH and clubroot

Growth room trials

Resting spore concentration influences the response to pH

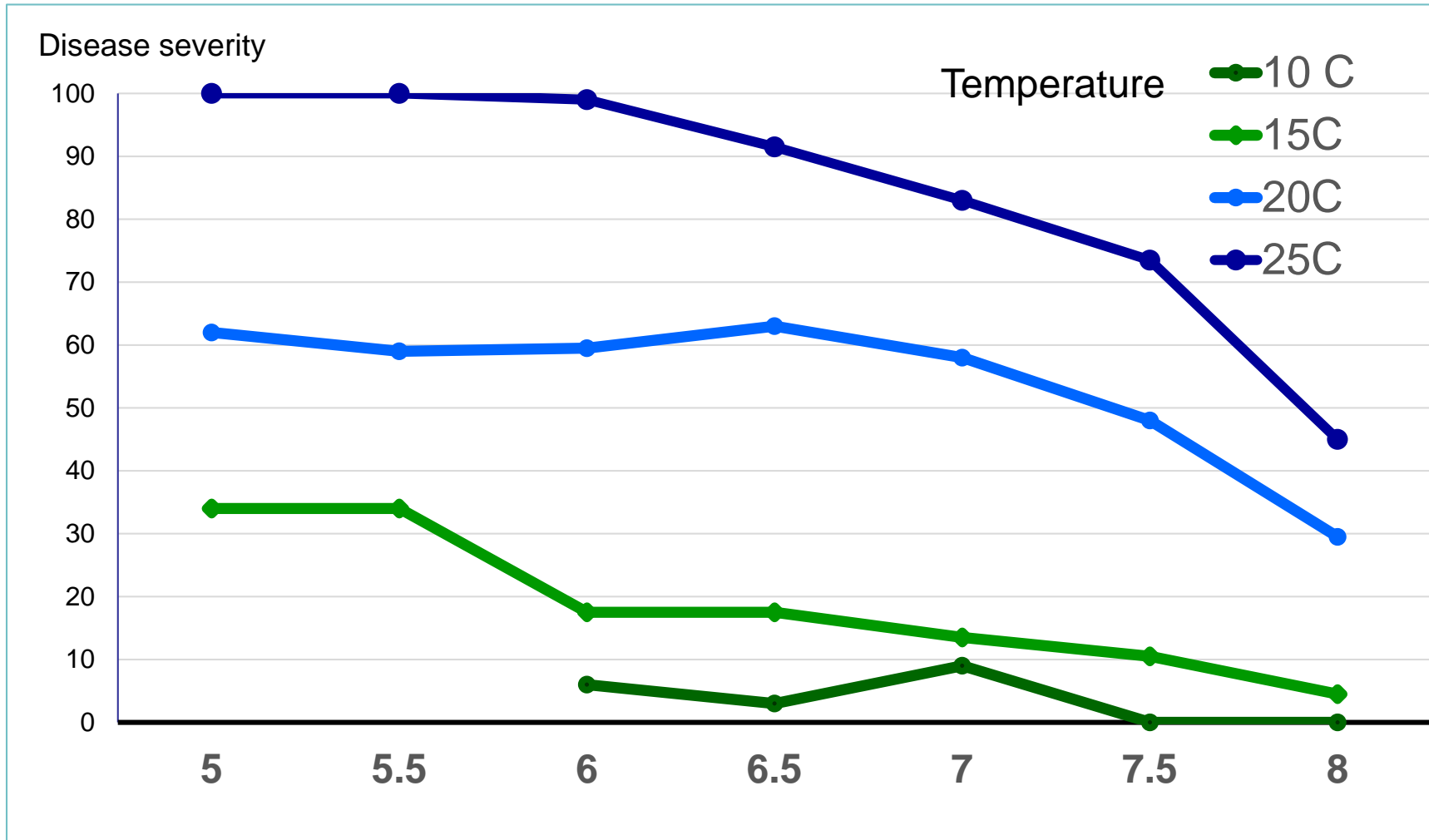
High spore concentration overcomes the effect of high pH in suppressing disease

(controlled environment studies)



Interaction of pH and temperature

Growth room trials with 1 million resting spores/g



pH

Soil pH and clubroot

- Use buffer pH to calculate rates of lime
- Clubroot can develop at high pH when other conditions are optimum
- pH may act separately from calcium
- Calcium content or calcium base saturation (over 70%?) may be important, but more research is needed



How to grow canola in the presence of clubroot?

Deal with the first small patches right away

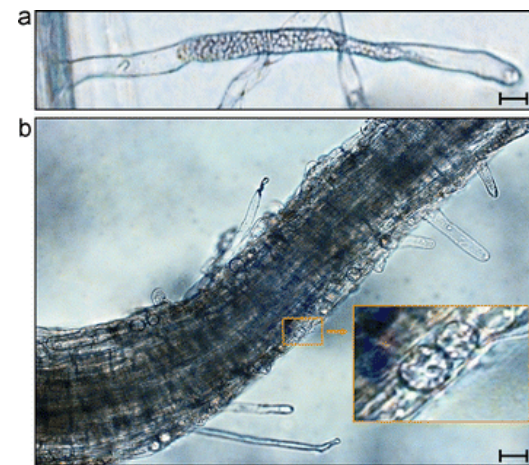


Remove plants and seed a perennial cover crop

Seed a grass cover crop: Can cover crops reduce resting spores in soil?

- **Grasses to hold soil in place**
- **Grass roots can stimulate the germination of resting spores**

- The root hairs of grasses can be infected by the pathogen
- But the pathogen does not infect the main root and does not produce resting spores, so no increase in the pathogen
(MacFarlane 1952, Feng et al. 2020)



Jie Feng et al., 2012

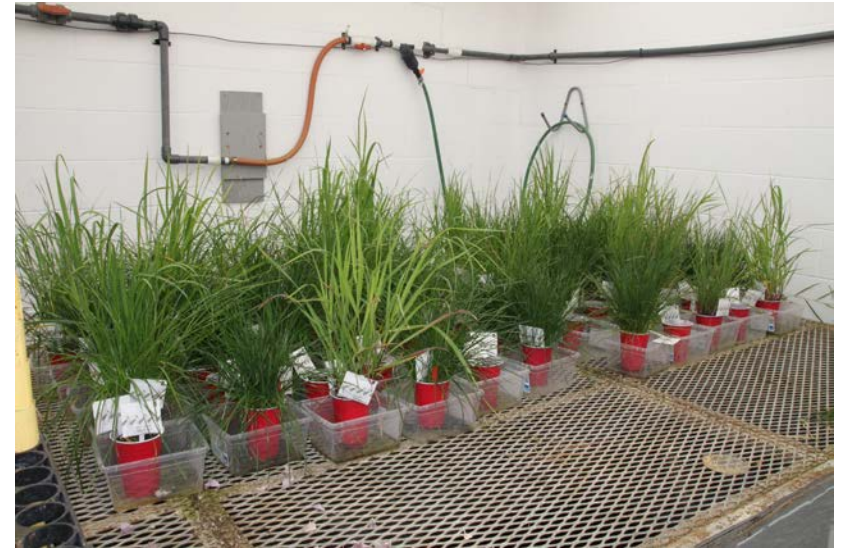
Perennial ryegrass

- “Trap crops” are not always effective, maybe because of high resting spores to start

Resting spore decline with grasses - Methods

Crops:

- Shanghai Pak Choy (*Brassica rapa*)
susceptible check
- Perennial ryegrass (*Lolium perenne* L.)
cv.s Norlea, All Star, and Fiesta
- Smooth bromegrass (*Bromus inermis* L.) Signal, Radisson, a common seed lot
- Meadow bromegrass (*B. riparius* R.) cv. Fleet
- Compared to no plants



Grown in inoculated field soil for 8 weeks (target 500,000 resting spores/gram and compared to bare soil

Resting spore concentration in soil with different grass cover crops

Crop	Cultivar	Spore concentration per gram soil
Pre-plant		1,600,000
Soil only		1,200,000 a
Perennial ryegrass	Norlea	590,000 a
Meadow brome grass	Fleet	500,000 a
Perennial ryegrass	All Star	490,000 a
Smooth brome grass	common lot	460,000 b
Perennial ryegrass	Fiesta	270,000 b

Plants grown for 8 weeks in soil inoculated with 5×10^5 resting spores per gram, 6 reps

Grass cover crops are important to prevent the movement of soil and may reduce resting spore numbers (some cultivars better than others?)

What about rotation crops?

Resting spore concentration in soil with different crops

Crop	Cultivar	Spore conc. g ⁻¹ soil
Pre-plant		250,000
Soil only (control)		115,000 a
Ryegrass	Norlea	159,000 a
Field pea	CDC Meadow	118,000 a
Wheat	AAC Connery	83,000 b
Barley	Trochu	76,000 b

Plants grown for 8 weeks in the soil inoculated with 5×10^5 resting spores mL⁻¹ based on qPCR (n = 6).

Preliminary data, still assessing the results. Spring wheat and barley may be useful for reducing resting spores- stay tuned.



Crop rotation has to include control Brassica weeds and volunteer canola

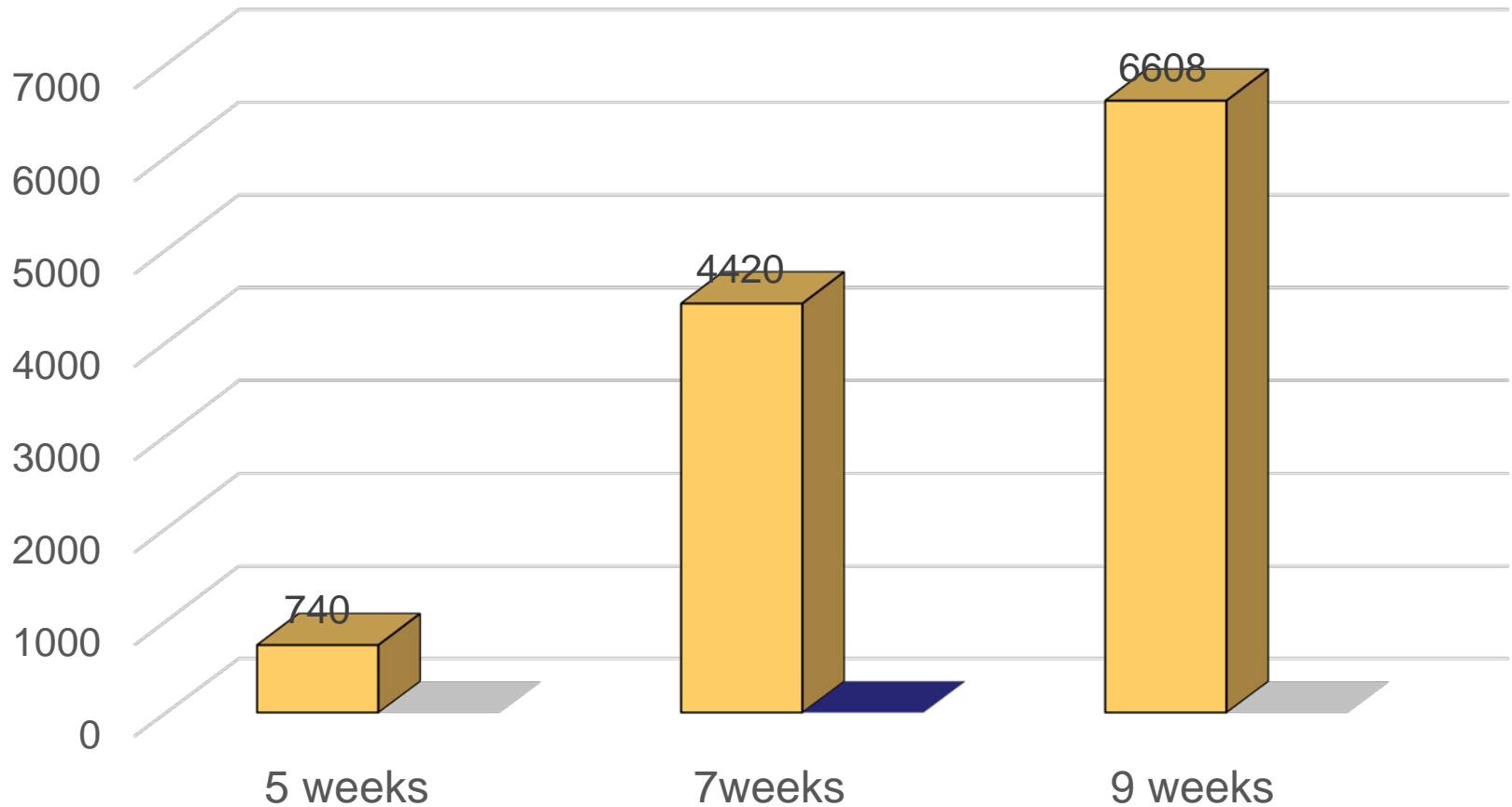
Weed in a field in Alberta that had canola 2 years before this picture



Volunteer canola at research site in Alberta, June 2018. Canola grown in 2017
When and how should these be controlled?

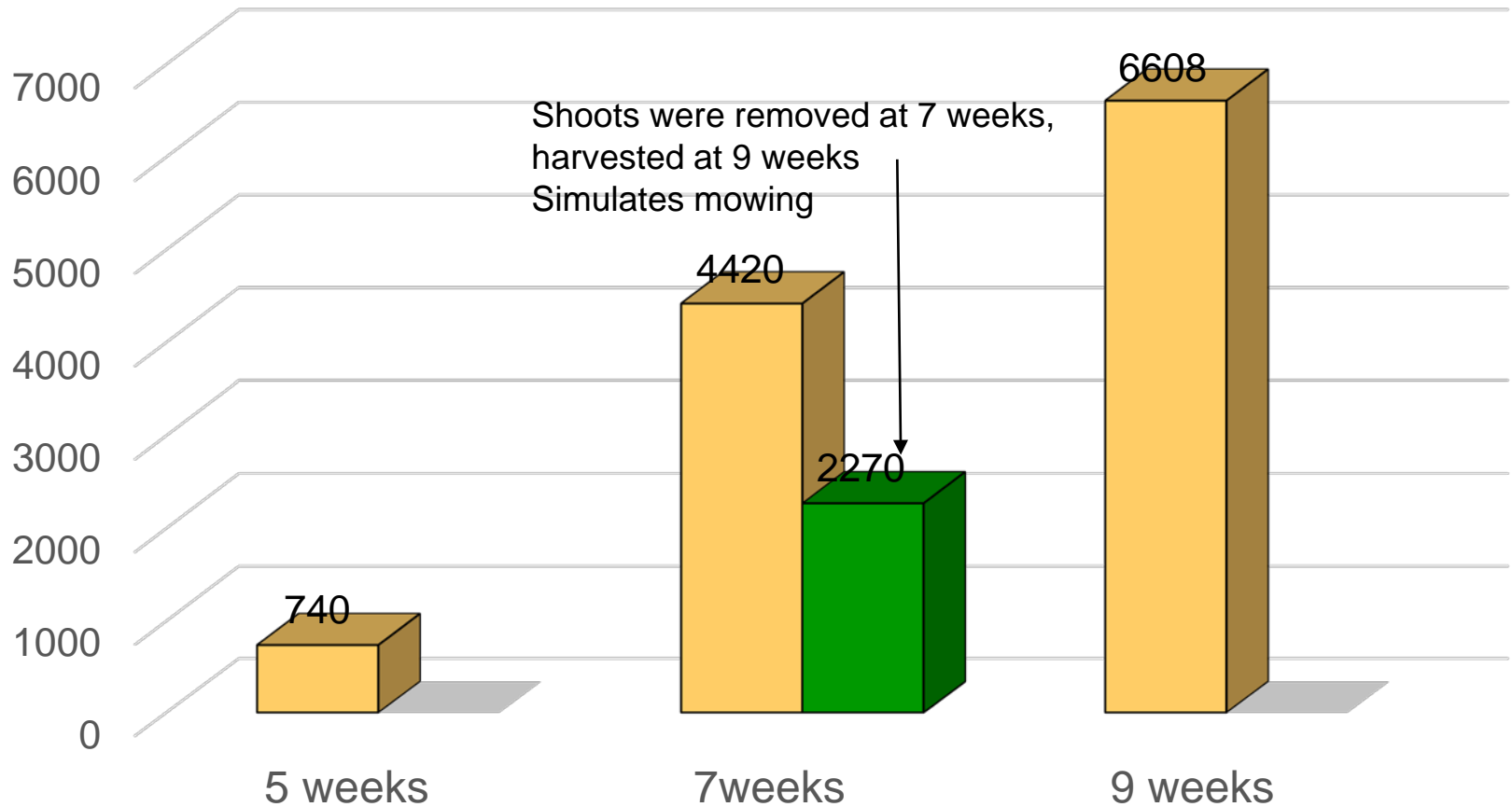
Increase in resting spores in canola roots over time (5- 9 weeks) 2016

Mature resting spore per club x 1 million



Increase in resting spores in canola roots over time (5- 9 weeks) 2016

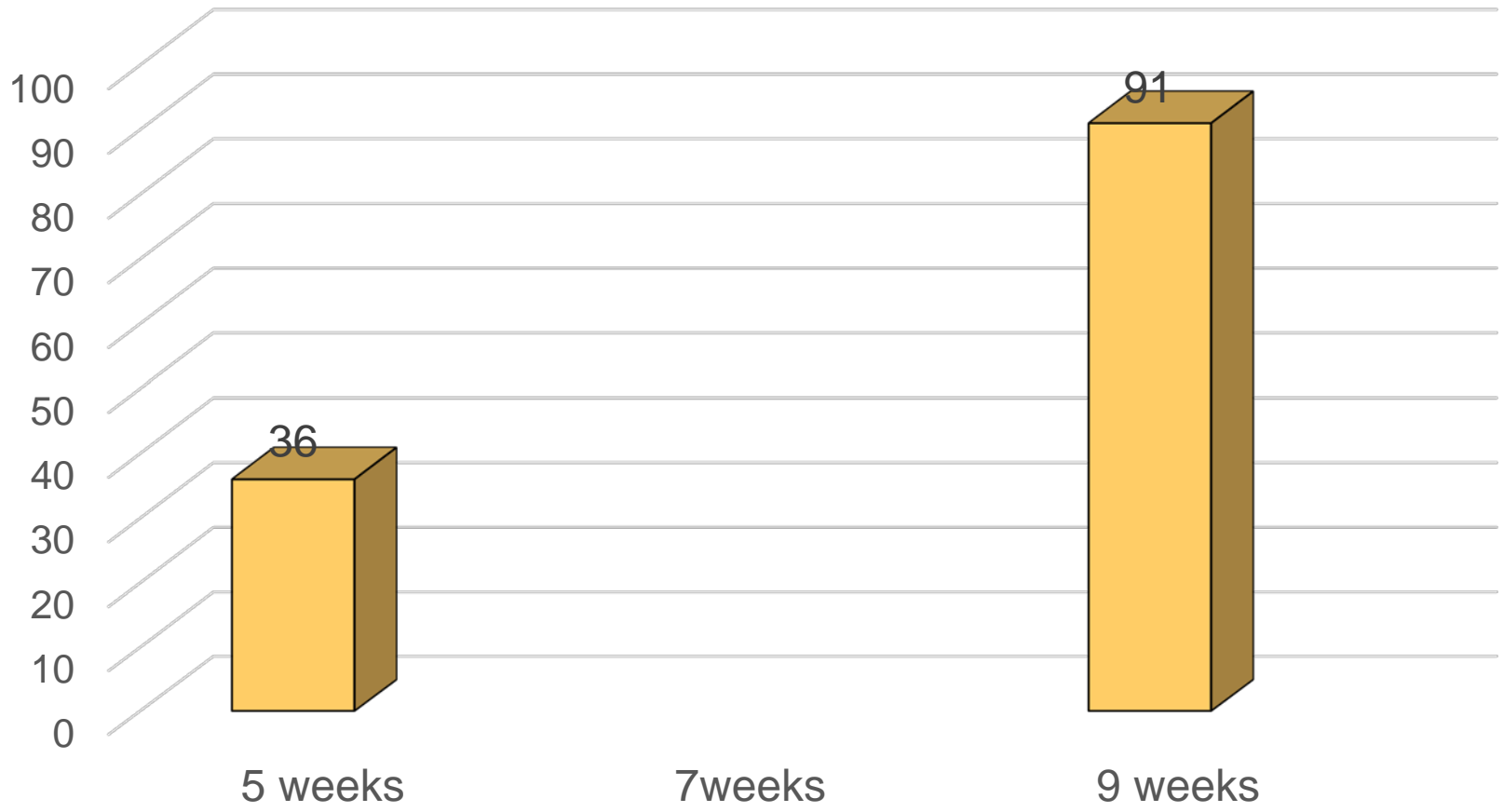
Mature resting spore per club x 1 million



Spray Roundup?

2017 trial

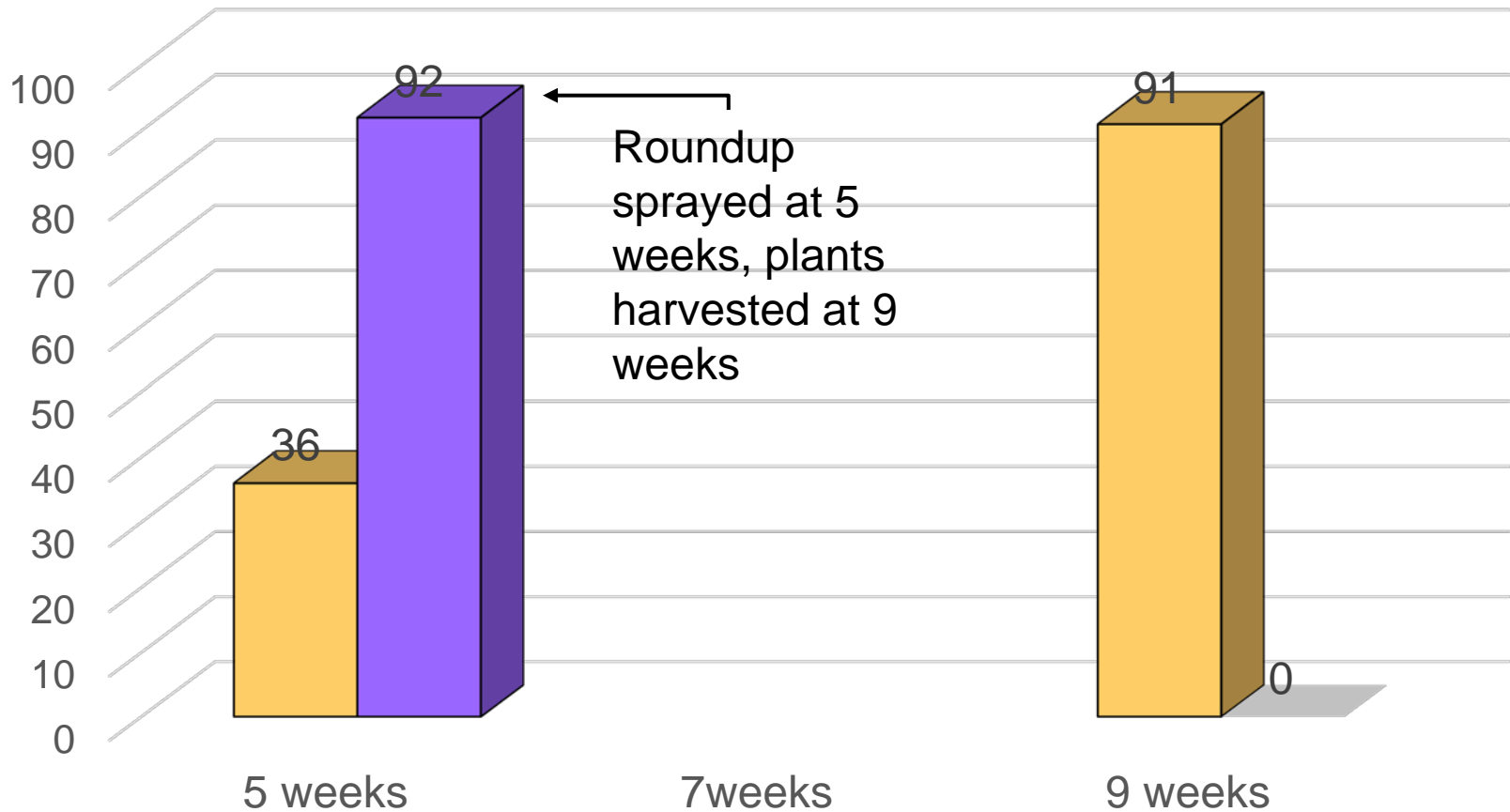
Mature resting spore per club x 1 billion



Spray Roundup?

2017 trial

Mature resting spore per club x 1 billion



When to control volunteer canola and Brassica weeds?

As early as possible!

- At the seedling stage

How to grow canola in the presence of clubroot?

Resistance

- ❑ Even with highly resistance varieties, 5-10% can develop clubroot (fact of life in the seed production process)
- ❑ Resistance can 'break down'
The pathogen can quickly adapt to the resistance gene (or genes?)

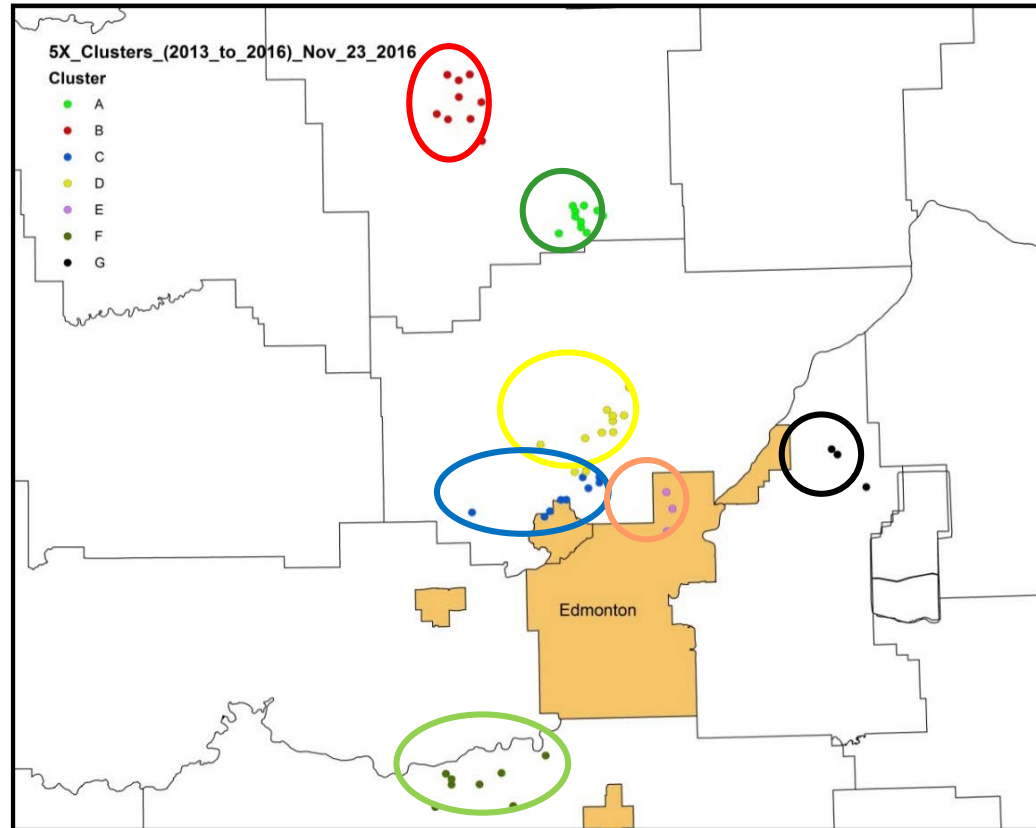
What are pathotypes?



- The pathogen exists as different strains, races or pathotypes that infect some, but not all crops or varieties
- In Ontario: pathotype 6 on vegetables, 2 on canola in Ontario,
- P3 on canola in Alberta, plus others
- **New pathotypes can overcome the resistance in canola such as 45H29 and others, 'x;'**
- These have been found at least 3 fields in Ontario
- Two were 2x and one was 3x

Clusters of Fields with New Strains in Alberta

- Clubroot resistant canola introduced in 2009
- New virulent pathotypes first found in 2013
- More found each year



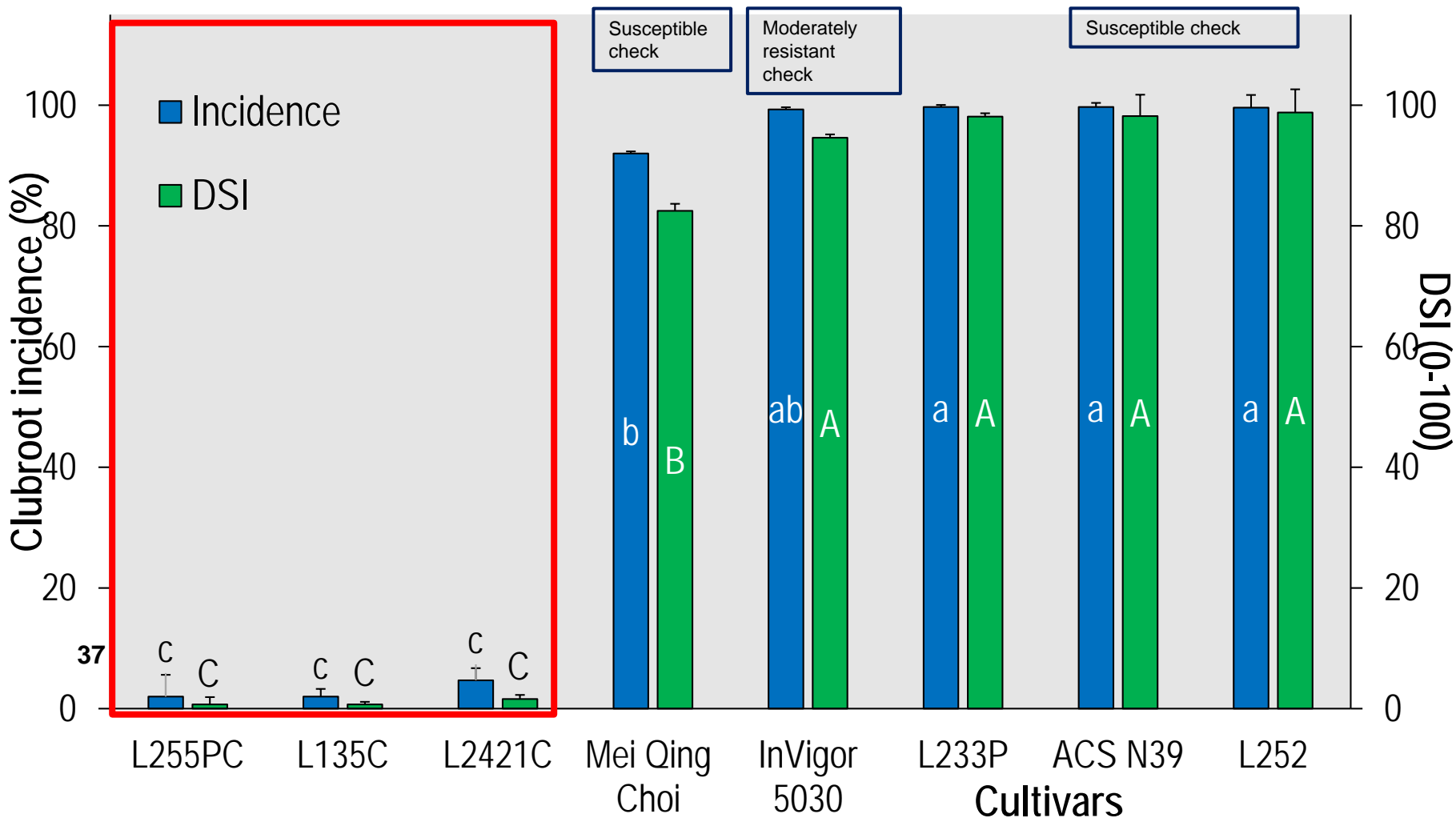
Strelkov & Hwang

Cultivars in canola field trial

Cultivar	Source	Resistance/ susceptibility
L241C	Bayer	resistant
L255PC	Bayer	resistant
L135C	Bayer	resistant
L233P	Bayer	-
L252	Bayer	-
ACS N39	AAFC	susceptible
InVigor 5030	Bayer	moderately resistant
Mei Qing Choi	Stokes Seeds	susceptible

controls

Canola field trial – Muck Crops Research Station: pathotype 2



First and second generation resistance to clubroot

- ❑ ‘First generation’ resistance – the first resistant cultivars that came out in 2009 (ie 45H29)
- ❑ Probably all resistance was based on the same gene
- ❑ First case of resistance overcome – 2013 in Alberta.
- ❑ Now at least 11 new pathotypes that are virulent on 45H29
- ❑ “Second generation” resistance in some canola, but breeders can’t keep up

Clubroot on canola

It is all about the numbers!

- ❑ Resting spores can build up to huge numbers (billions, trillions and quadrillions!) in one season in a heavily infested crop
- ❑ Everything works better under low disease pressure
- ❑ Keep spore numbers low
 - ❑ reduce soil movement
 - ❑ grow resistant canola if clubroot is in your area
 - ❑ apply lime
 - ❑ deal with small patches (remove plants, lime, grass?)
- ❑ **Crop rotation is important – 2 year break**
- ❑ **Never forget selection pressure: more spores = more new pathotypes = no resistance**

Scouting: Do Not Become Complacent

- Every year! Need to know when it first appears
- Even if growing a resistant variety
- During the season and after harvest
- Volunteer canola in the year after

- Wet areas
- Unhealthy looking areas, premature ripening
- Field entrances
- Border with neighbouring fields

- Send soil samples for clubroot test

Clubroot Symptoms can be Subtle



Top growth may or may not show symptoms of clubroot



Reducing Transmission of Spores

Farmers and Custom Apps

- Knock loose soil off equipment between fields
- Fields with high spore counts should be worked last
- Avoid working in fields when very muddy
- Manage soil erosion
- **Not just canola fields**
- Wash and disinfect when you can

Crop Scout and Agronomist

- Keep multiple pairs of boots in vehicle; soak in bleach 20 mins.
- Use separate shoes for driving and scouting
- Do not park in fields
- Clean/disinfect ATV tires
- **Not just canola fields**



Acknowledgements



- Ontario Canola Growers Association
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- Clubroot Mitigation Initiative
 - Canola Cluster of Growing Forward 2
 - Canadian Agricultural Partnership
- University of Guelph HQP Program
- Ontario Agri-Food Innovation Alliance

A wide-angle photograph of a vast field of bright yellow flowers, likely rapeseed, stretching to the horizon. In the foreground, a rustic wooden fence runs across the frame, with tall, brown-tipped grasses growing in front of it. The background features a dense line of green trees under a clear, light blue sky. The word "Questions?" is overlaid in the center of the image in a large, white, sans-serif font.

Questions?