Where are we with respect to clubroot management?

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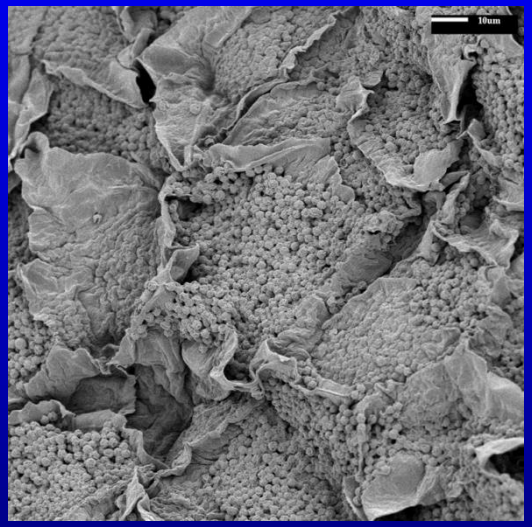
Outline of Presentation

- Introduction to clubroot
- Update on disease situation
- Resistance and pathotypes
- Emergence of new pathogen strains
- Implications & follow-up studies

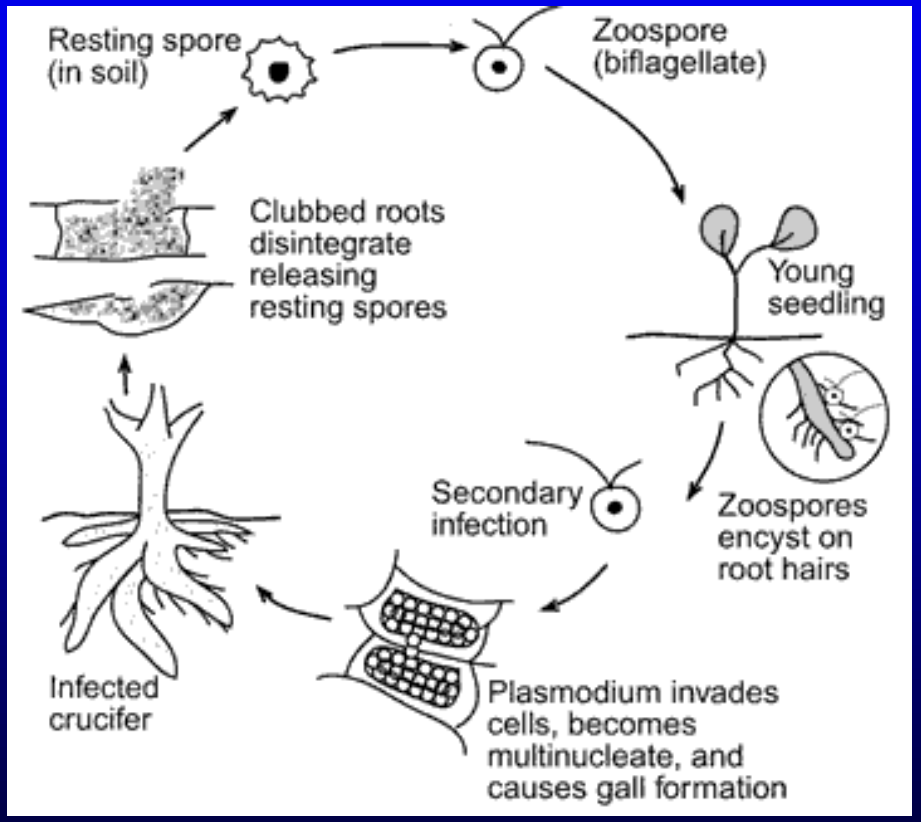
Clubroot of Crucifers

- Soilborne disease
- Caused by *Plasmodiophora brassicae*
- Attacks the roots, causing formation of galls or “clubs”
- Galls interfere with normal uptake of water and nutrients by the plant
  - Severe yield and quality losses

Clubroot Disease Cycle



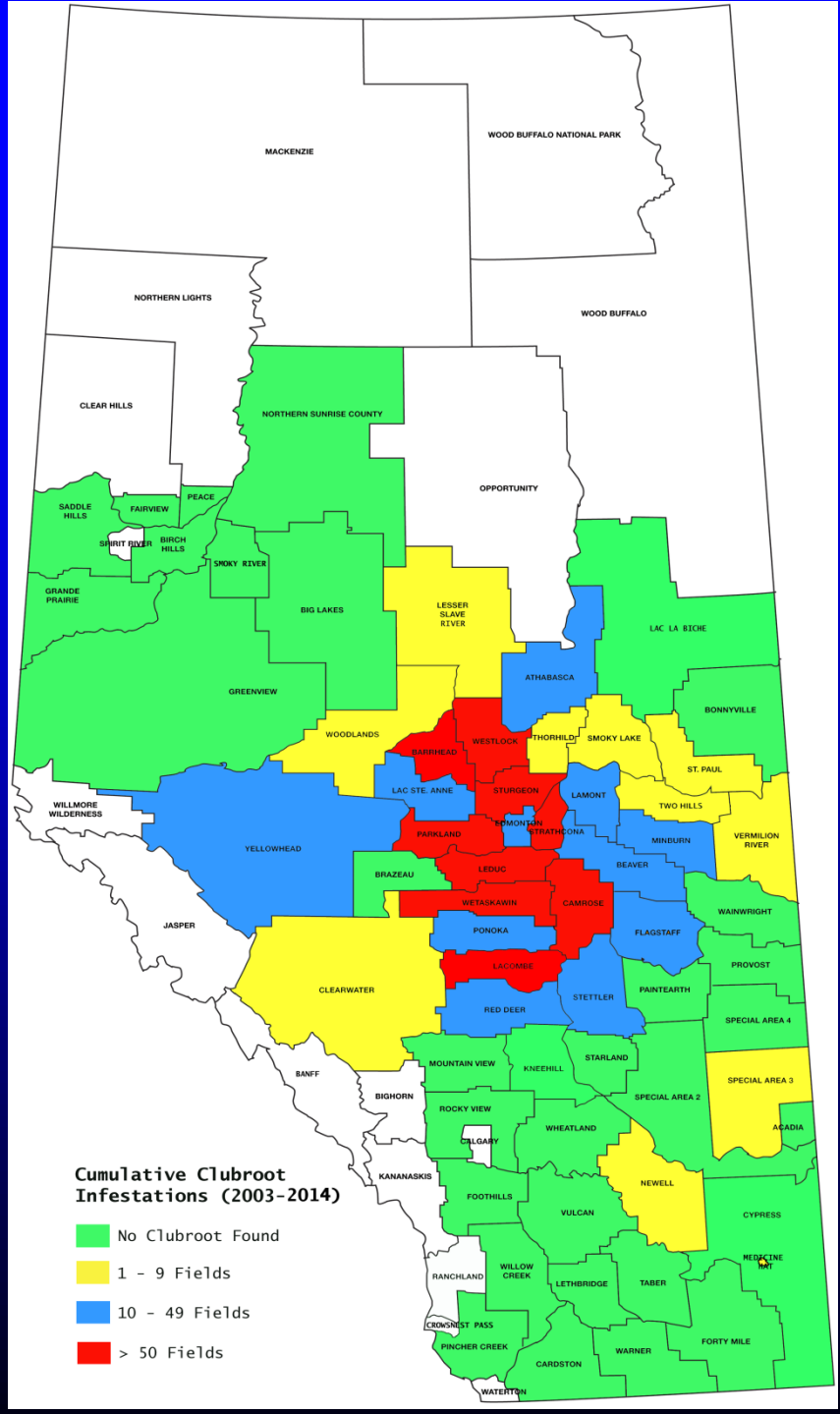
J.P. Tewari



Source: Ohio State University

Clubroot Infestations: 2003-2014

- *P. brassicae* has spread at a rapid pace for a soilborne pathogen
  - 1,868 fields in AB with confirmed infestations
  - 32 counties and municipalities
  - A few cases in SK & MB
- Various mechanisms implicated in spread



Strelkov et al.

Mechanisms of Spread

Equipment

Large amounts of soil moved, can quickly establish new infections

MITIGATION: equipment cleaning & sanitation

Dust & Water Erosion

Risk not fully assessed, likely contributes to short distance dispersal; risk is function of amount of soil & distance travelled

MITIGATION: minimize erosion processes

Seeds & Tubers

Limited amounts of inoculum, potential for long distance dispersal

MITIGATION: seed cleaning & seed treatments

Strelkov & Hwang, 2014

Management of Clubroot

- **Few management options available when clubroot first appeared**
  - **Rotation out of susceptible crops**
  - **Sanitization of field equipment**
- ***Development of resistant cultivars soon became a focus of canola breeders***

R.J. Howard

Genetic Resistance to Clubroot

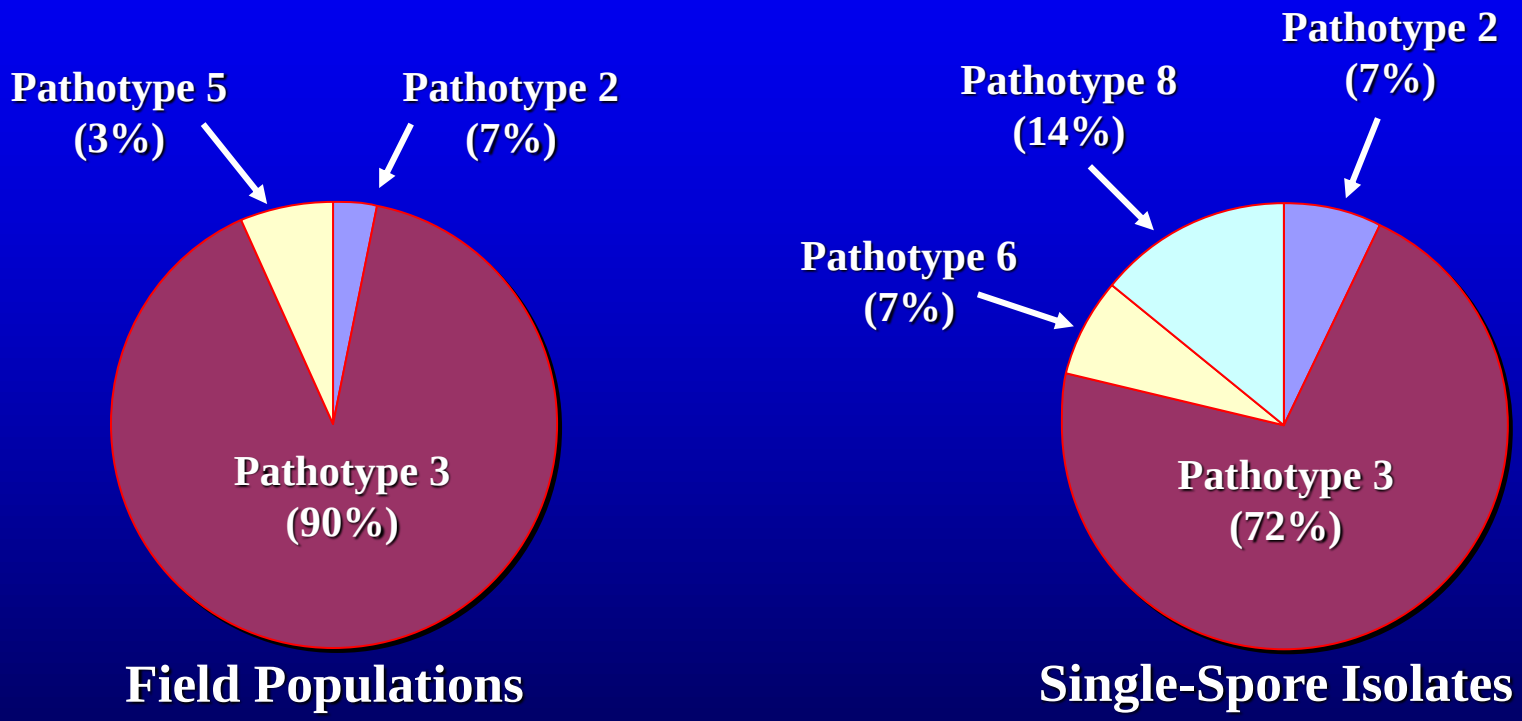
- **Breeding of canola with resistance to clubroot has been guided by studies on 'strain' or pathotype structure of *P. brassicae* in Canada**
  - **Pathotypes differ in their ability to infect specific host varieties**
- **Important to know which pathotypes are predominant in areas where a resistant cultivar will be grown**

Studies showed a fairly diverse pathotype composition in Canada

Province	Pathotype(s)		Reference(s)
	Populations	Single-spore isolates	
Alberta	3, 5, 2	3, 8, 2, 6	Strelkov et al., 2006; Strelkov et al., 2007b; Xue et al., 2008; Cao et al., 2009
British Columbia	6	6	Strelkov et al., 2006; Williams, 1966; Xue et al., 2008
Manitoba	5	--	Cao et al., 2009
Nova Scotia	3, 1, 2	--	Hildebrand & Delbridge, 1995
Ontario	6	3, 5, 8	Reyes et al., 1974; Strelkov et al., 2006; Xue et al., 2008; Cao et al., 2009
Quebec	2, 5	--	Williams, 1966; Cao et al., 2009
Saskatchewan	3	--	S.E. Strelkov, unpublished data

Pathotype designations on system of Williams (1966)

Pathotype 3 is Predominant in Alberta



Pathotype 3 (Williams) ≈ ECD 16/15/12 ≈ P_2 (Somé et al.)

Howard et al. 2010

Resistant Canola

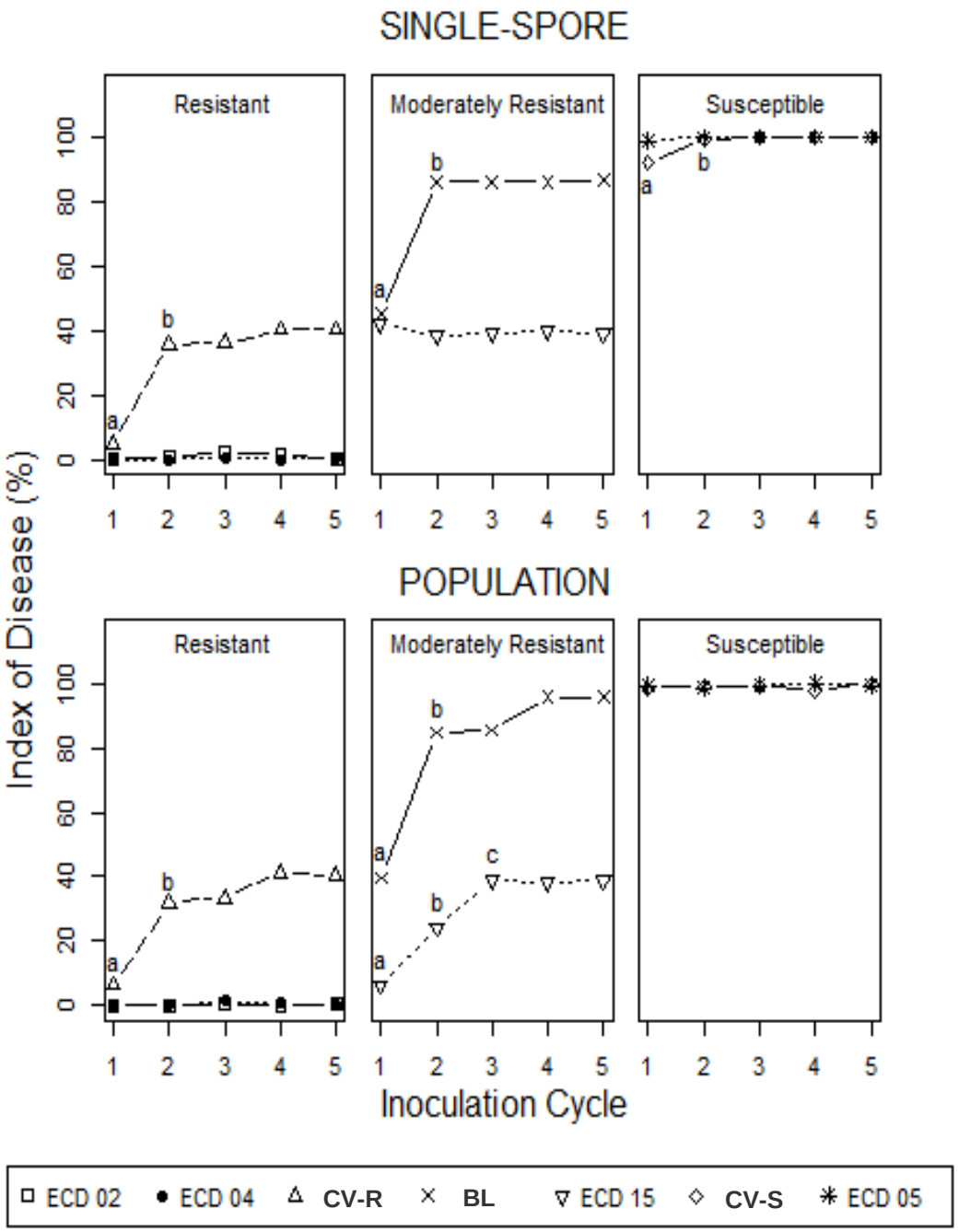
- Genetically resistant canola cultivars became available in 2009-10
  - Excellent resistance to known pathotypes
- Quickly became most important clubroot management tool

Pathogen Adaptation to Host Genotypes

Greenhouse studies showed that repeated exposure to a resistance source led to loss in effectiveness of that resistance

Highlighted the need for proper resistance stewardship!

LeBoldus et al. 2012



Resistance in the Field

- In spite of warnings, cropping of resistant canola in short rotation remains common practice in heavily infested regions
- Six fields identified in 2013 with higher clubroot severities than expected for resistant cultivars

Testing Virulence of Strains from CR Canola Crops

- Extracted spores from field-collected galls, and re-inoculated onto same varieties under greenhouse conditions
- Individually evaluated 3 galls from each "field of concern"
  - Spores from each gall also inoculated on a susceptible check
  - Each canola variety also inoculated with pathotype 3 (not exposed to resistance sources)

Strain of *P. brassicae* Virulent on 'Resistant' Canola

- Spores from galls from one of these fields were able to cause severe clubroot on the CR variety that had been planted in that field
- Indices of disease severity 99% – 100%
  - VS. 1.9% in response to pathotype 3

Infectivity of New Strain

- Virulence of this new strain was tested on CR canola varieties representing all companies in western Canada
  - All were susceptible
  - In most cases, indices of disease severity > 90%
- Serious threat to canola production in areas where clubroot is common

Pathotype Classification

- New strain of *P. brassicae* behaves like pathotype 5 based on classification system of Williams (1966)
  - But this does not reflect its increased virulence on CR canola
  - Highlights limitations of this pathotype designation system for identifying strains from Canadian canola
- New strain is referred to as ‘pathotype 5x’ for now

‘Pathotype 5x’

Host variety	Pathotype		
	3	5	5x
Jersey Queen (cabbage)	+	-	-
Badger Shipper (cabbage)	-	-	-
Laurentian (rutabaga)	+	-	-
Wilhemsburger (rutabaga)	-	-	-
Canadian ‘clubroot resistant’ canola	-	-	+

Pathotype designations as defined on system of Williams (1966)

Implications

- Emergence of new strain able to overcome clubroot resistance highlights continued vulnerability to *P. brassicae*
- Loss of resistance would represent loss of most effective clubroot management tool
- Resistance stewardship is very important
  - Need longer rotations out of canola in fields were clubroot is an issue

Follow-Up Studies

- In order to get better sense of the scale of the problem, additional surveying carried out in 2014
- Focused on CR canola crops
- Collected samples from 27 fields with higher than expected levels of clubroot

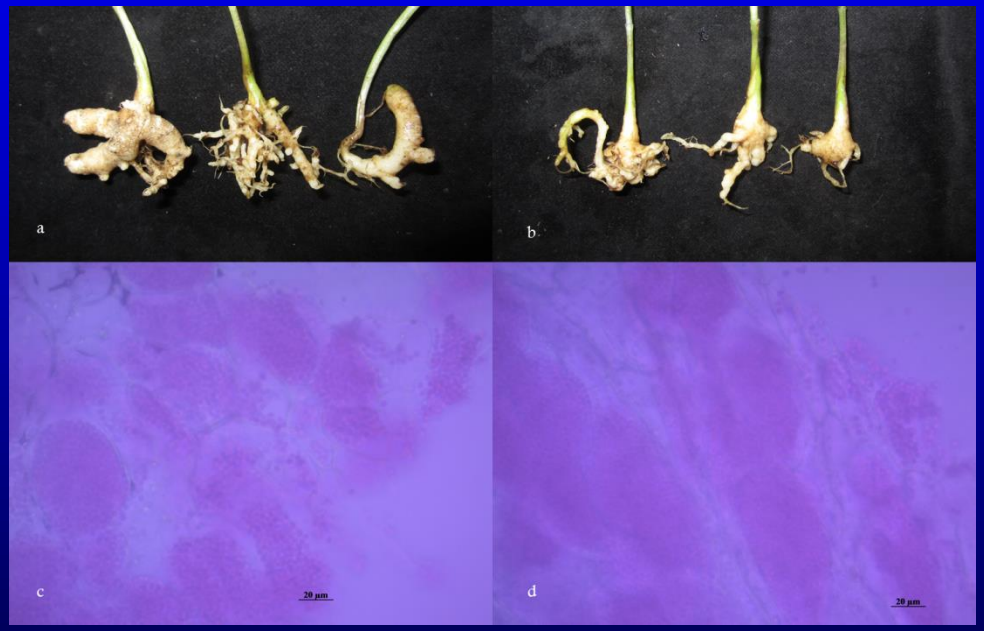
Characterization of 2014 Collections

- **Pathogen populations extracted from individual galls for testing in a stepwise manner:**
  1. **Assess virulence on cultivars from which populations were recovered**
  2. **If virulent, then test on various CR canola cultivars available on the market**
  3. **Obtain pathotype classification**

Testing of 2014 Collections

- **First phase of testing is completed**
  - **Increased virulence in *P. brassicae* populations from 16 of 27 fields of concern**
  - **Not restricted to the immediate vicinity of the 2013 case**

Resistant Canola Inoculated with New Strains of *P. brassicae*



Meaghan Nawrot, U of Alberta

Identification of Additional Virulent Strains

- Indicates that 2013 case was not an isolated incident
- Problem is more widespread than we hoped
  - Multiple canola cultivars affected
  - Seven counties/municipalities

Further Testing

- Don’t know relationship between these strains to each other or to original pathotype ‘5x’
- Testing on a suite of CR canola cultivars and various sets of differential hosts should provide some answers
- Development of molecular markers is a longer-term goal

Conclusions

- Clubroot continues to spread
- Resistance was first overcome in 2013
  - New strain highly virulent on CR canola
- 16 more cases identified in 2014
- Relationship between strains is not clear at this time
- Resistance stewardship is critical!

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