Where are we with respect to clubroot management?

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Soils and Crops 2015
Saskatoon, Saskatchewan
March 17th, 2015
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 brassicaceae*
- 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

Source: Ohio State University

J.P. Tewari
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
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
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
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

<table>
<thead>
<tr>
<th>Province</th>
<th>Pathotype(s)</th>
<th>Reference(s)</th>
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<tbody>
<tr>
<td></td>
<td>Populations</td>
<td>Single-spore isolates</td>
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<tr>
<td>Alberta</td>
<td>3, 5, 2</td>
<td>3, 8, 2, 6</td>
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<td>British Columbia</td>
<td>6</td>
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<td>Manitoba</td>
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<td>Quebec</td>
<td>2, 5</td>
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<tr>
<td>Saskatchewan</td>
<td>3</td>
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</tbody>
</table>

Pathotype designations on system of Williams (1966)
Pathotype 3 is Predominant in Alberta

Field Populations

Pathotype 3 (90%)
Pathotype 5 (3%)
Pathotype 2 (7%)

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

Single-Spore Isolates

Pathotype 3 (72%)
Pathotype 8 (14%)
Pathotype 6 (7%)
Pathotype 2 (7%)
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!
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’

<table>
<thead>
<tr>
<th>Host variety</th>
<th>Pathotype</th>
<th>Pathotype</th>
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<tbody>
<tr>
<td></td>
<td>3</td>
<td>5</td>
<td>5x</td>
</tr>
<tr>
<td>Jersey Queen (cabbage)</td>
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<td>-</td>
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<tr>
<td>Badger Shipper (cabbage)</td>
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<tr>
<td>Laurentian (rutabaga)</td>
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<td>-</td>
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<tr>
<td>Wilhemsburger (rutabaga)</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>Canadian ‘clubroot resistant’ canola</td>
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<td>-</td>
<td>+</td>
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</table>

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!
Acknowledgements

- Victor Manolii, Meaghan Nawrot, & other U of A students & staff
- AARD personnel
- CCC Agronomists & Agricultural Fieldmen
- ACIDF, WGRF, ACPC, SaskCanola, MCGA, AAFC & CCC (GF2 Program), other industry partners