CLUBROOT disease
Manitoba Perspective

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MB AgDays, Brandon
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Clubroot Disease

• Caused by soil-borne pathogen *Plasmodiophora brassicae* (protist – not fungus/slime mold)
• Favoured by wet soils and acidic pH
• A serious disease of Brassica crops
  – e.g. Cabbage, rutabaga, radish, cauliflower, broccoli, and Brussels sprouts.
• Susceptible *brassica weeds* – stinkweed, volunteers
• Susceptible *non-brassica plants* on the prairies
  – e.g. Creeping bent grass, Orchard grass, Strawberry, Perennial rye grass,

http://m.gov.mb.ca/agriculture/crops/plant-diseases/clubroot-brassica.html

2014 Clubroot – MB AgDays – Vikram MAFRD
Clubroot of Canola

- Pathogen infects roots
- Causes galls
  - excessive growth hormones cytokinins & auxins
- Restrict the flow of water and nutrients to the plant
  - Wilting, stunting, yellowing, seed shrivelling
  - Long lived resting spores

The role of cytokinins in clubroot formation
H.M. Dekhuijzen†, J.C. Overeem.
Wilting and Leaf Yellowing – Club root infected plant
Losses

Yield

- 100% plants infected leads to 50-80 % loss
  - From research in Sweden and Europe

- Every 2 % infection leads to 1% loss

Sales and Trade
Clubroot in Canada

• Likely introduced to Canada with infected fodder turnips
  – Well-established by late 19th/early 20th century

• Affected cruciferous vegetable production
  – Maritime provinces
  – Ontario, Quebec
  – British Columbia
Clubroot on Canola

Rapid spread in AB

- 2003: 12 cases, First identified near Edmonton
- 2009: 454 cases spread over 17 counties
- 2012: 1064 cases spread over 24 counties
- 2013: 1482 cases, 417 identified in one year

100 fold increase in 10 yrs
Manitoba Clubroot Timeline

- 1920s – in rutabaga
- 1980s – market garden south of Winnipeg
- 2005 – in breeding nursery
- 2011 – 2 DNA +ve soil samples (GH no symptoms)
- 2012 – 6 DNA +ve soil samples (2 soils produced infections in GH test on susc host)
- 2013 – 2 fields +ve plant symptoms
  - 2 DNA +ve soil samples (no GH symptoms)
# Clubroot in Prairies

<table>
<thead>
<tr>
<th></th>
<th>AB</th>
<th>SK</th>
<th>MB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulated Pest Act</strong></td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td><strong>First +ve soil/plant</strong></td>
<td>2003</td>
<td>2009 soil</td>
<td>2005 plant</td>
</tr>
<tr>
<td><strong>First Canola Incidence</strong></td>
<td>2003 12 fields, 4 growers</td>
<td>2011 2 fields</td>
<td>2012 2 fields 2 grower</td>
</tr>
<tr>
<td><strong>Total Plant Incidences to-date</strong></td>
<td>1482</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total fields +ve for DNA</strong></td>
<td>&gt;2000 – 4000 ?</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td><strong>Management started</strong></td>
<td>After field symptoms seen</td>
<td>Soil survey for DNA</td>
<td>Soil survey for DNA</td>
</tr>
</tbody>
</table>

2014 Clubroot – MB AgDays –Vikram MAFRD
Manitoba Clubroot Status

- Finding at low levels in some areas in the province (survey since 2009)
- Only surveyed 2% farms
- 3% of soil samples tested +ve for DNA

Clubroot pathogen once discovered has the possibility to be discovered in many more fields quickly
Clubroot Symptoms on canola found in Manitoba in 2013
Current situation in MB

- All cases have been identified by UoA lab, using PCR (can detect below \(1000 \ (10^3)/ \) gram of soil)

- Populations in MB soils often below infective levels
  - 1000 spores / g soil produce symptoms in greenhouse

- qPCR needed to quantify DNA in soil

- Commercial labs using qPCR, identify soil as +ve at or above \(10^5\) spores / gram soil

<table>
<thead>
<tr>
<th>&lt;1 x 10^5</th>
<th>1 x 10^5 – 1 x 10^8</th>
<th>1 x 10^8 – 1 x 10^10</th>
<th>&gt;1 x 10^{10}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Very High</td>
</tr>
</tbody>
</table>

AB

AB
Clubroot Disease Cycle

Canola Council of Canada
Spores in soil

Moved by Tillage
Spores can travel with water: in water channels & across fields.
In-field Distribution & Dispersal of Resting spores

Low lying areas – surface run-off
Who is Guilty of This?

Soil from an individual field can move a long way

Photo: Angela Brackenreed, Canola Council of Canada
Wind erosion of soil

1-2 km to long distances possible

- Soil particles <0.1 mm
- Soil particles 0.1-1 mm
- Soil particles >1 mm

- Clubroot resting spores < 10 um
  (1 um = 0.001 millimeters)

- Spore captured in dust: 0 to 220,000 resting spores/g soil
- In 2012, the highest levels captured at the lowest sampler height
Seed-borne Dispersal
External contaminant- Resting Spore Loads

<table>
<thead>
<tr>
<th>Crop</th>
<th>Spore Load per 10 g Seed (qPCR)</th>
<th>Viability (Evan’s Blue Staining)</th>
<th>Commercially Cleaned?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>$3.43 \times 10^4$</td>
<td>80%</td>
<td>No</td>
</tr>
<tr>
<td>Canola</td>
<td>$4.04 \times 10^3$</td>
<td>90%</td>
<td>No</td>
</tr>
<tr>
<td>Pea</td>
<td>&lt;1,000</td>
<td>98%</td>
<td>Yes</td>
</tr>
<tr>
<td>Potato</td>
<td>$1.40 \times 10^4$</td>
<td>90%</td>
<td>No</td>
</tr>
<tr>
<td>Pea ($\times 3$)</td>
<td>&lt;1,000</td>
<td>97 – 100%</td>
<td>No</td>
</tr>
</tbody>
</table>

Spore loads as determined by qPCR on samples testing positive by conventional PCR (Rennie et al. 2011)
Disease Spread: Relative ‘Risk Matrix’

**Equipment**

Large amounts of soil moved, can quickly establish new infections
Tractor – 150 kg; Cultivators – 50 kg (Ron Howard)
  • Oil and gas companies (seismic, drilling, pipelining, servicing)
  • Contractors (road building, excavating, trenching, hauling soil)

**MITIGATION:** equipment cleaning & sanitation

**Wind & Water Erosion**

Risk not fully assessed, may contribute 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

**Wildlife**

Very limited amounts of inoculum, short distances

**MITIGATION:** almost none
Manage Before Establishment

- Bio-security protocols
- Crop Rotation
- Crop Scouting
Follow Biosecurity Measures

For Self and Others on Farm

Assess Acceptable level of Risk

• Reduce Soil Movement into Field:
  – Clean vehicles, equipment and shoes of all soil
  – Disinfect equipment and shoes

• When buying equipment ensure that it is cleaned of all soil and disinfected

• Growers could restrict entry of outside vehicles into their fields and farm yards, especially if they are unclean
Based on acceptable risk

Steps to Prevent Introduction and spread

• **Rough Cleaning**
  – Scraper & hammer

• **Pressure Wash or Air-pressure**

• **Disinfect** (1-2% commercial bleach)
  – 30 min (10 spray + 20 retention)

**Bare Minimum**

**Hammer or Scraper on shanks and tires**

Ron Howard
Farm-level Biosecurity

Could help identify sources of Biosecurity risks to a farm.

Biosecurity protocol guidelines distributed to growers
Spore Survival and Rotation

• The resting spores are very long lived even in absence of the host *(Swedish & European studies)*
  – 10 – 20 years *(need research in prairies to confirm)*
  – 4-year half-life
  – 17 years was needed for disease to be non-detectable levels

• Spores can also survive livestock digestion, so growers may want to avoid use of straw, hay, feed, silage or manure from infested or suspect areas

2014 Clubroot – MB AgDays – Vikram MAFRD
SCOUTING for Clubroot

- Crop Scouting
  - Mid-season
  - Near maturation
  - At or after swathing - thinned areas
  - Low lying and water flow areas in field

- Correct Identification very critical
Phenoxy damage

- Galls all the way down the tap root and side roots
- Plants a little wilted, not healthy
- Mature galls pithy
- Decay rapidly

Hybridization nodules

- At root nodes
- Cross-section uniformly dense
- Do not decay

SCOUTING & correct diagnosis is important

NOT Clubroot

Clubroot

- Galls all the way down the tap root and side roots
- Plants a little wilted, not healthy
- Mature galls pithy
- Decay rapidly
Establishment

• Once a field is infested with clubroot, eradication is not feasible.
• The approach is to prevent production of high concentrations of spores.
• Soil conditions: Water Saturated, warm (20-24°C) and acidic – increase severity of disease.
Management after Establishment

Once a field becomes infested, there are really very few options for control

1. Use of **Resistance genetics**
2. **Crop rotations** of
   - at least four years,
   - 5-7 years or longer may be needed if spore concs are high. Levels below 1000 spores /gram soil are considered low for disease development.

- No chemical control possible in canola currently
- Research on bio-fungicides
Genetic Resistance

- Represents most important tool for clubroot management

- Resistant cultivars first became available in 2009
How Does Resistance Help

Prevents yield loss
Reduces new spore production
Galls on Canola Plants

Non-infected

Spheroid on R canola

Spindle on Susc canola
**Spindle Gall**

Proliferation of pathogen in stele leads to gall formation

- Mature resting spores (almost exclusively in periderm)

**Resistant Plants: Significantly less plasmodia and resting spores produced**

**Spheroid Gall**

- Plasmodia in stele
- Plasmodia in periderm

Rennie et al. Univ of Alberta
Spindle Gall

Proliferation of pathogen in stele leads to gall formation

Mature resting spores (almost exclusively in periderm)

Resistant Plants: Significantly less plasmodia and resting spores produced

Spheroid Gall

“Scale equalized”

Rennie et al.
Univ of Alberta
Clubroot Resistance

Major Pathotype  AB= #3 and MB = #5, ??

Pioneer Hi-Bred source

45H29 (Pioneer) 2, 3, 5, 6, 8
9558 GC (Viterra)
Proven VR 9562 GC (CPS)
D3152 (DuPont)

Monsanto source

74-54 CR (Dekalb) – 2, 3, 5, 6, 8
74-47 RR (Dekalb)
1960 (Canterra)

Bayer source

L135C

Brett-Young Seeds

6056 CR

SY 4000 series in pipeline
## Pathotype Composition

<table>
<thead>
<tr>
<th>Province</th>
<th>Pathotype(s)</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>3, 5, 2</td>
<td>Strelkov et al., 2006; Strelkov et al., 2007b; Xue et al., 2008; Cao et al., 2009</td>
</tr>
<tr>
<td>British Columbia</td>
<td>6</td>
<td>Strelkov et al., 2006; Williams, 1966; Xue et al., 2008</td>
</tr>
<tr>
<td>Manitoba</td>
<td>5</td>
<td>Cao et al., 2009</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>3, 1, 2</td>
<td>Hildebrand &amp; Delbridge, 1995</td>
</tr>
<tr>
<td>Ontario</td>
<td>6</td>
<td>Reyes et al., 1974; Strelkov et al., 2006; Xue et al., 2008; Cao et al., 2009</td>
</tr>
<tr>
<td>Quebec</td>
<td>2, 5</td>
<td>Williams, 1966; Cao et al., 2009</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>3</td>
<td>S.E. Strelkov, unpublished data</td>
</tr>
</tbody>
</table>

Pathotype designations on system of Williams (1966)
Resistant Varieties

- Infected plants seen in R variety fields
  - Volunteer or Resistance breaking
- Resistance can be broken by the fungus over time
- Need to change resistance genetics as part of R management.
# Clubroot Management

## Chemical Control on Crucifer Vegetables

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Product 1</th>
<th>Active Ingredient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>Allegro 500F</td>
<td>Fluazinam 40.0%</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>Quintozene</td>
<td>Terraclor 75%</td>
</tr>
<tr>
<td>Broccoli</td>
<td>Vapam Fumigant</td>
<td>Metam Sodium at 42%</td>
</tr>
<tr>
<td>Bok-Choy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chinese crucifer veggies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mustards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Crucifer veggies</td>
<td></td>
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</tr>
</tbody>
</table>

[http://m.gov.mb.ca/agriculture/crops/plant-diseases/clubroot-brassica.html](http://m.gov.mb.ca/agriculture/crops/plant-diseases/clubroot-brassica.html)
Prediction of the potential distribution and abundance of clubroot

**EcoClimatic Index (CLIMEX™)**

- Computer simulation program
  - Based on long-term climate normals
    - Provides measure of “favourableness” of location to a species

Sutherst et al. (1999)
Growth Index Values

- Describe suitability of locations for species survival and reproduction

**Growth Index (GI) values**
- 0 - 10 = little or no occurrence, not economic
- 10 - 20 = limited to low occurrence, generally not economic
- 20 - 30 = routinely occurs, economic impact
- >30 = very favourable, chronic economic impact

Year to year weather fluctuations will impact Index Values
Annual growth index for projected clubroot development based on long-term climate normals
CLIMEX annual growth index (GIₐ) values for incremental summer temperature and rainfall scenarios for the Prairie region of Canada.
EcoClimatic Index (Climex)

• Predicted potential economic impact from clubroot in some areas of the prairies
  – Wetter and warm areas of the prairie region
    • Consistent with observations from 2003-2013
  – Potential at risk areas include other regions of AB, eastern SK and MB
  – Drier areas likely have limited risk
    • Irrigated regions? Localized impact
• More rains in the South west - 150-200%

• Near normal in most MB
Presently:
- No yield impact observed at such low levels (a few plants in a field!)
- Risk level for production losses in Manitoba is low to uncertain.

Future: Yield Impacts depends greatly on
- weather patterns,
- bio-security precautions by various stakeholders of canola production industry
- Judicious use of resistance genetics
- ?

DON’T WORRY BE HAPPY
OR
SERIOUS ISSUE
Risk to Manitoba?

- **Warm and wetter conditions in MB** increase risk, in spite of higher soil pH
- **Annual/seasonal weather patterns** will greatly influence clubroot risk

- **MB in much better situation than AB in 2003**
  - More understanding of disease
  - Resistance available
  - More research work relevant to prairies
• Suspicious samples (plant or soil) can be tested for clubroot
  – Send plant samples to Crop Diagnostic Lab, MAFRD, Winnipeg
Acknowledgements

• All Growers: for voluntary participation in the survey
• Anastasia Kubinec and other MB Canola disease survey team
• Dr. Stephen Strelkov & lab
• Dr. Kelly Turkington & AAFC colleagues
• Canola Council of Canada – Clinton Jurke

THANK YOU
QUESTIONS ??

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