Fungicides/biofungicides, Cultivar resistance, crop rotation for control of clubroot on canola

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Resistance is the cornerstone in clubroot management

- Effective
- Economical
- Easy to use

Research plots

Commercial fields
**Resistant cultivars**
- resistant, but not immune
- none of the R genes is effective for all races
- resistance can be eroded with a change of pathogen race structure

**Questions:**
- How long will the resistance last?
- Is resistance alone enough?
- anything else that may help?
- Resistance stewardship
Additional control strategies

• Fungicides or biofungicides?

• Crop rotation?
Biofungicides & fungicides

- **Serenade** (*Bacillus subtilis*)
- **Prestop** (*Clonostachys rosea*)
- **Allegro** (Fluazinam)
- **Ranman** (Cyazofamid)

All applied as a liquid formulation
Selected products: soil drench was highly effective in controlled conditions

Pathogen control

Pathogen + biofungicide
Modes of action for Biofungicides

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Avg. disease index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prestop</td>
</tr>
<tr>
<td>Formulated product</td>
<td>2 a</td>
</tr>
<tr>
<td>Product filtrate (cell free)</td>
<td>11 a</td>
</tr>
<tr>
<td>Spore/cell suspension</td>
<td>50 b</td>
</tr>
<tr>
<td>Pathogen control</td>
<td>93 c</td>
</tr>
</tbody>
</table>

Resting spore germination (%):

- Water (control)
- Serenade product
- Fluazinam

Graph showing germination over time (days).
Field application of fungicides/biofungicides

- Liquid formulation
- in-furrow
- 500 L/ha

Poor efficacy for clubroot control
Effect of soil dryness on efficacy
(under controlled conditions)

Disease severity index (%)

- Inoculated control
- Prestop
- Serenade
- Allegro
- Ranman

Duration of dryness (wks)

- 0
- 1
- 2
- 3
- 4

Disease severity index (%)
Using the biofungicide Serenade with CR canola cv. (n=2)

In controlled conditions

- **Plasmodiophora brassicaea**
- Dose: 10,000 resting spores/plant

<table>
<thead>
<tr>
<th>Canola cultivar</th>
<th>Disease severity index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Susceptible</td>
<td>50 ± 10</td>
</tr>
<tr>
<td>M. resistance</td>
<td>20 ± 5</td>
</tr>
<tr>
<td>H. resistance</td>
<td>5 ± 1</td>
</tr>
</tbody>
</table>

- Untreated
- Serenade
Granular formulation of *Bacillus subtilis*

**GOAL:** deliver a high population of the biopesticide to the canola rhizosphere
- maximize *Bacillus subtilis* “spore” production in the fermenter
- develop cost effective formulations

**Formulation types**
- Granules
- Seed coating
Fermentation of *B. subtilis* – optimal “spore” production
<table>
<thead>
<tr>
<th>Formulation</th>
<th>Ingredients</th>
<th>B. subtilis (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Bentonite clay, corn starch, peat</td>
<td>75</td>
</tr>
<tr>
<td>A2</td>
<td>Bentonite clay, corn starch, peat</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>Bentonite clay, pea starch, peat</td>
<td>100</td>
</tr>
<tr>
<td>C</td>
<td>Bentonite clay, corn starch, peat, CMC</td>
<td>100</td>
</tr>
<tr>
<td>D</td>
<td>Bentonite clay, corn starch, peat, CMC</td>
<td>100</td>
</tr>
<tr>
<td>E</td>
<td>Bentonite clay, corn starch, peat, PVP</td>
<td>100</td>
</tr>
<tr>
<td>F</td>
<td>Exlite pea fibre, peat</td>
<td>250</td>
</tr>
<tr>
<td>G</td>
<td>Bentonite clay, corn starch, peat, PVP</td>
<td>100</td>
</tr>
<tr>
<td>G2</td>
<td>Bentonite clay, corn starch, peat, PVP</td>
<td>125</td>
</tr>
<tr>
<td>H</td>
<td>Bentonite clay, corn starch, peat, CMC</td>
<td>125</td>
</tr>
<tr>
<td>I</td>
<td>Bentonite clay, exlite pea fibre, peat</td>
<td>175</td>
</tr>
<tr>
<td>I2</td>
<td>Bentonite clay, exlite pea fibre, peat</td>
<td>200</td>
</tr>
<tr>
<td>J</td>
<td>Bentonite clay, exlite pea fibre, peat, PVP</td>
<td>175</td>
</tr>
<tr>
<td>K</td>
<td>Bentonite clay, exlite pea fibre, peat, CMC</td>
<td>200</td>
</tr>
<tr>
<td>Z</td>
<td>Corn starch, peat</td>
<td>171</td>
</tr>
</tbody>
</table>
Extrusion

Spheronization

Extrudate

Granular formulations
Disintegration rate of granules

![Graph showing disintegration rate of granules](image-url)
Corn-cub-grits granular formulation

- Easy to apply with canola seeding
- Granule source abundant & inexpensive
- Effective in controlled conditions
- Field application: 50 Kg/ha
2011 field trials
I. Fungicide/biofungicide x cv. resistance

- Leduc, AB
- Edmonton, AB
- Normandin, QC
- Two granular Serenade formulations
- corn-cub grit carrier (granules) for Allegro and Ranman
- CR and CS cultivars
Leduc, AB (2011)

- cv. resistance was highly effective; with substantial clubroot reduction and yield increase

- None of fungicide or biofungicide treatments was effective
Edmonton, AB (2011)

Almost exactly the same pattern as in Leduc, AB

Edmonton, AB
Seeding date: June 2, 2011
2011 field trials

Normandin, QC

Disease severity index (%)

0 20 40 60 80 100 120

Yield (g/plot)

0 450 1000 1500 2000 2500 3000 3500

Susceptible cultivar

Resistant cultivar

45H26 S

45H29 R

Treatment

Control

Serenade granules

Allegro grits

Ranman grits

Serenade grits
II. Biofungicide seed treatment x crop rotation (Normandin, QC 2011)

Three crop rotation scenarios:
1) Canola-barley-canola (short rotation)
2) Canola-barley-barley-pea-canola (long rotation)
3) 11-year continuous barley (extremely long break)

Biofungicide seed treatment
Low, medium, high, and very high rates (B. subtilis)

Bioassay & qPCR before and during trials
Pathogen inoculum pressure in varying rotation
Table 4. Estimate of *Plasmodiophora brassicae* inoculum pressure (soil-sample bioassay) and early pathogen development in canola roots using qPCR in plots of varying crop-rotation history (2011).  

<table>
<thead>
<tr>
<th>Crop rotation (Year of break)</th>
<th>Bioassay (%DSI)</th>
<th>qPCR (ng/g fresh root)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Field trial 1</td>
<td>Field trial 2</td>
</tr>
<tr>
<td>1</td>
<td>74.8 a</td>
<td>11.6 a</td>
</tr>
<tr>
<td>3</td>
<td>47.0 b</td>
<td>7.3 b</td>
</tr>
<tr>
<td>11</td>
<td>28.3 c</td>
<td>8.7 b</td>
</tr>
</tbody>
</table>

A Soil samples were taken prior to the trials and root samples were taken from nontreated control plots 4 weeks after seeding.
Results

Clubroot severity index

1-year break
Canola – barley - Canola

3-year break
Canola-barley-barley-pea-canola

11-year break
11-years of continuous barley
Crop condition assessment

Break from last canola crop (years)

Scale 0

Scale 4
Canola seed yield

- Seed treatment was of no benefit
- A longer break from a canola crop gave much higher yields in both trials
- Even a 3-year break doubled the year relative to 1-year break due to reduced impact to the crop by clubroot
Summary

- Biofungicides/fungicides, in liquid or granule formulations, showed no efficacy against clubroot on canola under field conditions.
- Resistance cultivars demonstrated high value in clubroot management, especially under high disease pressure conditions.
- Long crop rotation (>4 yrs) alleviated clubroot impact on canola, reducing yield losses.
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