Potato Cyst Nematodes: Changing dynamics in GB populations

Dr Matthew Back, Harper Adams University
Outline

1. Background on Potato Cyst Nematodes (PCN)
2. Survey conducted by Harper Adams University
3. Phenotyping experiment – an insight into the determination of pathotype
4. Survey results and interpretation
5. Summary of PCN characteristics and their practical use for growers
6. Management of PCN in the context of the survey results
7. Summary
Background: Potato Cyst Nematodes

**Globodera rostochiensis**
(yellow or golden potato cyst nematode)

**Globodera pallida**
(white potato cyst nematode)

Pathotypes:
- Ro1
- Ro2
- Ro3
- Ro4
- Ro5

Pathotypes:
- Pa1
- Pa2
- Pa3

Mitotypes:
- 1
- 2
- 3

Photographs: Katarzyna Dybal Lima, Victoria Taylor and Matthew Back
### Background: Key differences between PCN species

<table>
<thead>
<tr>
<th></th>
<th>Globodera rostochiensis</th>
<th>Globodera pallida</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Decline rate</strong></td>
<td>c. 30% per annum</td>
<td>c. 20% per annum</td>
</tr>
<tr>
<td><strong>Hatching duration</strong></td>
<td>12 weeks (rapid use of lipid reserves)</td>
<td>18 weeks (responds to hatching factors produced by older plants)</td>
</tr>
<tr>
<td><strong>Temperature requirement</strong></td>
<td>Base temperature = 6°C 398 day degrees</td>
<td>Base temperature = 4°C 450 day degrees Reproductive potential may be reduced above 15°C</td>
</tr>
<tr>
<td><strong>VARIetal resistance availability</strong></td>
<td>Many options for both fresh and processing markets</td>
<td>Options available for processing potatoes. Limited resistance available for fresh potatoes</td>
</tr>
</tbody>
</table>
Background: Pathotypes

• Term used to describe virulence (measure of pathogenicity for populations of the same species)

• Pathotypes reflect the ability of specific PCN populations to multiply on potato varieties based on their resistance genes

• ‘Pathotyping’ is achieved using specific potato differentials with known resistance genes (next slide)
# Background: Pathotypes (cont)

<table>
<thead>
<tr>
<th>Species</th>
<th>G.r.</th>
<th>G.p.</th>
<th>Pa1</th>
<th>Pa2</th>
<th>Pa3</th>
<th>Pa4</th>
<th>Pa5</th>
<th>Pa6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Globodera spp. virulence groups</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Ro1</td>
<td>Ro1</td>
<td>Ro3</td>
<td>Ro3</td>
<td>Ro5</td>
<td>Pa1</td>
<td>Pa1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ro4</td>
<td>Ro2</td>
<td>Ro3</td>
<td>Ro5</td>
<td>Pa1</td>
<td>Pa1</td>
<td></td>
<td>Pa2</td>
<td>Pa3</td>
</tr>
<tr>
<td><strong>European pathotypes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ro1</td>
<td>Ro4</td>
<td>Ro2</td>
<td>Ro3</td>
<td>Ro5</td>
<td>Pa1</td>
<td>Pa1</td>
<td>Pa2</td>
<td>Pa3</td>
</tr>
<tr>
<td><strong>South American pathotypes</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>R1A</td>
<td>R1B</td>
<td>R2A</td>
<td>R3A</td>
<td></td>
<td>P1A</td>
<td>P1B</td>
<td>P2A</td>
<td>P3A</td>
</tr>
<tr>
<td><strong>Potato species and accession</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Solanum tuberosum ssp. tuberosum</td>
<td>+/-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>S. tuberosum ssp. andigena CPC 1673</td>
<td>_</td>
<td>_</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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</tr>
<tr>
<td>S. kurtzianum KTT 60.21.19</td>
<td>_</td>
<td>(+)</td>
<td>_</td>
<td>(+)</td>
<td>(+)</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>S. vernei GLKS 58.1642.4</td>
<td>_</td>
<td>+</td>
<td>_</td>
<td>_</td>
<td>+</td>
<td>+</td>
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<tr>
<td>S. vernei Vt 62.33.3</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>+</td>
<td>+</td>
<td>+</td>
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</tr>
<tr>
<td>ex. S. multidissectum hybrid P55/7</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>_</td>
<td>_</td>
<td>_/+</td>
<td>+</td>
</tr>
<tr>
<td>S.t.spp. andigena CIP 280090.10</td>
<td>+</td>
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<tr>
<td>CIP 280090.10</td>
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</tr>
<tr>
<td>S. vernei hybrid 69.1377/94</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>S. vernei hybrid 63.346/19</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>S. specazzinii: Fa = H1</td>
<td>_</td>
<td>_</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

Source: Turner and Subbotin, 2013
Survey of PCN in England and Wales - Katarzyna (Kasia) Dybal-Lima

• First survey since Minnis et al. (2002)

• Sampling stratified using AHDB potato plantings data

• Samples - 50 cores taken in a rectangular grid pattern to provide c.2 kg of soil

• Additional data (68 fields) obtained from a national annual survey conducted by APHA
PCN survey of PCN in England and Wales - Katarzyna Dybal-Lima

491 soil samples collected from England and Wales

All samples assessed for presence of PCN

All samples with PCN tested with qPCR to determine PCN species

All samples with *G. pallida* (n=249) sequenced to determine mitotype

9 samples selected to determine pathotype
Phenotyping experiment: design

12 PCN populations:
- HAU 152
- HAU 164
- HAU 165
- HAU 166
- HAU 167
- HAU 178
- HAU 298
- HAU 351
- HAU 356
- Luffness
- Pa 1 (B)
- E 2010

Survey populations

4 potato varieties:
- Desiree
- Innovator
- P55/7
- Vales Everest

Control populations

192 pots x 4
Phenotyping experiment: assessment

- Experiment running time = 10 weeks
- Soil from each pot was dried individually and cysts were extracted
- Sachets with 20 cysts used for infection were recovered and kept for further assessment
- Number of newly produced cysts were counted and recorded
Survey: main headlines

48% of England and Wales found to be infested with PCN

• 89% contained pure *G. pallida*

• 5% contained pure *G. rostochiensis*

• 6% contained a mixed population
Globodera pallida 67%

Globodera rostochiensis 8%

Mixed populations 25%

2000
Minnis et al. (2002)

Globodera rostochiensis 5%

Mixed populations 6%

Globodera pallida 89%

2016
Dybal-Lima (Unpublished)
North West (n=30)
- PCN detected
- PCN undetected

Yorkshire and the Humber (n=63)
- PCN detected
- PCN undetected

West Midlands (n=81)
- PCN detected
- PCN undetected
- mixed

East Midlands (n=86)
- PCN detected
- PCN undetected
- mixed
Wales (n= 5)
- PCN undetected
- PCN detected

South West (n=31)
- PCN undetected
- PCN detected

East of England (n=175)
- PCN undetected
- PCN detected

South East (n=17)
- PCN undetected
- PCN detected

Variants:
- mixed
- Pa
- Ro
Implications

1. Elevated prevalence of *Globodera pallida* highlights the need to use varietal resistance where it is available

2. Reduced incidence of PCN could be due to pure populations of *G. rostochiensis* being reduced by cultivation of varieties with the *H1* gene

3. Varietal resistance is a key component of PCN management – very few options are available for fresh potatoes
## How can/could characteristics of PCN be used?

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Next Step</th>
<th>Commercially Avail?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard cyst and egg counts</td>
<td>Population density</td>
<td>✓</td>
</tr>
<tr>
<td>Viability test</td>
<td>Egg viability</td>
<td>✗</td>
</tr>
<tr>
<td>qPCR</td>
<td>Species delineation</td>
<td>✓</td>
</tr>
<tr>
<td>Phenotyping with potato differentials</td>
<td>Pathotype</td>
<td>✗</td>
</tr>
<tr>
<td>Sequencing for mitotype</td>
<td>Mitotype</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Nematicide use, variety choice, rotation length etc.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>A more accurate assessment?/ Assessment of soil fumigation</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Variety choice</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Variety choice?</td>
<td>✗</td>
</tr>
<tr>
<td></td>
<td>Variety choice?</td>
<td>✗</td>
</tr>
</tbody>
</table>
The resistance status of the top ten ware potato varieties grown in Great Britain in 2016 (adapted from AHDB, 2016)

<table>
<thead>
<tr>
<th>Potato Variety</th>
<th>GB planted area (ha) - Estimated area</th>
<th>Resistance status against <em>G. pallida</em> Pa2/3,1 (rating)</th>
<th>Resistance status against <em>G. rostochiensis</em> (Ro1)(rating)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maris Piper</td>
<td>12,000</td>
<td>Susceptible (2)</td>
<td>Resistant (9)</td>
</tr>
<tr>
<td>Markies</td>
<td>5,600</td>
<td>Susceptible (2)</td>
<td>Resistant (9)</td>
</tr>
<tr>
<td>Maris Peer</td>
<td>3,700</td>
<td>Susceptible (2)</td>
<td>Susceptible (2)</td>
</tr>
<tr>
<td>Melody</td>
<td>3,500</td>
<td>Susceptible (2)</td>
<td>Resistant (9)</td>
</tr>
<tr>
<td>Lady Rossetta</td>
<td>3,300</td>
<td>Susceptible (2)</td>
<td>Resistant (9)</td>
</tr>
<tr>
<td>Estima</td>
<td>2,700</td>
<td>Susceptible (2)</td>
<td>Susceptible (2)</td>
</tr>
<tr>
<td>Pentland Dell</td>
<td>2,500</td>
<td>Susceptible (2)</td>
<td>Susceptible (2)</td>
</tr>
<tr>
<td>Taurus</td>
<td>2,400</td>
<td>Low partial resistance (3)</td>
<td>Susceptible (8)</td>
</tr>
<tr>
<td>Royal</td>
<td>2,200</td>
<td>Low partial resistance (3)</td>
<td>Susceptible (9)</td>
</tr>
<tr>
<td>Marfona</td>
<td>2,200</td>
<td>Susceptible(2)</td>
<td>Susceptible (2)</td>
</tr>
</tbody>
</table>
## Commercially available potato varieties with resistance to *G. pallida*

<table>
<thead>
<tr>
<th>Potato Variety</th>
<th>Resistance status against <em>G. pallida</em> Pa2/3,1 (rating)</th>
<th>Resistance status against <em>G. rostochiensis</em> (Ro1)(rating)</th>
<th>End market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenal</td>
<td>8-9</td>
<td>8-9</td>
<td>Fries/chips</td>
</tr>
<tr>
<td>Crisps4all</td>
<td>6</td>
<td>9</td>
<td>Crisping</td>
</tr>
<tr>
<td>Eurostar</td>
<td>8-9</td>
<td>8-9</td>
<td>Fries/chips</td>
</tr>
<tr>
<td>Harmony</td>
<td>4</td>
<td>4</td>
<td>Ware (pre-pack/bakers)</td>
</tr>
<tr>
<td>Innovator</td>
<td>8-9</td>
<td>(not resistant)</td>
<td>Fries/chips</td>
</tr>
<tr>
<td>Panther</td>
<td>8</td>
<td>3</td>
<td>Ware</td>
</tr>
<tr>
<td>Performa</td>
<td>8-9</td>
<td>4-6? (partially resistant)</td>
<td>Fries/chips</td>
</tr>
<tr>
<td>Maritiema</td>
<td>5</td>
<td>8</td>
<td>Ware/fries</td>
</tr>
<tr>
<td>Ramos</td>
<td>4</td>
<td>8</td>
<td>Fries/chips</td>
</tr>
<tr>
<td>Vales Everest</td>
<td>6</td>
<td>4</td>
<td>Processing (chips)</td>
</tr>
</tbody>
</table>
VYDATE® BACK IN ARMOURY
A RELIEF FOR GROWERS

Losing the PCN and in-furrow FLN nematicide Vydate (oxamyl) from the potato pesticide portfolio last year had a serious impact on management strategies, contracts, varietal choices and field selection, which demonstrates why it has been so critical to have it back in the armoury this year.

Norfolk-based specialist potato agronomist and consultant, Andy Alexander advises across around 3000 acres of potatoes of which about 85% receives a nematicide and at least 50% of this is Vydate.

To grow potatoes requires an investment of up to £7000/ha, but about 70% of land used to grow potatoes on is infected with PCN,” he says. “With such high initial costs one can see why having nematicides to control nematode is so critical.

‘Vydate has an advantage over other nematicides in that it is the only product on the market with an in-furrow application rate for tackling FLN which carries the spraing virus. Many growers – especially those that grow the variety Pentland Dell – definitely felt the impact of not having Vydate to hand.

Experience tells me that we need more actives not fewer,” says Mr Alexander. ‘Potatoes are a high value crop so we have to protect all the nematicides at our disposal. Without the nematicide oxamyl it would just

strates how important it is to protect all PCN products.

‘To help safeguard nematicides for the future, the potato industry has to demonstrate good stewardship which is why every nematicide user needs to

PCN cysts.

Source: Potato Review (2016)
Summary

• The amount of land infested with PCN has reduced since the last survey, but the incidence of sites infested with *G. pallida* has increased

• A greater emphasis needs to be placed on using resistant varieties where options are available

• Understanding the link between mitotypes and resistance could be important in future decision making

• Integrated pest management is still the best approach with PCN
Acknowledgements

Research conducted by **Katarzyna Lima-Dybal**

Studentship: AHDB Potatoes

**Supervisors:** Matthew Back (HAU) - Ivan Grove (HAU) - Simon Edwards (HAU) - Vivian Blok (JHI)

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**Determination of mitotype:** Sebastian Eves-van den Akker (University of Dundee)