Epidemiology, diagnostics and control of potato diseases

Alison Lees & Jennie Brierley
Predicting disease as a pro-active management tool

- Quantitative assay – which pathogen and how much?
  - Presence/absence tests useful but not necessarily related to risk
- Neutral and functional markers to characterise populations
- Sampling strategy – can we find the pathogen in the field?
- What do the results mean?
  - Inoculum thresholds for risk
  - Epidemiology of individual diseases
  - Population characteristics
  - Effect of environment on disease risk
  - Available control measures
- Disease Management
Background

• Assays for the detection/quantification/characterisation of potato pathogens are available.
• Technology is not the limiting factor.
• Translation of results into practice is critical.
• Practical applications and take-up
• Focus on
  • *Colletotrichum coccodes* (black dot)
  • *Spongospora subterranea* (powdery scab)
Laboratory comparisons – powdery scab assay

<table>
<thead>
<tr>
<th>Sample</th>
<th>CV%</th>
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<tbody>
<tr>
<td>High</td>
<td>3.5</td>
</tr>
<tr>
<td>Medium</td>
<td>9.8</td>
</tr>
<tr>
<td>Low</td>
<td>27.7</td>
</tr>
<tr>
<td>Nil</td>
<td>0.0</td>
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Sampling strategy: soil-borne pathogens

Underpins the reliability of soil testing.

- must be representative of field scale
- must be practical (sampling/processing time/cost)
- based on “old” PCN sampling strategy

- Sampling area: 4ha or less. (divide larger fields)
- Sample size: 1Kg for standard testing
- Sampling points: 100 x 10g samples (0-15 cm depth)
- Sampling pattern: W pattern.
- DNA extraction: 60g from 1kg

Epidemiology of individual diseases

Re-visiting basic questions using quantitative tools/markers

• Sources of inoculum?

• When does infection takes place?

• What factors affect the development of symptoms?

• What are the characteristics of the pathogen population?
Sources of inoculum

- Relationship between inoculum and disease
Effect of seed- and soil-borne inoculum on progeny tuber contamination by *C. coccodes*

Lees et al., 2010. *Plant Pathology* 59, 693-702
Colletotrichum coccodes - black dot soil inoculum

120 commercial fields x 3 years

Unmarketable tubers

‘Low’ 2%  ‘Medium’ 7%  ‘High’ 22%

The percentage of crops with powdery scab increased from 25% to 65% according to pre-plant levels of soil inoculum. Seed-borne inoculum was responsible for disease where no soil-borne inoculum detected.
Relationship between inoculum and disease in the field (x 3 years): powdery scab

Level of soil inoculum significantly affects powdery scab incidence and severity on progeny tubers.

Evidence towards use of diagnostic test for field selection

How does environment affect infection and disease? - targeting control timing for powdery scab

- 9 trials internationally (Scotland, Australia, Tasmania)
- One susceptible (Agria, Estima, Kennebec) and one intermediate cultivar (Desiree, Nicola, Saturna)
- No seed treatment. Irrigation applied for up to 4 weeks after tuber initiation. Herbicide, Late Blight and aphid control as per standard practice.
- Infection and disease assessments
- Environmental monitoring
Real-time PCR assessment of samples

- Assessed root and tuber samples weekly for disease and for presence of *S. subterranea* DNA using real-time PCR
- Soil inoculum level was measured
- Timing of infection and disease development are given as days after planting (DAP).
Root infection occurred earlier in Victoria = earlier emergence (warmer soil)
Root galling occurred over a three week time span at all sites (48 to 70 DAP)
Root galling was not observed until ~ 3 weeks after root infection
Determining time of tuber infection and symptom development (*S. subterranea*)

At all sites, tuber infection was observed at the first sampling time after tuber initiation.

Until 64 DAP symptom development was negligible.
Timeline – infection and symptom development across all trials (*S. subterranea*)

- Associated environmental variables known
- Can study relationship between environment and infection/disease
Interpreting results

- Epidemiological knowledge of individual diseases is critical for interpreting results and making control recommendations.

- Environmental and agronomic parameters must be factored into practical management advice.

- Successful adoption of predictive diagnostic tools to inform management decisions relies on a truly integrated approach.
Black dot- controlled environment

Lees et al. 2010. Plant Pathology
Effect of Irrigation and Azoxystrobin on black dot (Maris Piper)

England
76-132 DAP: lsd = 10.9
146-160 DAP: lsd = 14.3

Scotland
60-126 DAP: lsd = 4.9
140-154 DAP: lsd = 17.6

- Irrigation/- Azoxystrobin □
- Irrigation/+ Azoxystrobin ■
+ Irrigation/- Azoxystrobin Δ
+ Irrigation/+ Azoxystrobin ▲
Effect of cultivar on black dot

Recorded at 2 weekly intervals and at early and late harvests

- Maris Piper (4)
- Sante (5)
- Saxon (7)

Brierley et al. Plant Pathology (submitted)
Effect of harvest date (crop duration) on black dot

Maris Piper

Saxon

% Unmarketable tubers

Harvest Date

Average l.s.d. (5%)

+ irrigation/- azoxystrobin (Δ)
- irrigation/- azoxystrobin (□)
+ irrigation/+ azoxystrobin (▲)
- irrigation/+ azoxystrobin (■)

Brierley et al. Plant Pathology (submitted)
Storage

Disease accumulated after 20 weeks storage (@ 3.5°C after rapid pull-down)

Black Dot

Main Effects:

- Soil inoculum levels relate to disease risk
- Seed inoculum is relatively unimportant
- Cultivar resistance significantly reduces black dot
- Irrigation increases black dot incidence and severity
- Azoxystrobin significantly reduced disease even with later harvests (26.7% to 14.6 % unmarketable tubers of Maris Piper over all trials).
- Delayed harvest significantly increases disease particularly at high soil inoculum levels
Disease Management – bringing the information together

**Quantify inoculum** ▶️ **Select Field** ▶️ **Select Cultivar**

**Chemical Control**

**Agronomy**

**Less Disease**

**Economic & Environmental benefits**

Understanding individual and combined effects of inoculum, environment and control measures

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**Managing the risk of black dot**

<table>
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<tr>
<th>MHDI RISK</th>
<th>FACTOR</th>
<th>ACTION</th>
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</thead>
<tbody>
<tr>
<td>High</td>
<td>inoculum, environment, control measures</td>
<td>Select, manage, monitor, monitor</td>
</tr>
<tr>
<td>Medium</td>
<td>inoculum, environment, control measures</td>
<td>Manage, monitor, monitor</td>
</tr>
<tr>
<td>Low</td>
<td>inoculum, environment, control measures</td>
<td>Monitor, monitor</td>
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</table>

**Technical**

- **Check resistant varieties**
  - Although many resistant varieties are commercially available, there are many more with low inoculum levels.
  - Agribusinesses with a high level of inoculum may be more susceptible to disease.

- **Select field**
  - Perform a black dot soil test to test the level of inoculum in the field.
  - Choose fields with a low level of inoculum.

- **Avoid contaminated seed**
  - Harvest early October or in the ground according to susceptibility and maturity group.
  - Avoid planting seed from fields that have been inoculated.

- **Prevent water stress**
  - Avoid over-irrigation, especially in susceptible and long-duration crops.
  - Prevent excessive irrigation, especially in susceptible and long-duration crops.

- **Management**
  - Rapid cool down to holding temperature.
  - Reduce seed inoculum, reducing the risk of disease.

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Potential Benefits

- Knowledge of potential disease risk
- Facilitates decision making
  - Choice of field/crop/cultivar/rotations/control options
- Part of an integrated disease management programme
- Legislation for reduced pesticide use or evidence for need for application
- Research tool
Commercial soil diagnostic testing - powdery scab
SRUC 2009/10 and 2010/11

Graph showing trend towards 'low' risk samples,
suggests increased awareness of growers.

- Trend towards ‘low’ risk samples
- suggests increased awareness of growers
Barriers to uptake

- Lack of service provision
  - Research providers?
  - Commercial organisations?
  - In-house?

- Provision of testing service without advice
  - Requires advisory input

- Lack of understanding of potential benefits
  - Training

- Cost
  - Cost:benefit may not be clear
Predicta Pt (SARDI)

- Assess risk based on soil tests
- Powdery scab, root knot nematode, black dot
- Training workshop – soil sampling and interpretation
- Advisor manual
- Advice for decision making
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