Epidemiology and control of Sclerotinia

Dr John Clarkson
Warwick Crop Centre, University of Warwick
Talk Outline

• *Sclerotinia sclerotiorum* in the UK

• Approaches to control:
  • Sclerotia, apothecial production and biofumigation
  • Ascospores, infection and disease forecasting
Lifecycle of *Sclerotinia sclerotiorum*

- **Sclerotia survive in soil over winter**
- **Carpogenic germination of sclerotia near soil surface to produce apothecia**
- **Apothecia release ascospores**
- **> 400 host species including: oilseed rape, lettuce, carrot, potatoes, beans, peas, sunflower, celery…etc**
- **Further sclerotia form and released into soil**
- **Ascospores infect carrot**
Sclerotinia disease in the UK

- Caused by *Sclerotinia sclerotiorum*
  - Little *S. minor*
  - Some *S. subarctica* in Scotland

- Significant losses in all susceptible crops

- Incidence is increasing year on year

- Shortened rotations

- Problem in timing fungicides
Oilseed Rape (600,000 ha)

• Occasional outbreaks with 50-80% loss
• Average 18% of crops affected each year
• 10% incidence = loss of 0.2t / ha
Lettuce (6000 ha)

- Typical losses are 5-10% each year but can be up to 50%
Carrot (10,000 ha)
• Losses up to 50%
Wild hosts

**Cirsium** (thistle)

**Ranunculus** (buttercup)

**Urtica** (nettle)

**Chenopodium** (fat hen)
The ‘bank’ of sclerotia
Number of sclerotia produced per plant

![Graph showing the number of sclerotia produced per plant for various crops: Lettuce, Bean, Carrot, Potato, and OSR. The graph includes error bars for each category.](image)
Weight per sclerotium

![Graph showing weight of individual sclerotium (g) for different crops: Lettuce, Bean, Carrot, Potato, and OSR. The graph indicates the weight per sclerotium in grams for each crop, with error bars to show variability.]
Number of sclerotia produced per square metre

Crop density (plants m\(^{-2}\)): Lettuce = 8, Bean = 40, Carrot = 150, Potato = 3, OSR = 28
Effect of sclerotial size on germination
Approaches for Sclerotinia control

- Reduce soil inoculum (sclerotia)
  - Perlka – calcium cyanamide
  - Biocontrol – Contans
  - Biofumigation

- Kill ascospores – improve fungicide timing by forecasting

- Plant resistance
  - Tolerant varieties only?
  - Breeding efforts focussed on brassica
  - Warwick project on lettuce resistance
Biofumigation

- Biofumigants e.g. mustards
  - Growth and / or incorporation stimulates beneficial microorganisms
  - Glucosinolates converted to fungitoxic isothiocyanates (ITCs)
ITCs inhibit mycelial growth of *S. sclerotiorum*
Volatiles directly affect germination of sclerotia

![Bar chart showing mean germination of sclerotia for different treatments.](image)

- Mean germination after removal of treatment
- Mean germination after 80 days

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean germination after removal of treatment</th>
<th>Mean germination after 80 days</th>
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<tbody>
<tr>
<td>B. juncea 'Vittasso'</td>
<td></td>
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<tr>
<td>B. juncea 'Pacific Gold'</td>
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<td></td>
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<tr>
<td>S. alba 'Brisant'</td>
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<td>B. juncea 'Caliente 99'</td>
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<td>R. sativus 'Terranova'</td>
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<td></td>
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<td>E. sativa 'Nemat'</td>
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<td></td>
</tr>
<tr>
<td>B. napus 'Temple'</td>
<td></td>
<td></td>
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<tr>
<td>Untreated</td>
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</table>
Effect of biofumigants on germination of *S. sclerotiorum* sclerotia (microcosms)
S. sclerotiorum polytunnel experiment

![Graph showing number of germinated sclerotia per 150 for different treatments: B. juncea 'Pacific Gold', B. juncea 'Vittasso', B. juncea 'Caliente', and Untreated. The graph compares Experiment 1 and Experiment 2.](Image)
Forecasting Sclerotinia

- How can we assess disease risk?

1) Direct detection of airborne ascospores
   - PCR test has now been developed (Rothamsted)

2) Monitoring / predicting production of apothecia
   - model developed which predicts germination of sclerotia using weather data.

3) Predicting infection
   - Infection / disease development dependent on RH / temperature.

4) Crop growth stage models
   - Senescent material important in Sclerotinia disease development
Spore trap monitoring by PCR in oilseed rape (Rothamsted)

2015 Burkard spore trap data, Sclerotinia

Sclerotinia DNA (pg)

- Devon DNA
- Herefordshire DNA
- Yorkshire DNA
- Hertfordshire DNA
- Lincs. DNA

Warwick Crop Centre
Monitoring sclerotial germination

Sclerotinia Monitoring in Oilseed Rape
ADAS and BASF have run a service for several years, which has proved a popular management tool, to help advisors and growers, assess the disease risk and optimise treatment timing.

Track sclerotia germination
Advisors and growers are invited to log on to track sclerotia germination in their region, to assess disease risk.

But when to bury sclerotia?
Two processes control germination of sclerotia

Production of apothecia by germinating sclerotia involves two processes:

1) **Conditioning**
   - Chilling required for rapid production of apothecia (optimum <7°C)
   - Requires soil moisture ( > - 100 kPa)
   - Varying response between isolates

2) **Germination**
   - Temperature dependent (optimum 15-18°C)
   - Requires soil moisture ( > - 100 kPa)

We produced a prediction model based on soil temperature and moisture.

*Defra funded project in collaboration with Caroline Young, ADAS. Model published: Clarkson et al., Phytopathology 2007.*
Germination of sclerotia in the field driven by temperature / moisture

- **% germination**
  - winter 23/12
  - burial 1 04/3
  - burial 3 31/3
  - burial 5 28/4
  - burial 6 12/5
  - burial 7 27/5
  - burial 8 10/6

- **Temperature**
  - soil temp

- **Soil Moisture**

- **Dates**:
  - winter 23/12
  - burial 1 04/3
  - burial 3 31/3
  - burial 5 28/4
  - burial 6 12/5
  - burial 7 27/5
  - burial 8 10/6
Model Prediction and observed germination

Soil temperature
Rainfall
Predicted germination progress
Observed germination

Predicted germination 25th April
Observed germination 2nd May
Spray timing and Sclerotinia infection in lettuce

The chart shows the percentage of plants with Sclerotinia infection across different treatments and sites:

- **Untreated**
- **1 spray**
- **2 spray**
- **3 spray**
- **Model (1 spray)**

The bars are color-coded:

- **Light blue** for **Site 1**
- **Dark blue** for **Site 2**

The y-axis represents the percentage of plants with Sclerotinia, while the x-axis lists the treatment types.
Further development:

- Improve prediction of soil moisture from rainfall for the model
- Understand what happens to sclerotia buried at different depths
- Determine any effect of isolate variation
- Envisage network of weather stations combined with direct ‘depot’ observations
Predicting infection by ascospores
Predicting infection: humidity and disease development

Disease development on lettuce at 20C

- Sclerotinia infects lettuce in the absence of free water as microsites around stem base are still conducive to infection.
- BUT ambient RH modifies no. of effective microsites and rate of disease development
- Reducing RH in crop canopies will reduce the number of infections
Clipping carrot foliage

Source: Root Crop Consultancy Limited with support from BASF
Predicting infection: temperature and disease development

Disease development at 85% RH

Sklero Pro model developed for oilseed rape (Koch et al., 2007)

23 continuous hours required where
RH > 80%
Air temperature > 7°C
Combined approach to Sclerotinia prediction in oilseed rape (ADAS)

- **Inputs**
  - Crop growth stage (flowering)
  - Sklero Pro infection criteria met
  - Petal testing (by plating or PCR)
  - Presence of airborne inoculum

<table>
<thead>
<tr>
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<th>Weather based infection alert (Sklero Pro)</th>
<th>Petals testing positive</th>
<th>Spore trap positive</th>
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<tbody>
<tr>
<td>Crop not in flower</td>
<td>low</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Crop flowering</td>
<td>moderate</td>
<td>high</td>
<td>high</td>
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Population Structure and Diversity
Why study diversity and population structure?

• No previous studies in the UK or on wild hosts.

• Is diversity related to biological variation in
  • isolate aggressiveness
  • ability of sclerotia to germinate and produce apothecia

• Are certain Sclerotinia genotypes adapted to particular hosts?

• Is there genotype exchange between wild and agricultural hosts?
<table>
<thead>
<tr>
<th>Plant</th>
<th>Image</th>
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<tbody>
<tr>
<td>lettuce</td>
<td><img src="lettuce.jpg" alt="lettuce" /></td>
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<tr>
<td>oilseed rape</td>
<td><img src="oilseed-rape.jpg" alt="oilseed rape" /></td>
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<tr>
<td>buttercup</td>
<td><img src="buttercup.jpg" alt="buttercup" /></td>
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<tr>
<td>carrot</td>
<td><img src="carrot.jpg" alt="carrot" /></td>
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<tr>
<td>celery</td>
<td><img src="celery.jpg" alt="celery" /></td>
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<tr>
<td>pea</td>
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S. sclerotiorum microsatellite genotypes

- **Sclerotinia is diverse**: 386 genotypes from 687 isolates (multiple isolates just in one field)

- **Genotypes are shared between crop plants and / or wild hosts: prevalent**: 56 genotypes shared between one or more population, 29 genotypes shared between crop plants and buttercup.

- **One genotype is common and widespread**: prevalent genotype comprises 10% of isolates and is found year after year at different locations
Back to biology: pathogenicity variation for 18 *S. sclerotiorum* isolates from crop plants and buttercup
Acknowledgements

Project funding: Defra, HDC

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Norway Collaboration: Berit Nordskog and Andrea Ficke
Thank you for listening
Cavity spot on carrot

- The major disease of carrot in the UK: losses of £3-5 million per season

- Caused primarily by the oomycete *P. violae*, in the UK and to a lesser extent *P. sulcatum*

- Investigating biology of *Pythium* spp. involved, artificial inoculation techniques and further developing specific PCR test (PhD).
Fusarium on onion

• Caused by *Fusarium oxysporum* f. sp. *cepae* (FOC)

• One of the biggest problems for UK onion growers and set producers

• Infects roots and basal plate

• Fundamental research investigating genetic basis for pathogenicity and development of resistant onion lines with Hazera Seeds
Focus Group SOIL-BORNE DISEASES

Mini-paper - Biofumigation for the control of soil-borne diseases

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