Virus Yellows – an increasing threat to future sugar beet production?

Dr Mark Stevens
Head of Science
12/10/18
Virus Yellows
Classic Virus-Vector-Host Interaction

HOST

VIRUS

VECTOR
Aerial view of symptoms

- At least 3 viruses involved.
- Yield loss = up to 49%
- Worldwide distribution.
- No commercially resistant varieties.

- In 2018, 99% of UK crop protected with neonicotinoid seed treatments
- Preventing yield losses of up to £51M in high risk years.
Impact of yellowing viruses on yield

- Beet yellows virus
- Beet mild yellowing virus
- Beet chlorosis virus

**Early June infection**

<table>
<thead>
<tr>
<th>Virus</th>
<th>Yield decrease (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYV</td>
<td>50</td>
</tr>
<tr>
<td>BMYV</td>
<td>30</td>
</tr>
<tr>
<td>BChV</td>
<td>20</td>
</tr>
</tbody>
</table>

Diagram showing the impact of yellowing viruses on yield, with early June infection indicating significant decrease in yield for Beet yellows virus.

Inoculation date
(numbers above bars indicate % decrease in yield)
Modes of virus transmission by aphids

Circulative (persistent)
BMYV, BChV

Non-circulative (non-persistent)

Semi-persistent
BYV
Acquisition hours
Retention a few days
Virus Transmission

**Myzus persicae**

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Winter hosts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Weeds, Brassicas, Winter OSR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Migration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Migration of winged aphids</td>
<td></td>
<td></td>
<td></td>
<td>Migration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Summer hosts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Brassicas, sugar beet, lettuce, potatoes</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

BBRO
Prevalence of yellowing viruses across Europe

Poleroviruses

closterovirus
Virus Yellows remains a threat:

- Narrow choice of approved products for beet
- Aphid resistance (MACE, kdr, neonicotinoid)
- Lack of new/novel active ingredients
- Changing insecticide use in other arable crops
- Climate change – mild winters?
- Loss of neonicotinoid seed treatments
Options for control

Current

• Removal of sources of infection
  - Seed treatments
• Chemicals applied as:
  - Granules at drilling
  - Post-emergence sprays

Provisos:
- Conserve aphid predators
- Beware resistant aphids

Decision Support

- General farm hygiene
- Risk maps
- Risk maps + Forecast
- Forecasts + Spray Warning Scheme
Options for control

**Current**
- Removal of sources of infection
- Seed treatments
- Chemicals applied as:
  - Granules at drilling
  - Post-emergence sprays

**Provisos:**
- Conserve aphid predators
- Beware resistant aphids

**Future:**
- Resistant varieties

**Decision Support**
- General farm hygiene
- Risk maps
- Risk maps + Forecast
- Forecasts + Spray Warning Scheme
- Cost
- Risk maps
- Performance
Modelling virus yellows in sugar beet

\[ \frac{dy}{dt} = (r_pP(1 - Y) + r_sY(1 - Y))z(t)Q(x)G(x) \]
### Virus Yellows Forecast for 2017

<table>
<thead>
<tr>
<th>Factory Area</th>
<th>Option</th>
<th>Virus yellows (%) on Sowing Dates of Intended use of insecticide treated seed*</th>
<th>Mean Temperature (Jan/Feb)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>15 March</td>
<td>30 March</td>
</tr>
<tr>
<td>Bury</td>
<td>No Pest Control</td>
<td>17.7</td>
<td>23.9</td>
</tr>
<tr>
<td></td>
<td>+ Pest Control</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Cantley</td>
<td>No Pest Control</td>
<td>14.5</td>
<td>19.8</td>
</tr>
<tr>
<td></td>
<td>+ Pest Control</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Wissington</td>
<td>No Pest Control</td>
<td>17.7</td>
<td>23.9</td>
</tr>
<tr>
<td></td>
<td>+ Pest Control</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Newark</td>
<td>No Pest Control</td>
<td>19.8</td>
<td>28.3</td>
</tr>
<tr>
<td></td>
<td>+ Pest Control</td>
<td>0.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>

*source: British Sugar*
Virus Yellows forecasts

Virus yellows incidence in sugar beet in Eastern England

- Observed incidence
- Model estimates with PM
- Model estimates without PM

Crops infected (%)

Year

Monitoring
Aphid trapping
2017 aphid monitoring data

2017 Aphid Survey
Monitoring aphids and their infectivity

*M. persicae* distribution
3 May - 19 July

- Used by Industry as warning system
- Adopted in other crops
- Prevents prophylactic insecticide use.
Evaluating *Myzus persicae* distribution and subsequent Virus Yellows incidence.
Myzus persicae field samples containing MACE, kdr and super-kdr\textsubscript{ne} aphids

Year


% samples containing resistant aphids

MACE  kdr  super-kdr\textsubscript{ne} Tested from 2011 onwards
FUTURE CONTROL

Is it possible?
Virus Yellows: current options

• No foliar insecticides currently registered for *Myzus persicae* (one appl. of Teppeki in 2019 permitted)

• Resistance to pyrethroids and carbamates is a major issue (often impacting beneficial insects if applied)

• No resistant varieties currently available

• On farm crop hygiene crucial
Protecting the UK sugar beet crop

• Importance for alternative strategies:
  - New/novel insecticides
  - Resistant/tolerant varieties
  - Maximising beneficials
  - Biocontrol
Green aphid control

**Green Aphids: Grimston 3rd July 2015**

LSD = 0.67
Autumn aphicide trial: Morley 2017
Developing disease resistance strategies

• **Conventional resistance**
  - Beta germplasm evaluation and analysis

• **Alternative resistance**
  - Pathogen-derived using Arabidopsis as model system.
  - CRISPR-cas9
Inoculated breeding trial
BBRO priorities

• Accelerate virus breeding work

• Enhance pest monitoring network

• Further assess foliar treatments as seed treatments

• Evaluate plant resistance to aphids

• Field trials to study push-pull and aphid barrier strategies

• Real-time data on dedicated BBRO webpage to assist growers.
South Lincolnshire: mid-1970s
Questions?