How IPM is critical for managing pyrethroid resistance in aphids

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Barley Yellow Dwarfing Virus is spread by aphid feeding, particularly Grain, Bird Cherry Oat and Rose Grain Aphids.

Traditionally, good control was achieved with pyrethroid insecticides.

In 2011 (UK) and 2013 (Ireland) a partially resistant grain aphid clone (SA3) was detected.

To manage risk of BYDV, alternative insecticide options were used.

From 2019 onwards only 2 different ‘modes of action’ available for BYDV control.
Available ‘modes of action’ for aphid control

<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>Insecticide Class</th>
<th>IRAC Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorpyrifos</td>
<td>Organophosphate</td>
<td>1b</td>
</tr>
<tr>
<td>Cypermethrin</td>
<td>Pyrethroid</td>
<td>3a</td>
</tr>
<tr>
<td>Deltamethrin</td>
<td>Pyrethroid</td>
<td>3a</td>
</tr>
<tr>
<td>Dimethoate</td>
<td>Organophosphate</td>
<td>1b</td>
</tr>
<tr>
<td>Esfenvalerate</td>
<td>Pyrethroid</td>
<td>3a</td>
</tr>
<tr>
<td>Lambda-Cyhalothrin</td>
<td>Pyrethroid</td>
<td>3a</td>
</tr>
<tr>
<td>Pirimicarb</td>
<td>Carbamate</td>
<td>1a</td>
</tr>
<tr>
<td>Clothianidin / prothioconazole</td>
<td>Neonicitoid</td>
<td>4a</td>
</tr>
</tbody>
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<tr>
<td>Deltamethrin</td>
<td>Pyrethroid</td>
<td>3a</td>
</tr>
<tr>
<td>Esfenvalerate</td>
<td>Pyrethroid</td>
<td>3a</td>
</tr>
<tr>
<td>Lambda-Cyhalothrin</td>
<td>Pyrethroid</td>
<td>3a</td>
</tr>
<tr>
<td>Thiacloprid (Biscaya)(^1)</td>
<td>Neonicitoid</td>
<td>4a</td>
</tr>
<tr>
<td>Sulfoxaflor (Transform)(^2)</td>
<td>Sulfoximines</td>
<td>4c</td>
</tr>
<tr>
<td>Flonicamid (Teppeki)</td>
<td>Pyridine</td>
<td>29</td>
</tr>
</tbody>
</table>

1 Decision in Q4 by EU governments against renewal of license (timeline tbc)
2 Application at Flag Leaf Ligule visible (GS39)
The number of resistant clones detected in 2016 was statistically different to 2017 and 2018.
In 2017, field occurrence of grain aphid varied 15 - 27%.
Grain aphid (SA3) clone now the most common.

Walsh et al, Submitted. *Biology and Environment*
Variation in the detection of the SA3 clone in Irish tillage fields 2016-2018

Percentage of aphids resistant/susceptible

<table>
<thead>
<tr>
<th>Crop</th>
<th>WB</th>
<th>WB</th>
<th>WB</th>
<th>WB</th>
<th>WB</th>
<th>WW</th>
<th>WW</th>
<th>O</th>
<th>WW</th>
<th>SB</th>
<th>SB</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>0%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>SS</td>
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<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
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</tr>
</tbody>
</table>

Crop
Variation in sensitivity of grain aphid clones to pyrethroid

- L-cyhalothrin sensitivity variable within and between clones
- SS populations highly susceptible to pyrethroids
- SR population is variable, with some susceptible to field application rate (5g a.i./ha) but majority surviving field rate & continuing to replicate
Additional resistance mechanisms in grain aphid

Predicted mean mortality

Treatment + SE
Additional resistance mechanisms in grain aphid

Results in 5 out of 8 populations indicate that in addition to kdr, the grain aphid can also detoxify pyrethroids.

Mortality increased significantly with the addition of the synergist (PBO), which blocks enzyme-detoxification.

Treatment + SE
Why using IPM approaches for resistance management is important

- The pyrethroid resistant grain aphid clone (SA3) is widespread
- Limited number of insecticide classes available
- While its response to pyrethroids is variable
- There is evidence that SA3 possess additional resistance mechanisms

Therefore, utilising existing IPM advice, such as planting date and rotating insecticide mode of actions is important

A survey of 45 fields and 460 tested aphids over 3 three years indicates that there was a significant relationship between the presence of the resistance clone and pyrethroid application (p=0.033)
Potential implications of over reliance on a single insecticide class

(1) Potential development of homozygous resistance (Full resistance)

- SR population has the ability to form sexual forms

- However the SR clone produces female aphids at a lower rate to SS

- Similarly the SR clone produces male aphids at a lower rate to SS

While these assays were performed in the lab, they do indicate that the SA3 clone has retained sexual capacity (arrows indicate female scent organs)

Walsh et al, 2019. IJAFR
Potential implications of over reliance on a single insecticide class

(2) Development of pyrethroid tolerance in other BYDV vectors

- 2019 study compared the performance of 3 BYDV vectors to L-cyhalothrin
  - *S. avenae*, *R. padi*, *M. dirhodum*
  - Data indicated that *R. padi* clone had an LC$_{50}$ of 3.7 g a.i./ha

While lower than the LC$_{50}$ of SA3 clones, it possibly indicates an emerging issue

Conclusions

- Partially resistant grain aphids (SA3) continue to be detected in Irish fields
- Number of active ingredients available is limited
- Field survey indicates an increased likelihood of locating a resistant aphid in a field previously treated with a pyrethroid (p=0.033)
- Research indicates several new issues which may emerge in time
- As our ability to predict the occurrence of both BYDV and the SA3 clone is limited, it is important to use IPM approaches to protect the efficacy of the pyrethroid class of insecticides
- Planting early for spring cereals is the most effective IPM measure, and if needed
- Apply aphicide at the 3-4 leaf stage (only one application) and only if warranted
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