Integrating resistance elicitors into evolving crop protection programmes

Dr Neil Havis
IPM (or more accurately ICM)

- Chemical control
- Biological control
- Mechanical, physical, natural control
- Monitoring, forecasting, warning systems
- Agronomic practices such as crop rotation, resistant varieties, undersowing, intercropping, protection and enhancement of beneficials

Agronomic practices | Monitoring | Physical control | Biological control
What are elicitors derived from natural products?

- Products derived from plant or other natural material.

- Antifungal proteins have been characterised from many plant species.

- Many plant products also initiate the defence mechanism in crop plants.

*Ascophylum nodosum*
Primining for resistance
Systemic Acquired Resistance (SAR)

accumulation of:
- salicylic acid
- PR proteins e.g. PR-1

enhanced resistance to further infection
[broad spectrum]

systemic movement of signal

infection by necrotizing Pathogen, biotroph or application of elicitor
Induced Systemic Resistance (ISR)

1. Colonisation of roots by PGPR
2. Movement of systemic signal
3. Enhanced resistance to pathogen infection

Dependent on jasmonic acid/ethylene signalling
Range of ‘elicitors’ capable of inducing resistance

Agents or compounds that

• mimic action of natural elicitors e.g. Chitosan

• generate natural elicitors e.g. phosphate, phosphites

• mimic action of signals e.g. acibenzolar-s-methyl (BION/Innimisso)

• pathogens - prior infection (role for biologicals)

• mycorrhizal infection
Early work - Elicitors from fungal cell walls

<table>
<thead>
<tr>
<th>SC6</th>
<th>SC3</th>
<th>SC1</th>
<th>Control</th>
</tr>
</thead>
</table>

Elicitors from yeast

All elicit PAL activity and increase speed and size of papilla formation

From work conducted At JHI by Gary Lyon and Adrian Newton
Renewed interest - Elicitor (Bion) effect on clubroot galling

- Untreated No clubroot
- No Elicitor Foliar water spray + clubroot
- Elicitor foliar spray + clubroot
- Elicitor root drench + clubroot

No Elicitor Water root drench + clubroot
Winter barley

GS 21-25
GS 25-30
GS 31-32
GS 49-59

T0
T0
T1
T2
Spring barley

(Gs21-24) GS24-30 Gs39-49

T0 T1 T2

Growth GS21 GS30 GS31 GS39 GS59 GS71 GS87 Harvest
Yield responses to fungicides

- **T0**
  - Yield response SB: Low
  - Yield response WB: Medium

- **Stem extension**
  - Yield response SB: Medium
  - Yield response WB: High

- **Booting GS45-49**
  - Yield response SB: High
  - Yield response WB: Medium

Legend:
- **Yield response SB**
- **Yield response WB**
Using elicitors and fungicides

**Fungicide =**
GS31
prothioconazole +
cyprodinil +
picoxystrobin

GS39
prothioconazole +
chlorothalonil

**Elicitor =**
cis-jasmone +
BABA + ASM
Elicitors and fungicides – field experiments 2008

Best control achieved using elicitor + fungicide combinations

Spring barley
variety = Optic
Evaluating seed treatment options

• A range of elicitors and biologicals were compared to conventional seed treatments over 2 seasons.

• Untreated
• Raxil seed treatment
• Regalia ®
• Biological 1
• Laminarin
• Companion (Bacillus subtilis GB03)

• Winter and spring barley trials scored for disease and taken to yield
Elicitors in trial

Brown seaweed (*Laminaria* species)

Giant knotweed, (*Reynoutria sachalinensis*)
### Foliar treatments – seed treatment comparison

<table>
<thead>
<tr>
<th></th>
<th>T0 GS 24</th>
<th>T1 GS 31</th>
<th>T2 GS 53</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>Untreated</td>
<td>Untreated</td>
<td>Untreated</td>
</tr>
<tr>
<td>Untreated</td>
<td>SiltraXpro 0.5l/ha + Comet 0.5l/ha</td>
<td>Proline 0.4l/ha + Bravo 1.0l/ha</td>
<td></td>
</tr>
<tr>
<td>Regalia 2.5l/ha</td>
<td>SiltraXpro 0.25l/ha + Comet 0.25l/ha</td>
<td>Proline 0.25l/ha + Bravo 0.5l/ha</td>
<td></td>
</tr>
</tbody>
</table>
Major disease threats
Effect of seed treatments on disease control in winter barley

W Barley 2 years data

AUDPC (Disease levels)

Yield (T/ha) at 85% DM

No fung Full fung Elic+ fung No fung Full fung Elic+ fung No fung Full fung Elic+ fung No fung Full fung Elic+ fung No fung Full fung Elic+ fung No fung Full fung Elic+ fung No fung Full fung Elic+ fung

Untreated Fung seed trt Regalia Biological 1 Laminarin Companion

LSD Mild 77.9; Rhyn 36.2; Ram 2.16; Yield 0.51

No sig yield increase
Effect of seed treatments on disease control in spring barley (cv Propino)

LSD (P=0.05) 103.1; Ram 140.8; Yield 0.4

Sig yield response
Effect of seed treatments on disease control in spring barley (cv Laureate)

LSD P=0.05 Rhyncho 29.6; Ram 140.8; Yield 0.4

Sig yield response
Evaluating T0 options

- Treated (Laminarin) and untreated seed given various T0 (GS 24) spray treatments followed by conventional fungicide programme at a reduced rate
- Kayak (0.3), Amino Flo (1.0), Biological 1, Laminarin (0.75), Companion (6.0), Bion (Innimisso) (0.175), Sitko-SA (2.5), Zynergy (1.0)

- T1 (GS 30) Siltra Xpro (0.25) + Comet (0.25)
- T2 (GS 53) Proline (0.25) + Bravo (1.0)

- Winter and spring barley trials scored for disease and taken to yield
LSD(P=0.05), Mildew 18.15; Rhyncho 102.9; Yield 0.56

Sig yield response
W barley (over years)

LSD(P=0.05), Mildew 18.15; Rhyncho 102.9; Yield 0.56  Sig yield response
S barley 2019

Propino 2019 untreated seed

Disease audpc

Yield (t/ha)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Disease</th>
<th>Yield T/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>400</td>
<td>6.0</td>
</tr>
<tr>
<td>Kayak 0.3l/ha</td>
<td>350</td>
<td>5.8</td>
</tr>
<tr>
<td>Regalia 2.5l/ha</td>
<td>300</td>
<td>5.6</td>
</tr>
<tr>
<td>biological 1</td>
<td>250</td>
<td>5.4</td>
</tr>
<tr>
<td>Laminarin 0.75 l/ha</td>
<td>200</td>
<td>5.2</td>
</tr>
<tr>
<td>Companion 6l/ha</td>
<td>150</td>
<td>5.0</td>
</tr>
<tr>
<td>Innimisso 0.175g/litre</td>
<td>100</td>
<td>4.8</td>
</tr>
<tr>
<td>Sitko-SA 2.5 l/ha</td>
<td>50</td>
<td>6.2</td>
</tr>
<tr>
<td>Chitosan 1.67 g/ha</td>
<td>0</td>
<td>6.0</td>
</tr>
</tbody>
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LSD (P=0.05) Rhyncho 137.9; Mildew 95.9; Yield 1.24

No sig yield response
S barley 2019

Propino 2019 Laminarin treated seed

Disease audpc

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LSD (P=0.05) Rhyncho 137.9; Mildew 95.9; Yield 1.24

No sig yield response
S barley 2019

Laureate 2019 - untreated seed

LSD (P=0.05) Rhyncho 137.9; Mildew 95.9; Yield 1.24

No sig yield repsonse
S barley 2019

Laureate 2019 Laminarin treated seed

LSD (P=0.05) Rhyncho 137.9; Mildew 95.9; Yield 1.24

No sig yield response
Evaluating T0 options (2020 onwards)

- Treated (Laminarin) and untreated seed given various T0 (GS 24) spray treatments followed by conventional fungicide programme at a reduced rate
- Kayak (0.3), Amino Flo (1.0) or Phyter (2.0), Biological 1, Laminarin (0.75), Companion (6.0), Bion (Innimisso) (0.175), Sitko-SA (2.5), Zynergy (1.0)

- T1 (GS 30) Siltra Xpro (0.25) + Comet (0.25)
- T2 (GS 45) Revystar (0.35) + Folpet (0.5)

- Winter and spring barley trials scored for disease and taken to yield
LSD (P=0.05) Mild 22.48: Rhyncho 27.99; Yield 0.592

No sig yield response
LSD (P=0.05) Mild 22.48: Rhyncho 27.99; Yield 0.592
Sig yield response
S barley 2021

LSD P=0.05 Rhyn 22.0; Mild 30.69; N Blotch 109.26; Yield 0.296
S barley 2021

S Barley (Propino-Laminarin) 2021

Disease aurpc

Yield (t/ha)

LSD P=0.05 Rhyn 22.0; Mild 30.69; N Blotch 109.26; Yield 0.296

Sig yield response
S barley 2021

S Barley (Laureate Unt)

Disease audpc

Yield (t/ha)

- Untreated
- Kayak 0.3l/ha
- Phyer 2.0l/ha
- biological 1
- Laminarin (0.75 l/ha)
- Companion (6l/ha)
- Innimoso (0.175g/litre)
- Sitko-SA 2.5 l/ha
- Chitosan 1.67 g/ha

LSD (P=0.05) Rhyncho 22.0; Ram 17.25; Yield 0.296

Sig yield response for 2 treatments
S barley 2021

LSD (P=0.05) Rhyncho 22.0; Ram 17.25; Yield 0.296

No sig yield response
Spring barley IPM trial cv Laureate

Yield benefit full programme = 0.9 t/ha = £153 feed or £181 malt
(AHDB SACC Harvest 2018 – ex farm)

Yield t/ha

Rhyncho audpc

Untreated  Full fung  Elictor+red fung  Untreated  Full fung  Elictor+red fung  Untreated  Full fung  Elictor+red fung  Untreated  Full fung  Elictor+red fung

Rhyncho  yield

£51  £39
Full  Lam +Red rate

£39 Lam +Red rate

£51 Full
Conclusions

• The integration of elicitors into programmes for cereal crops will require careful management

• Control will be more variable than that achieved by conventional programmes

• Seasonal disease pressure needs to be factored in to programmes

• The effects of crop stress may affect elicitor performance

• The influence of variety needs to be tested more extensively
Future prospects

• Conventional chemistry options reducing

• Increasing interest in eliciting the defence response in crops

• More products in testing

• Where is the line drawn between elicitors and biostimulants?

• New pipelines for registration?
• This work is funded by the Scottish Government RESAS (Work package 2.1), AHDB and commercial sponsors
Thank you for your attention