Development of IPM systems at The James Hutton Institute: Soft fruit, cereals, potato, vegetables

Nick Birch + JHI IPM team (c. 50 contributors)

Agroecology Group, Ecological Sciences

James Hutton Institute, Scotland (Dundee)

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The James Hutton Institute

• Based in Dundee and Aberdeen, 3 experimental farms

• Globally-recognised multidisciplinary research

• Soil, plant, animal scientists, ecologists, geographers, socio- economists, agronomists, chemists, bioinformaticians and IT specialists

• (~550 staff and 120 PhD students)

• Meet the needs of government policy advisers, agricultural industries, water industry and statutory environmental protection agencies

• Long history of crop research and plant breeding (1930/50...2017)

- Pesticide applications (all) increasing
- Yield level
- Yield per unit pesticide decreasing
- No reduction in weed seed population 2000-2015
- Weed shift towards grasses
- ‘System malfunction’

Original pesticide data from SASA reports –
PAI (pesticide area index) = area treated with all formulations / area sown with crop
Squire et al. JHI (in press)
IPM is central to sustainable farming and pesticide reductions (EU)

UK Voluntary Initiative (2001) based mainly on:
Pesticide Risk Management
- Improved pesticide application
- Cultivation practice (rotations)
- Monitoring
- Pesticide Resistance Management,

National Action Plans (IPM) compared: 
From Jan 2014

www.endure-network.eu/about_ipm/national_policy_documents

IPPM (+ Pollinators)
The new focus in EU
Integrated Farm Management (LEAF) includes IPM: On-farm application of research.

38 Demonstration Farms and 8 Innovation Centres
8 Key Principles of IPM:
‘EU Pesticide Reduction Package’
(‘pest’ = generic EU usage)

• P1 = Prevention and Suppression
• P2 = Monitoring
• P3 = Decision making
• P4 = Non-chemical methods preferred over chemical methods
• P5 = Pesticide selection (NTOs, environment, health)
• P6 = Reduced pesticide use
• P7 = Anti-resistance strategies (chemicals and R genes)
• P8 = Evaluation of success and improvements
IPM@Hutton website

Pest and disease resistance

Biocontrol

Rotations and crop diversity

Weed management

Alternative crop protectants and biopesticides

Biodiversity

Pest and pathogen populations and epidemiology

Landscape management and ecological engineering

Pollinators
Choosing IPM tools for the toolbox:

Flexible crop and region specific options

Some spanners in works
IPM Hutton: IPM toolboxes /crop

RESAS Strategic Research Programme 2016-2021

- Prevent pest outbreaks
  - Pest and disease resistance
- Non-chemical methods
  - Reduced pesticide use
  - Alternative crop protectants and biopesticides
- Rotations and crop diversity
- Biodiversity
- Weed management
- Monitoring and decision-making
  - Pest epidemiology
- Landscape management and ecological engineering
- Pollinators

Evaluate promising tool combinations
Raspberry and IPM research @ JHI

- Raspberry production has increased dramatically in the UK (2001-3 to 2011-13; FAOSTAT):
  - Land area harvested has increased by 20%
  - Fruit yield has increased by 55%

- Yield losses from pathogens and pests
  - Can lead to large plantation areas lost
  - Reduce dependence on chemical crop protection by adopting IPM

- Impacts of changing climate / stress and practices on crop protection

What solutions are available for Integrated Management of pests and diseases in raspberry?
Research provides IPM solutions

• **Aphid resistant raspberries** bred at JHI for 50 years.

• Plant breeding = main crop protection strategy for >40 years (Scottish soft fruit).

• **BUT**….single IPM tools (e.g. R varieties) fail over time, due to co-evolution (selection pressure for virulent pest biotypes).

• **Tipping point:** Pests break existing R genes faster than plant breeders introduce new R genes (**10 years**).
• **Toolbox contains several complementary technologies.**
• **Crop- and region- specific.**
• **Dynamic and responsive to changing pest pressures.**
• **Target key primary pests first.**
• **Based on 8 Principles of IPM:**
  - R varieties form foundation to build the IPM system (P1+7).
  - Avoid soil root rot: Raised pots/coir (P1).
  - Pest monitoring + thresholds (P2+3).
  - Biocontrol of key pests (P4).
  - Biopesticides replace broadest spectrum conventional pesticides (P5+7).
  - Enhanced pollination and biocontrol with added floral resources (P4+6).
  - Adaptive; to suppress new pest species/populations (eg potato aphid, R-breaking biotypes of LRA, SWD; P8).
Raspberry genetics: Breeding for root rot and aphid resistance

- Markers for pest + disease resistance identified by QTL Mapping
  Markers validated in germplasm and deployed in crosses

Root rot: Resistant v Susceptible

Breeding for aphid resistance

Selections with marker

Selections without marker
IPM toolbox with multiple tools:

Adding biopesticides and biocontrol to aphid R cvs

- How to make genetic resistance more durable in the system?
- Add biopesticides with biocontrol (parasitoid wasp release),
- Used in combination are as effective as current insecticide.

New biopesticides suppress aphids. Hortlink SCEPTRE, glasshouse trials

Parasitoids released weekly can achieve 40% (F) - 90% (GH) control of raspberry aphids (with Koppert Ltd and Viridaxis Ltd)
Biocontrol of aphids on *Rubus*

- Four year study of biocontrol options for large raspberry aphid *A. idaei* and potato aphid *M. euphorbiae*
- Optimal combinations of biopesticides and parasitoids identified
- IPM trials in polytunnels using ‘Glen Ample’ confirmed 50+% decrease in aphid numbers in most biocontrol treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Spray timing (week)</th>
<th>% reduction of:</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Potato aphid (wk 2)</td>
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<tr>
<td></td>
<td></td>
<td>Adults</td>
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<tr>
<td></td>
<td></td>
<td>Large raspberry aphid (wk 6)</td>
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<tr>
<td></td>
<td></td>
<td>Adults</td>
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<tr>
<td>1. Water control</td>
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<tr>
<td>2. Calypso (C)</td>
<td>✓ ✓ - ✓</td>
<td>50</td>
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<tr>
<td>3. RAS-59 (C)</td>
<td>✓ - ✓</td>
<td>32</td>
</tr>
<tr>
<td>4. RAS-50 (C)</td>
<td>✓ ✓ -</td>
<td>63</td>
</tr>
<tr>
<td>5. RAS-62 (B)</td>
<td>✓ ✓ ✓ ✓</td>
<td>46</td>
</tr>
<tr>
<td>6. RAS-130 (B)</td>
<td>✓ - ✓</td>
<td>39</td>
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</tbody>
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AHDB project SCEPTRE: Nick Birch
Raspberry plant health: Diagnostics

- Biological and molecular diagnostics to test nuclear stock plants every year (c. 30 viruses and 2 oomycetes).
- Sole UK provider of pathogen-free plants for entry in the UK Plant Health Certification Scheme
- Scottish, UK and EPPO guidelines
- Provide fruit producers and propagators; known health standard and purity
- Prevents spread of pests and diseases
Rubus phenotyping: accelerating translation of traits into new varieties

- Rapid screening of 100s of plants for spectral signatures of desirable traits and plant responses to stress
- True colour image generated from VNIR camera
- NDVI map generated from VNIR camera

Innovate UK Imaging project: Williams & Prashar, JHI
IPM Hutton: Potato

- Pest and disease resistance
- Biocontrol
- Rotations and crop diversity
- Weed management
- Alternative crop protectants and biopesticides
- Biodiversity
- Pest and pathogen populations and epidemiology
- Landscape management and ecological engineering
- Pollinators
Changes in *Myzus persicae* populations attacking potato (IRM)

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Evaluating potato disease risk using real-time PCR

Identifying pest and pathogen levels before planting can help growers make decisions on site selection, varieties and chemical control treatments in particular fields.
IPM Hutton: Cereals

- Pest and disease resistance
- Biocontrol
- Rotations and crop diversity

- Weed management
- Alternative crop protectants and biopesticides
- Biodiversity

- Pest and pathogen populations and epidemiology
- Landscape management and ecological engineering
- Pollinators
Mixtures: Disease reduction, yield increase and stability

- Less lodging in mixtures – structural support
- Convergence of heading dates, maturity and height
IPM Hutton: Vegetable IPM

- Pest and disease resistance
- Biocontrol
- Rotations and crop diversity

- Weed management
- Alternative crop protectants and biopesticides
- Biodiversity

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- Landscape management and ecological engineering
- Pollinators
IPM for vegetables (brassicas + onion)
AHDB-funded project FV 417

Aim to assess commercially available elicitors on diseases of Brassica and Allium crops

Disease systems:
Cabbage (Tundra) and Xanthomonas
Red onion (Red baron) and Burkholderia

Successful treatments:
ProAct® (Harpin) on cabbage & onion
Bion® on onion

Observed Responses to Harpins - Summary

- Improved Plant Growth and Crop Yield
- Enhanced Disease and Nematode Resistance
- Improved Post-harvest Quality
- Plant Reactions

Application

Signal Amplification
- Systemic acquired resistance pathway activation
- Jasmonic acid/ethylene pathway activation
- Increased photosynthesis and nutrient uptake
IPM Hutton: Area wide IPM

- Pest and disease resistance
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- Pollinators
Precision agriculture and Geographic information systems (GIS)

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Land use and cropping patterns

Habitats
- Intensity
- Complexity
- Fragmentation
- Beneficial habitats

Crop
- Crop type
- Pesticide
- Resistance

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The Centre for Sustainable Cropping

A whole-systems approach for optimising crop production and environmental health for long term food security.
Pollinator decline:
Multiple stressors/ key eco-services

Spread biocontrol agents
Coordinated, interdisciplinary research - strategic to applied research

Already shown IPM can reduce pesticides by >30% in soft fruit
Acknowledgements

Many other commercial and funders