Chemical ecology research and Integrated Pest Management (IPM):

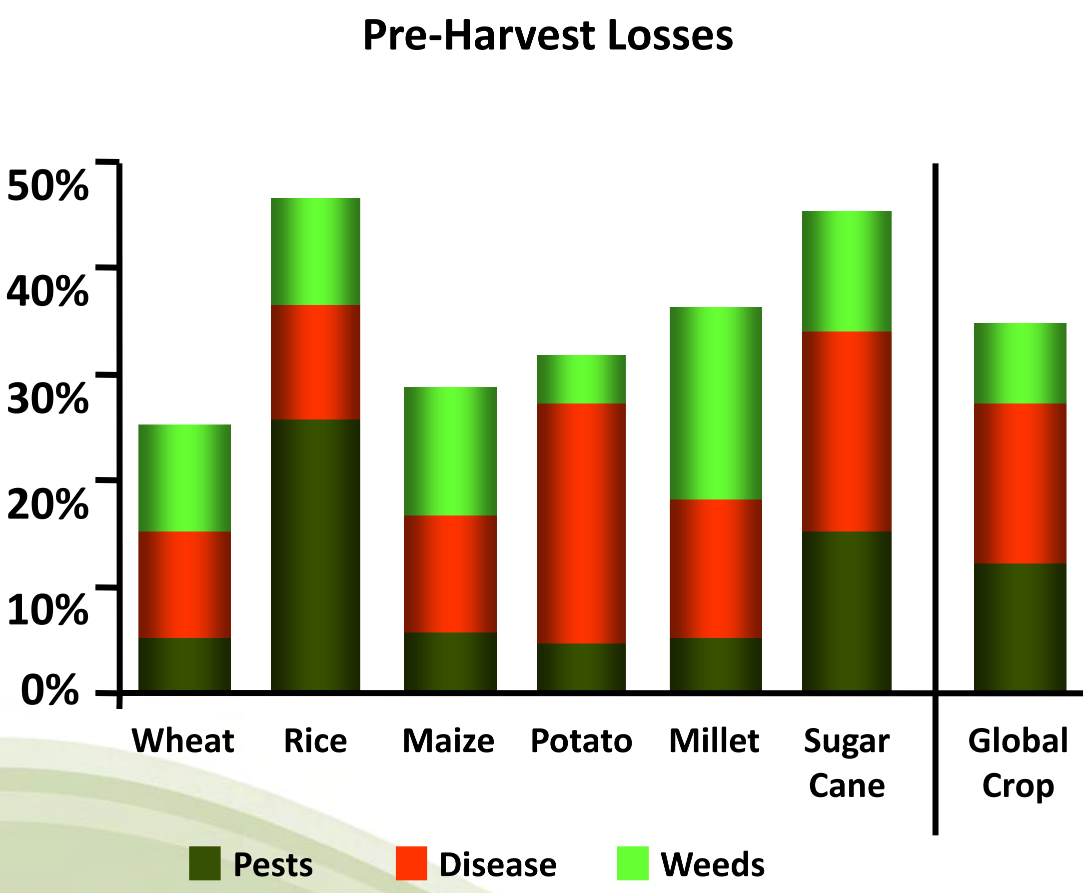
From basic to applied research with useful outcomes.

The James Hutton Institute

Nick Birch

Environment Plant Interactions
SCRI, Dundee, U.K.

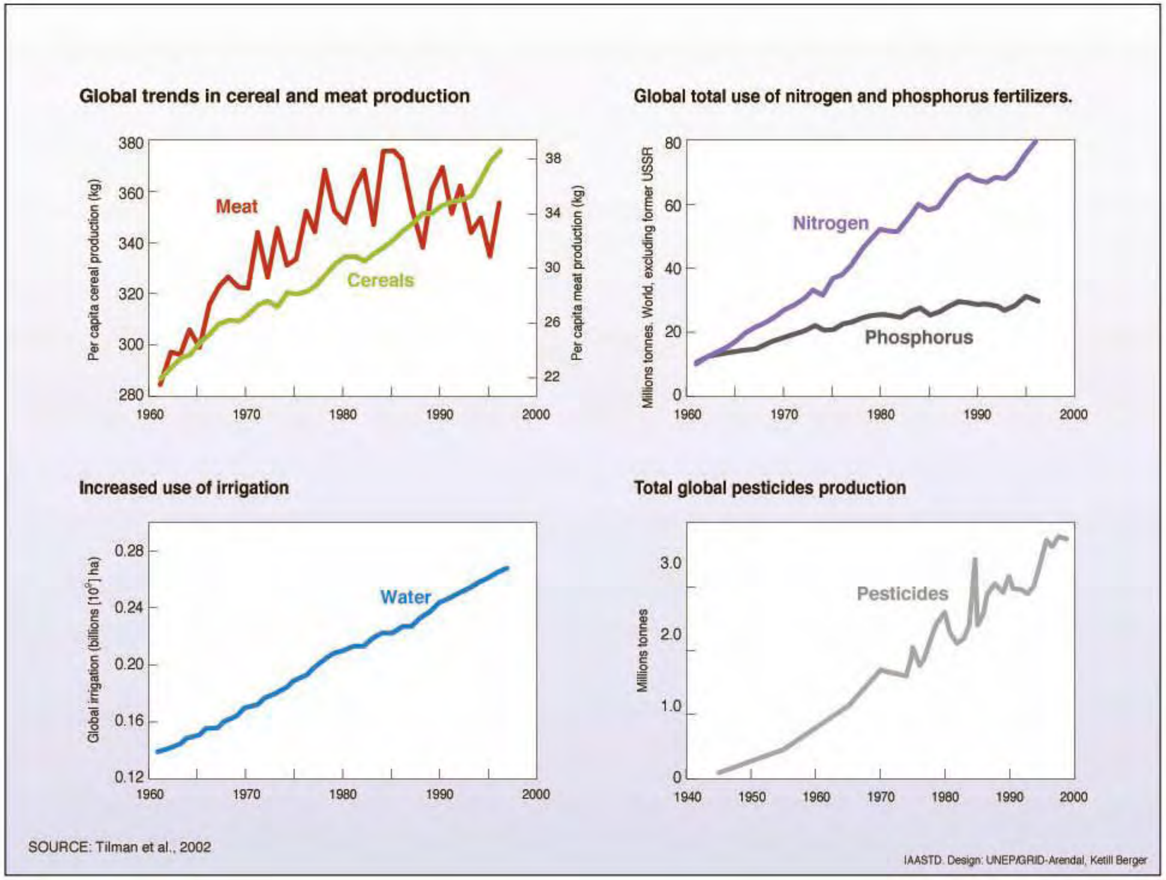
Pest Impacts: Crops that never reach the table



Food Security Issues

- **Increasing human population: 9 billion+ by 2050.** Already > 1 billion hungry or malnourished. = **80 million extra mouths/year.**
- **Increasing water and land scarcity: Per capita cropland decreasing.**
- **Agricultural productivity: Rate of yield increase slowing (except China).**
- **Adverse impacts of climate change: More abiotic and biotic stressors. Less predictable pest outbreaks. New pests. longer seasons.**
- **Fewer pesticides: 91/414 + new EU Directives (IPM).**
- **Resource consumption increasing: Food (meat), fuel, consumer demands. Food supply is decreasing in many poor areas.**
- **Food prices 37% higher than a year ago (UN Food Price Index).**
- **Biofuels demand growing: Replace depleting fossil fuels, but competes with food crops for resources .**

Rapidly increasing inputs: Pesticides



Pesticide over-reliance?

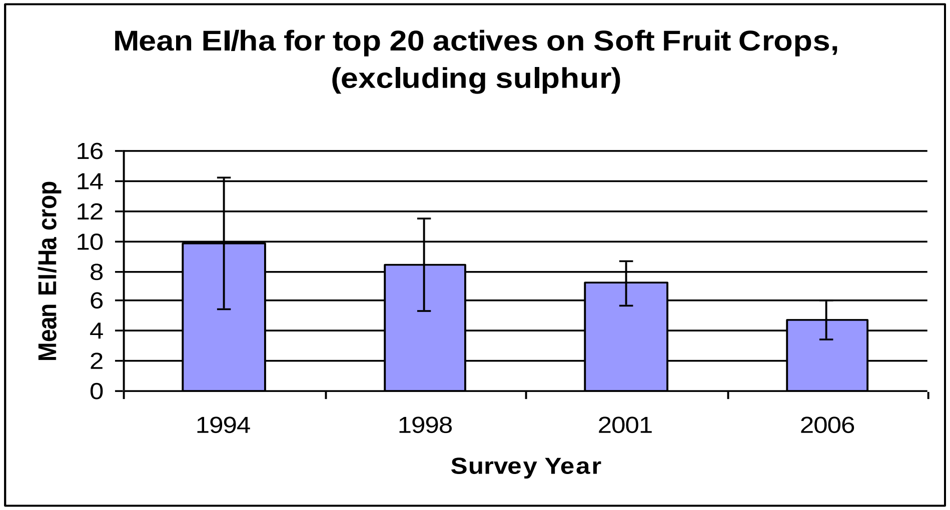
- **$9.1 billion** / year spent globally on insecticides
- **$32.6 billion on all pesticides**: herbicides (45%), insecticides(28%), fungicides (22%), others (5%)
- Despite these inputs, **insects destroy 30-40% of crops** before food reaches humans or our livestock (pre-harvest + post-harvest)
- Each year insects eat crops which would feed **1 billion people**
- Insects also important **vector diseases** of plants and animals
- **> 600 insect pest spp are now resistant to current insecticides**

(e.g. aphids in UK –**multiple insecticide resistance**) _and_ to some **pest-resistant crops** (**virulent biotypes overcome R genes in raspberry**)

→ WE NEED NEW, MORE SUSTAINABLE CROP PROTECTION SOLUTIONS.

Rapidly changing pesticide landscape in EU:
Case study: Environmental Impact Analysis

EI pesticide = (EI farm worker + EI consumer + EI environment) / 3



→ Decreasing environmental impact of SF pesticides, *apart from sulphur*.

Collaborators: SASA

IPM Principles (general)

IPM is the coordinated use of complimentary tactics to simultaneously suppress multiple pests, weeds and diseases below economic thresholds.

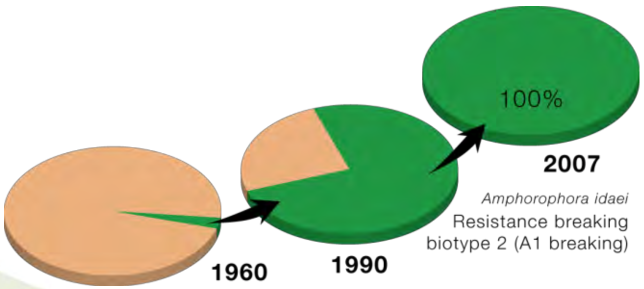
- **Multiple tactics: chemical, biological, bio-technological**
- **Systems approach: insects, pathogens, weeds, crops, vertebrates**
- **Eco-services are vital: biocontrol, pollination, soil heath**



IPM approach: The principles

- The principles: An integrated approach (‘IPM toolbox’) that is based on understanding the functioning of the whole agro-ecosystem.
- SHIFT FROM SINGLE SOLUTIONS TO SYNERGISTIC IPM COMPONENTS
- It combines complementary ‘IPM tools’ to suppress pests, weeds and diseases below economic thresholds, integrating biological and chemical control strategies.
- The use of multiple IPM tools reduces evolutionary selection pressure (crop protection failures) on the individual IPM tools
- E.g. R gene breakdown (raspberry) as an example of why and how IPM is key to *‘sustainable intensification’*.

Birch et al., 2007



R genes on their own select for virulent pest biotypes:
Now at ‘tipping point’ in co-evolutionary arms race

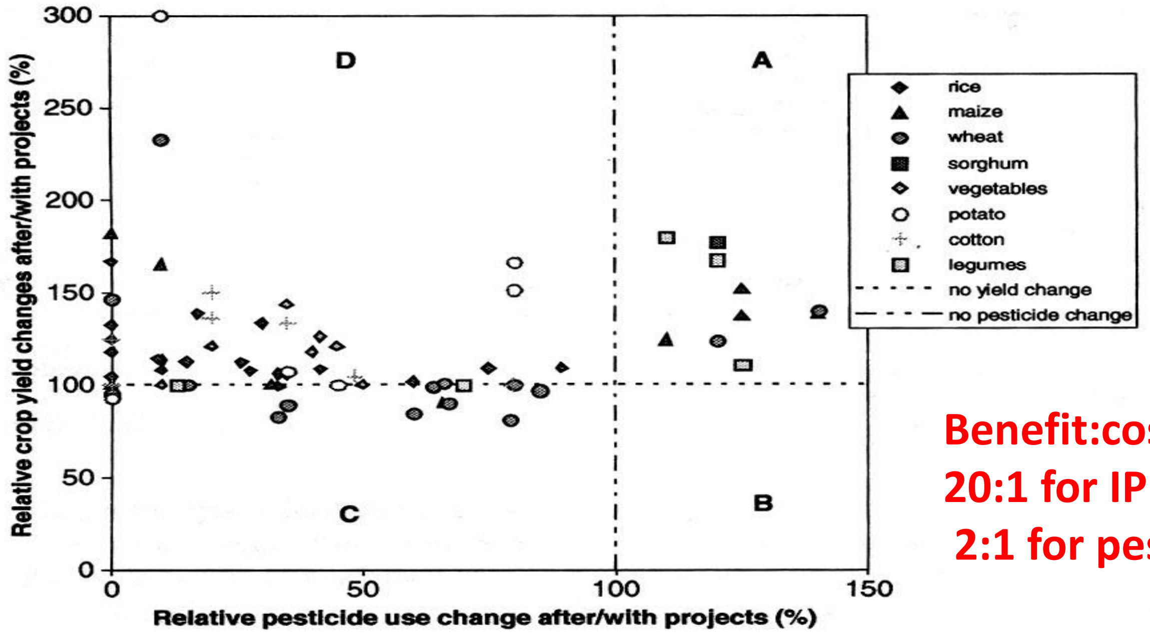
IPM tools: Pros and Cons

The James Hutton Institute

Technology	Example –ve impacts	Example + ve impacts
Synthetic pesticides (soft/non-persistent/targeted/precsion use)*	Non target impacts, resistance, 2ndary pests, food residues 1:200,000 success	Fast and effective, narrow-broad spectrum
Biopesticides + plant bio-actives *	Non target impacts Some are slow acting	Repellents/deterrents prevent pest feeding.
Pheromones + host volatiles *	Blend and release rates need to be precise	Species-specific monitoring and control
Biocontrol agents *	Too late/slow, unless managed well.	Complements R cvs, if developed in parallel. Need supporting habitats. 1:10 success
Resistant cvs (conventional + GM) *	Virulent pest biotypes selected. Long term strategy (10 + yrs)	Can complement biocontrol, reduce pesticide use, if developed in parallel
'Ecological engineering' of fields/landscapes* Adapted from RS 'Reaping The Benefits' Report 2009	Loss of productive land. Spatio-temporal complexity, scaling effects, regional differences.	Can complement R cvs biocontrol + pollination. Floral resources reduce 'boom and bust' for Nes.

Impacts of IPM on yield and pesticide use:

62 projects in 26 countries



Benefit:cost
20:1 for IPM
2:1 for pesticides

Figure 1 *Association between pesticide use and crop yields (data from 81 studies of crops, 62 projects, 26 countries)*[33]

without yield penalties. In principle, there are four possible trajectories of impact if IPM is introduced:

i. both pesticide use and yields increase (A);
ii. pesticide use increases but yields decline (B);
iii. both pesticide use and yields fall (C);
iv. pesticide use declines, but yields increase (D).

JHI's IPM research

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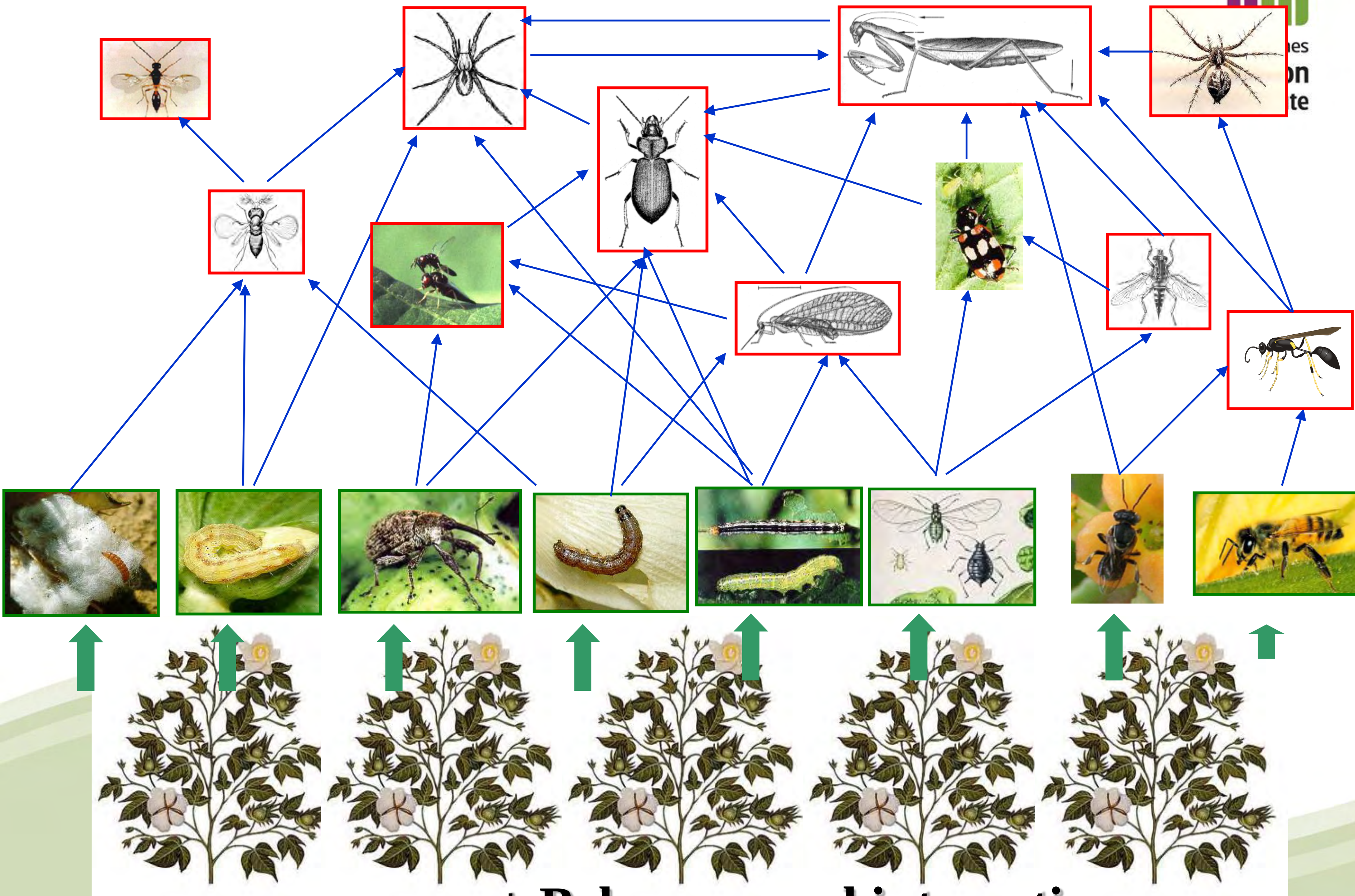
What about climate change?

- Will climate change increase the challenges for food production in the U.K. under the EU’s reducing pesticide policies?
- How can we predict effects for soft fruit?

Food webs and functions –trophic interactions:



+ Below ground interactions

Rubus food web studies:
Major cv and climatic effects on aphid pests and NEs

2007 +-2008 DATA:
EXTRACTED

Tunnel (~ +3C)	**Ample S**	**Rosa R**
Orb spiders (NE)	**1.7Y**	**5X**
Hoverfly larvae (NE)	**6Y**	**2X**
Aphis idaei (pest)	0	**2X**
Amphorophora idaei (pest)	**2.2Y**	0
Macrosiphum euphorbiae (pest)	**25Y**	**2**

Field (ambient)	**Ample S**	**Rosa R**
Orb spiders	Y	X
Hoverfly larvae	Y	X
Aphis idaei	0	X
Amphorophora idaei	Y	0
Macrosiphum euphorbiae	Y	0

S = A_1 gene; now overcome by *Amph. idaei*   R = A_{10}, still effective v *Amph. Ideai in Scotland but not England (time bomb for breeders).*

G x E interactions complex but vital for IPM!

Biocontrol enhancement: ‘Ecological engineering’

The James Hutton Institute

Buckwheat attracts and retains hoverflies

Inundative release of 6 parasitoid spp

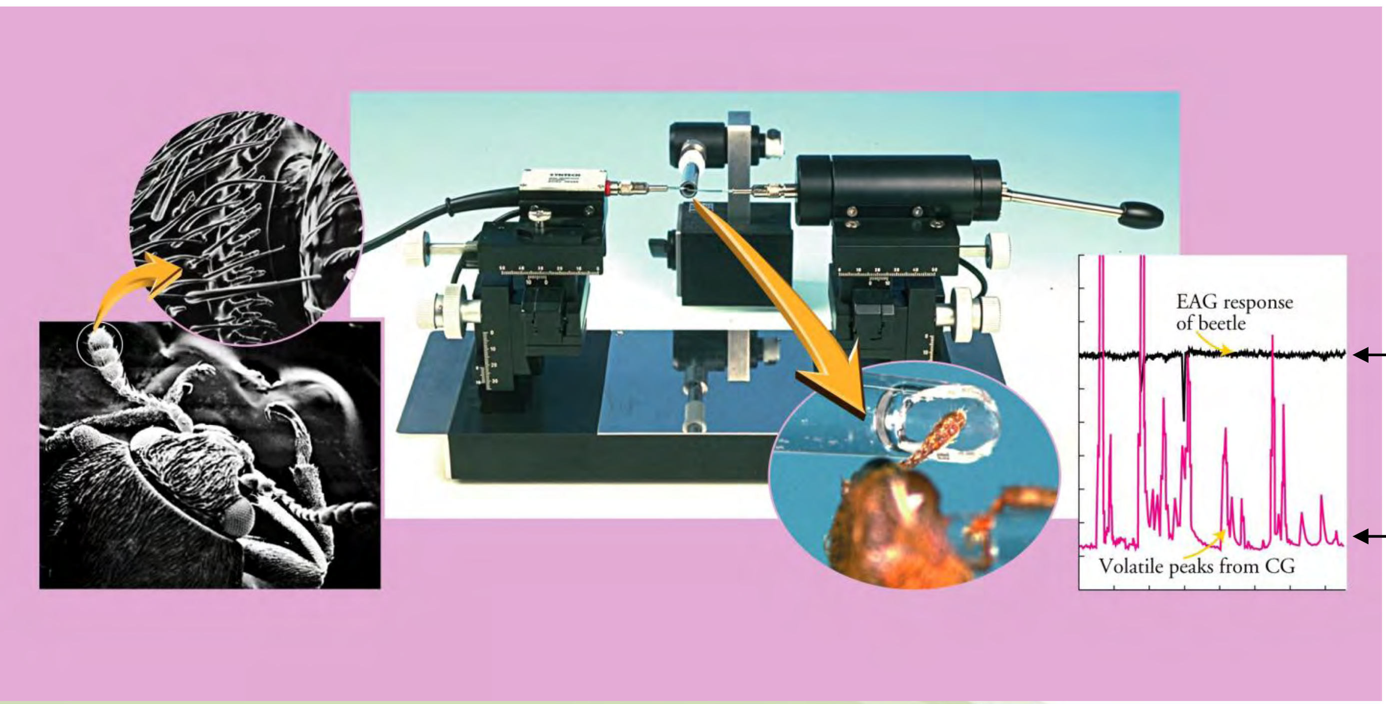
5% → 80% parasitism

With Koppert Ltd and BioProtection Centre + Lincoln University, N.Z.

Semiochemicals:

Host flower volatiles as IPM tools

- **Electrophysiology (EAG)** - identify key volatiles by responses of beetle antenna to each GC-MS peak
- **2 main flower attractant volatiles selected for commercial development**



Raspberry Hotlink Project: A UK IPDM strategy tested at farm scale

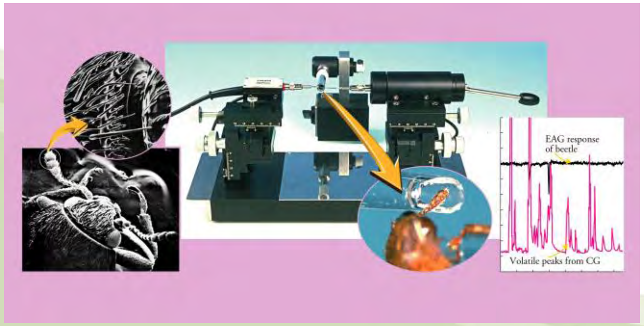
The James Hutton Institute

Semiochemicals: GC-EAG identified key host plant attractants (bio-mimicry)

1. **Raspberry beetle trap + lure design** with optimised spatial deployment.
- End user delivery involving commercial partners, growers, supermarkets.
- On-farm trials: UK, Norway, Switzerland, France, USA over 5 years.

2. **Cane midge sex pheromone + cane wound volatile attractants** for cane midge males + females
- Monitoring system for targeting insecticides v multiple generations.

Biopesticides + biocontrol agents aphid pests



Fresh Produce Journal Sept 2008

Pesticide-free – the new organics?

The list of pesticides available to conventional growers has been getting shorter every year. New proposals for EU regulations were being reviewed as FPJ went to press and, in response to the possible outcome, growing methods less reliant on pesticides are being increasingly explored. Damaris Freeman looks into pesticide-free and residue-free production

Pesticide-free and residue-free production are farming methods that aim to give growers an alternative to conventional farming. These systems offer a move away from pesticides and appeal to a consumer base that is becoming more aware of health and environmental issues. Both researchers and growers are looking to see how plants fare against pests and diseases without the pesticides they have relied on for their entire careers. It could be the first step into a brave new world, but growers first need to know if crop yield and quality can be sustained without the use of pesticides.

Andreas Moll, who heads up South Africa-based grower Bio-Select, came into the industry when he started to grow what he calls residue-free blueberries and blackberries. It took five seasons for the firm to develop its production methods. Moll is passionate about reducing pesticide use, and he is keen to stress the difference between pesticide-free and residue-free production and organic methods. "With organic farming, you are still allowed to use organic-registered chemicals," he explains. "If a grower uses organic-registered chemicals, residues can still be picked up with spectrometry.

"Organic fertiliser on the market is also sold and marketed in terms of nitrogen, phosphate and potassium. This is the basis of chemical farming and the number-one reason for our deteriorating soil life and plants with zero disease resistance."

He claims there are significant environmental advantages to using fewer or even no pesticides. "It is sustainable in terms of soil health and input costs," he says. "With residue-free production, the input cost is under the control of the grower and not the chemical company."

Dr Nick Birch, a senior entomologist at the Scottish Crop Research Institute (SCRI) in Dundee, has 25 years' experience in raspberry crop production and protection. He says that he is struggling to keep up with new interest in pesticide-free methods, largely due to increasing consumer demand and recently proposed changes to EU legislation.

The institute works on ways to help growers find ecologically based alternatives for the use of pesticides, "especially those on the EU hit list", says Birch. "Growers are just beginning to realise that the pesticides they have relied on for 10 or 20 years are going to be taken away," he explains.

However, the timing of the EU proposals may prove problematic. "It can take at least 10 years to develop techniques for pest- and disease-resistant plant varieties and EU restrictions on pesticides are coming in ▶

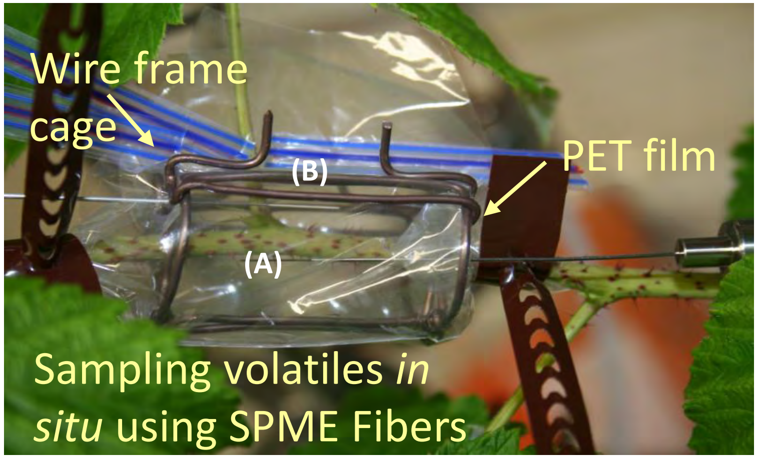
5 SEPTEMBER 2008 FPJ 17

Collaborators: EMR, NRI, ADAS, Agrisense, Agroscope (CH), Ctifl (Fr), M+S, Waitrose, Co-op, LEAF, Growers consortia

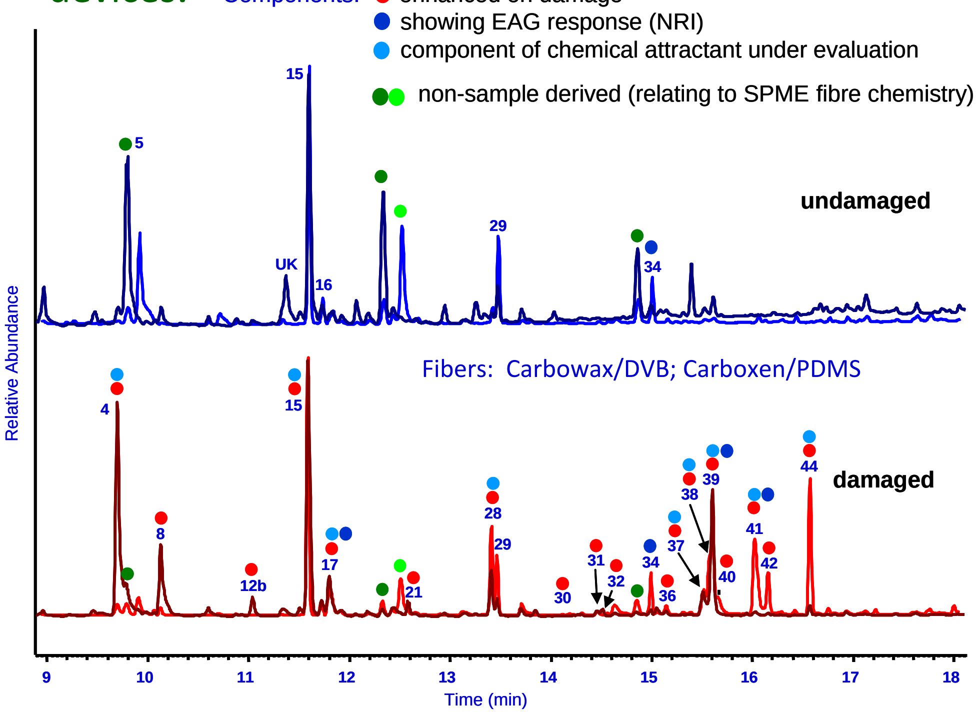
Metabolite profiling of raspberry stem wound volatiles using SPME-GC-MS: IPM for high quality raspberry production

Nick Birch, Tom shepherd, JHI;
David Hall, NRI, Jerry Cross, EMR

Red raspberry, *Rubus idaeus* L.– Cane midge, *Resseliella theobaldi*



- Canes split naturally - females attracted by volatiles from splits and lay eggs. Feeding larvae cause damage and disease.
- For IPM we need to identify attractants to lure females to monitoring or mass trapping devices.



4: *cis*-3-hexen-1-ol
5: camphene
8: 2-heptanol;
12b: unknown terpene
15: *cis*-3-hexen-1-ol acetate
16: 6-methyl-5-hepten-2-one
17: 6-methyl-5-hepten-2-ol
21: 5-ethyl-2(5H)-furanone or 5-methyl-4-hexen-3-one
28: linalool
29: *n*-nonanal
30: citronellal
31: *trans*-pinocarveol or *trans*-verbenol;
32: unknown
34: *n*-decanal
36: methylsalicylate
37: myrtenol
38: β-citronellol
39: myrtenal
40: nerol
41: geraniol
42: neral
44: geranial

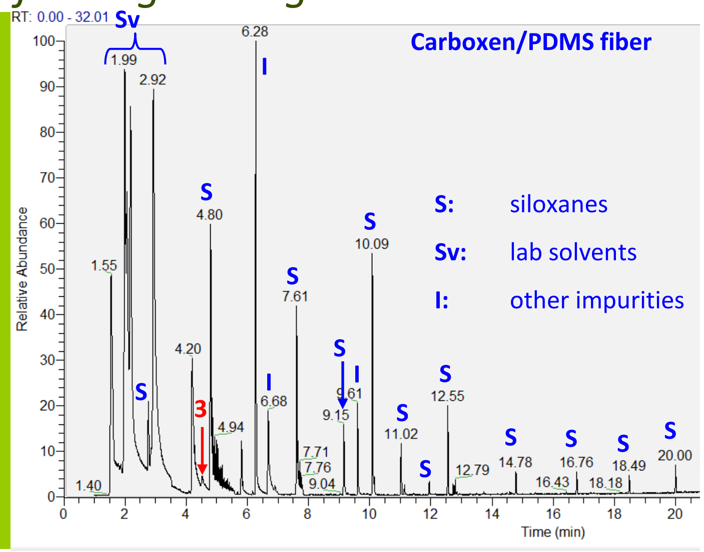
Methods paper in preparation.

Field testing of chemical lures and trapping devices.

Hall, D., Shepherd, T., Fountain, M., Vetek, G., Birch, A.N.E., Jorna, C.S., Farman, D. & Cross, J. 2011. Investigation of attraction of raspberry cane midge, *Resseliella theobaldii*, to volatiles from wounded raspberry primocanes. In: Cross, J. & Linder, C. (ed.) *Integrated Plant Protection in Fruit Crops, IOBC/wprs Bulletin* **70**, 1-9.

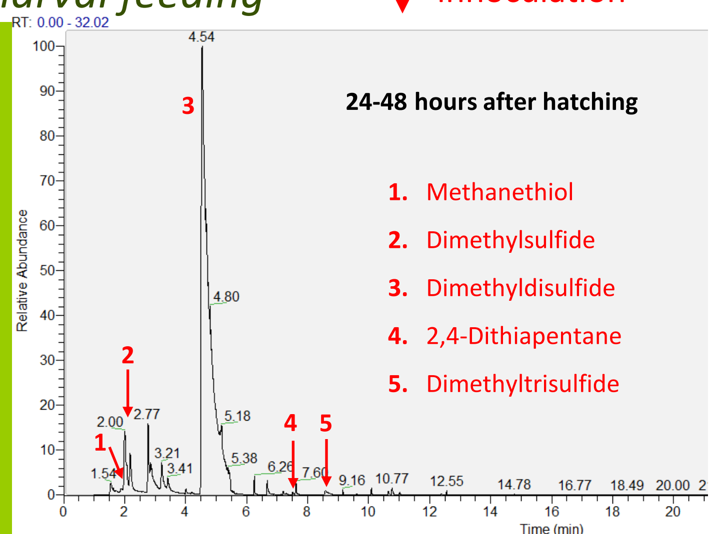
Metabolite profiling of root-zone volatiles using SPME-GC-MS

Pre-cabbage root fly larval feeding damage

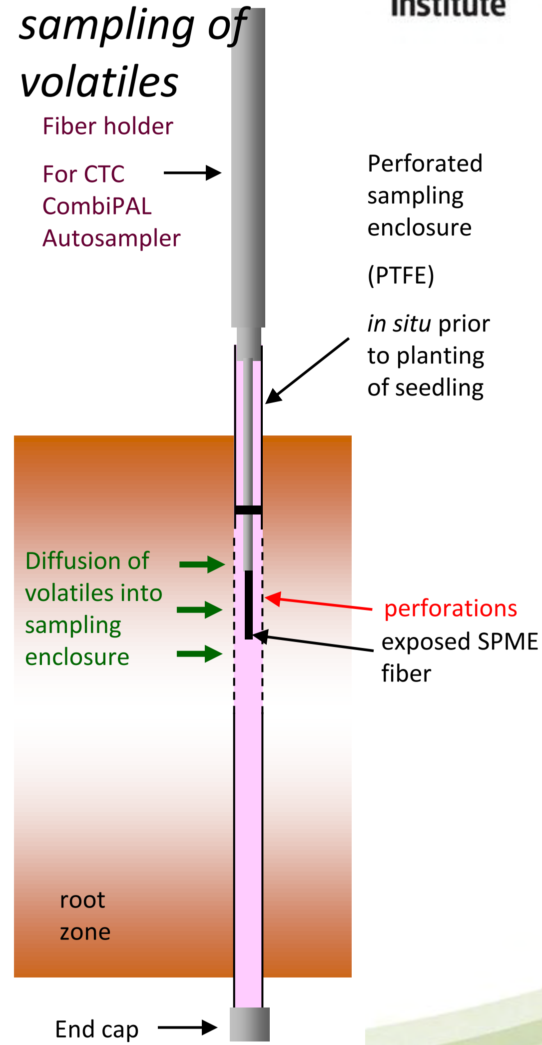


1 week post innocculation

Post-cabbage root fly larval feeding damage



in situ sampling of volatiles



The James Hutton Institute

Sustainable Crop and Environment Protection - Targeted Research for Edibles (SCEPTRE)

HortLINK project HL01109

David Piccaver, Jepco
Tim O'Neill, ADAS
Steve Tones, HDC

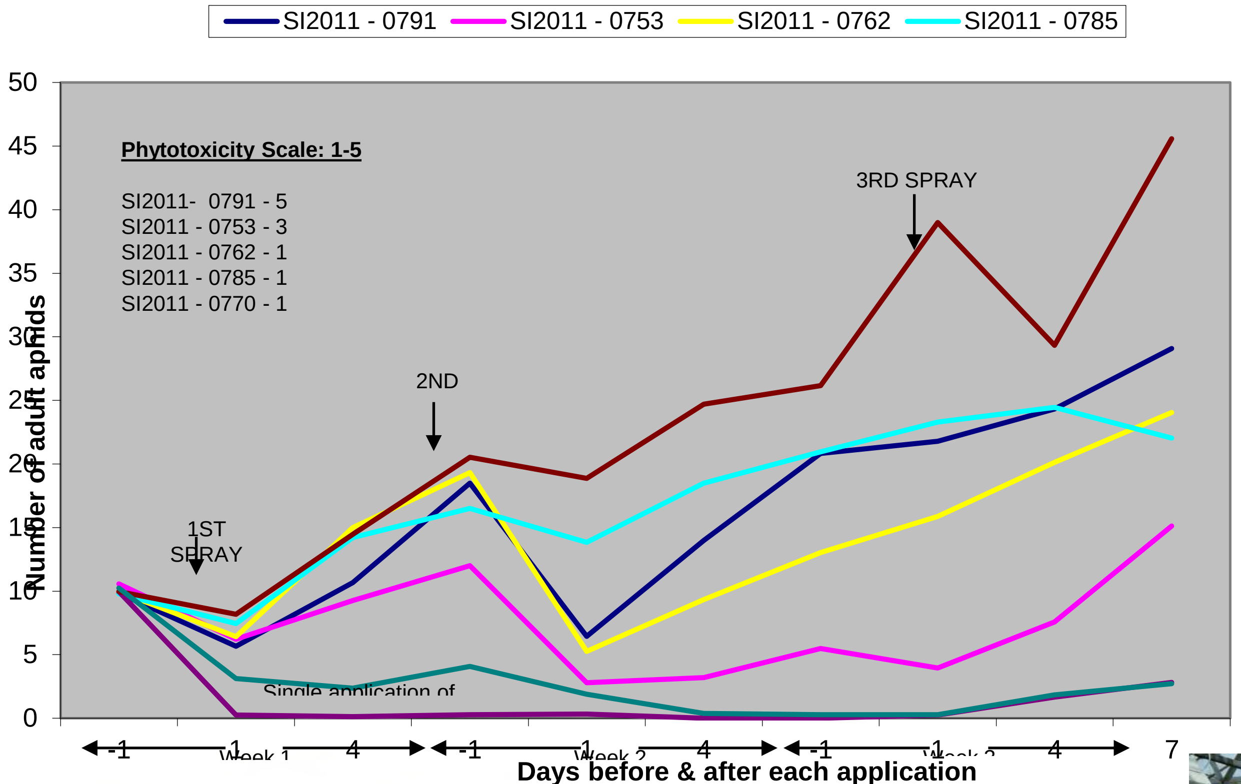
October 2010 - September 2014

defra
Department for Environment Food and Rural Affairs

HortLink

HDC

Testing biopesticides for raspberry: Hortlink SCEPTRE



Scaling up: Area-wide IPM

Overview of the PURE project

Pesticide Use and risk Reduction in European farming systems with Integrated Pest Management.

22 EU partners, including The James Hutton Institute

(FP7, 2011-2014)

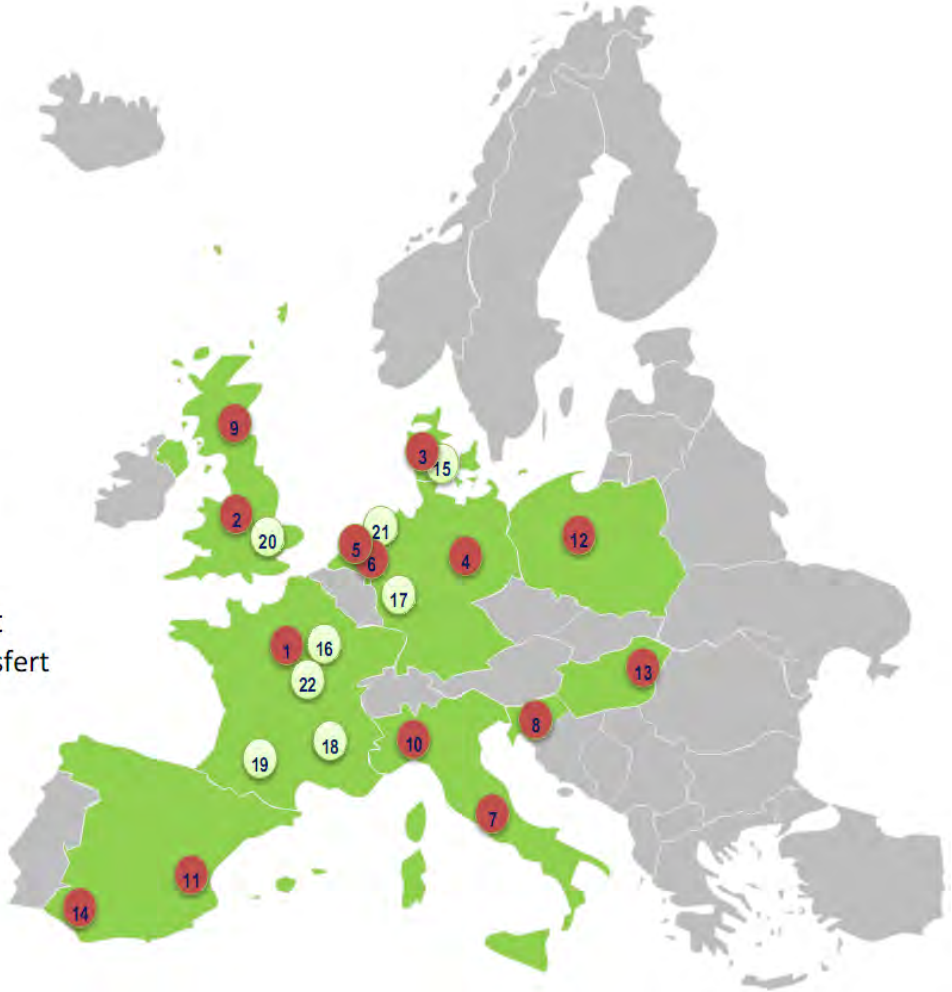
PURE partnership

Research
1 - INRA
2 - RRES
3 - AU
4 - JKI
5 - Stichting DLO
6 - WUR
7 - CNR
8 - KIS
9 - SCRI
10 - FEM
11 - IVIA
12 - IOR
13 - UDCAS
14 - JRC-IPTS

Extension
15 - DAAS
16 - ACTA

Industry
17 - BCS
18 - Biotop
19 - NPP
20 - Burkard
21 - Blgg

Management
22 - INRA Transfert



WP 10
Ecological engineering for IPM:

From field to landscape scale

Graham Begg, Nick Birch, Geoff Squire

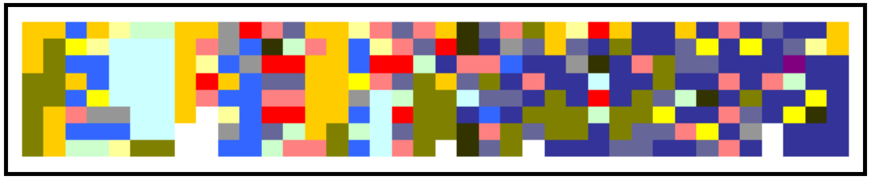
pure

The James Hutton Institute

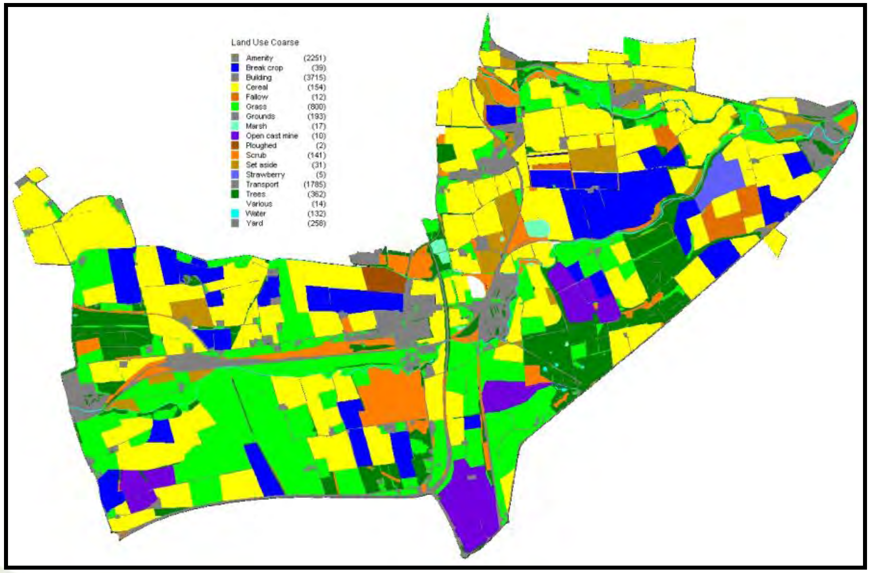
Landscape scale modelling: tools for ‘ecological engineering’

- Spatially explicit population models
- Coupling landscape and pest populations
- Crop and non-crop habitats with intrinsic values for fitness
- Multiple pest and natural enemy types
- Simulate landscape design scenarios to test ‘area wide’ (regional) IPDM designs

Temporal cropping pattern:



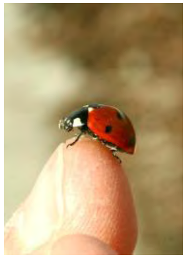
Spatial cropping pattern:



IPM and 'ecological engineering': Impacts and Future directions

The James Hutton Institute

- On-farm IPM trials : 44% reduction in pesticides (raspberry). Expanding IPM tools to major crops via EU PURE project (2011-15).
- Enhancing biocontrol + pollination (functional ecology groups) using tailored floral resources and innundative NE releases (e.g. 5% → 80% aphid parasitism increase).
- Novel defence elicitors: Sugar sensing/induced multiple defences (INRA, Koppert, Volcani Centre, Israel).
- Quantitative food web analysis: IPM to meet challenges from climate change, pesticide withdrawal, food security.
- Farm to landscape scale 'ecological engineering' (EU 'PURE' IPDM project: 12 million euros) .
- Modelling climate change impact scenarios (soft fruit ecosystem as model)
- Linking crop protection systems to food quality, human health and socio-economics



→ **Greener solutions for farmers, consumers and policy makers**

HDC

defra

A LEAF Linking Environment And Farming INNOVATION CENTRE

UNIVERSITY OF DUNDEE

Funding and collaborations:

> £1.5 million on IPM at James Hutton Institute

- **JHI colleagues**; **Ecological Sciences, Environmental, Biochemical Sciences**
- **Scottish Government Themes : ES and IPM (WPs 1.1, 6.4).**
- **EU PURE** : **IPM and ecological engineering (2011-15).**
- **EU AMIGA: GM crop biosafety + IPM (2012-16).**
- **Norwegian Government**: **Bioforsk vegetable IPM/climate change (2010-14).**
- **Lincoln University, NZ: New joint PhD on biodiesel crops/IPM (2012-16).**
- **Idaho University: Visiting professorship, IPM (2012- ongoing)**
- **AHDC SCEPTRE**. **Biopesticides and biocontrol for UK fruit and veg (2011-15).**
- **Koppert. Innudative biocontrol for soft fruit; elicitors for glasshouse crops (2011-ongoing).**
- **AHDC**. **PhD with SAC on cabbage root fly chemical ecology (2011-14)**.
- Thanks for listening!

From Chemical Ecology to Practical IPM Tools for Soft Fruit: A Research and Industry Perspective

David Loughlin, Sentomol Ltd

Sentomol™
Pest Management Solutions

The Fundamentals

Smell

- Critical sense
- Vital communication about
  - Food
  - Security
  - Social environment
  - Sex

Pentatomid bug nymphs aggregating on a plant in Bangalore, India

Definitions

Semiochemicals are chemical substances or mixtures that carry a message

Pheromones are chemicals, or mixtures released by one insect which then causes a response in another insect of the same species. Intraspecific.

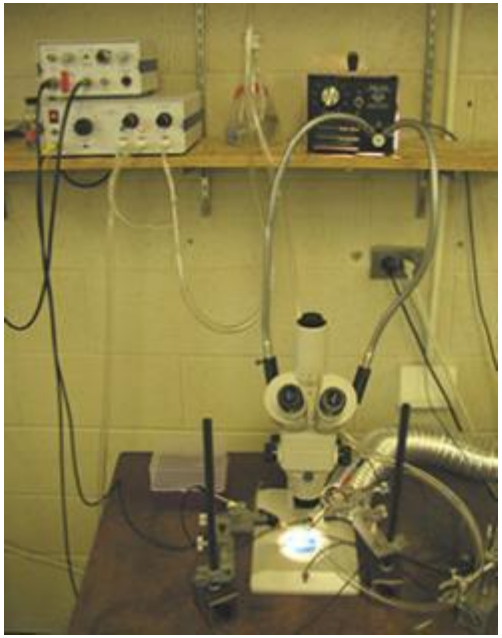
Allomones are chemical substances produced and released by an individual of one species that affects the behaviour of a member of another species to the benefit of the originator but not the receiver. Interspecific.

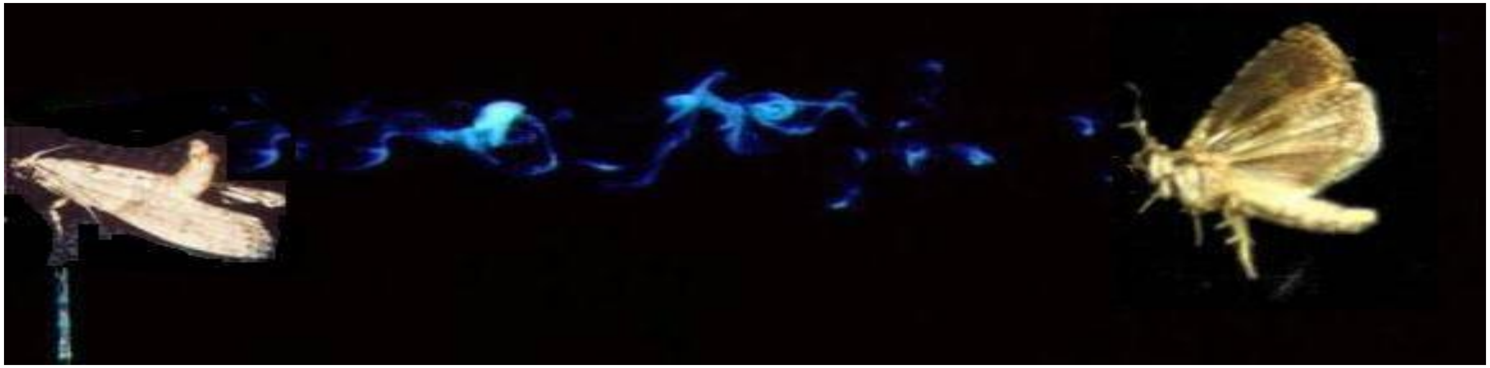
Kairomones are emitted by an organism, which mediates interactions in a way that benefits an individual of another species which receives it, without benefitting the emitter. Interspecific

Developing the Technology

Imitating nature

- Matching the chemical blend
  - Identify pheromone
  - Copy (synthesise) nature
- Delivery
  - Controlled release
  - Stabilising volatile pheromone
  - Making a user friendly presentation

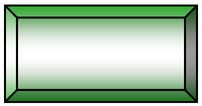




Dispenser Technology

Types of Delivery Systems

Matrix systems



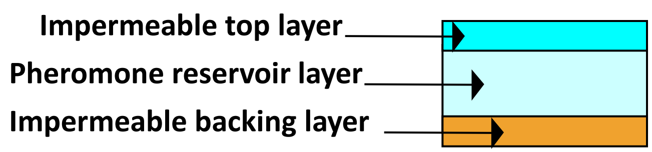
Attractant incorporated into structure of device

Low to high doses of pheromone.

Extrusions

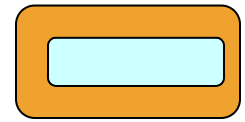
Septa

Laminates



Laminate

Reservoirs



Attractant mostly stored in enclosed lumen

Usually for high dose pheromones

Sachets

Filled Vials

Application of Pheromones and Traps

Monitoring

- Early detection of the presence of insects
- Detection of low levels of infestation which would otherwise go unnoticed
- Details of insect distribution
  - throughout a locality
  - throughout a season
  - sources of infestation

- Optimum timing for insecticide application
- Assessment of the efficacy of control measures

Semiochemicals as Control Products

Insect Pheromones Identified = 1000's
Pheromones used for monitoring = 100's
Pheromones used for control = <100

Critical Criteria
Simple Pest – Plant Relationships
Low Pest Population Density
Reliable Dispenser System
Area Wide IPM Approach
= potential to replace insecticides

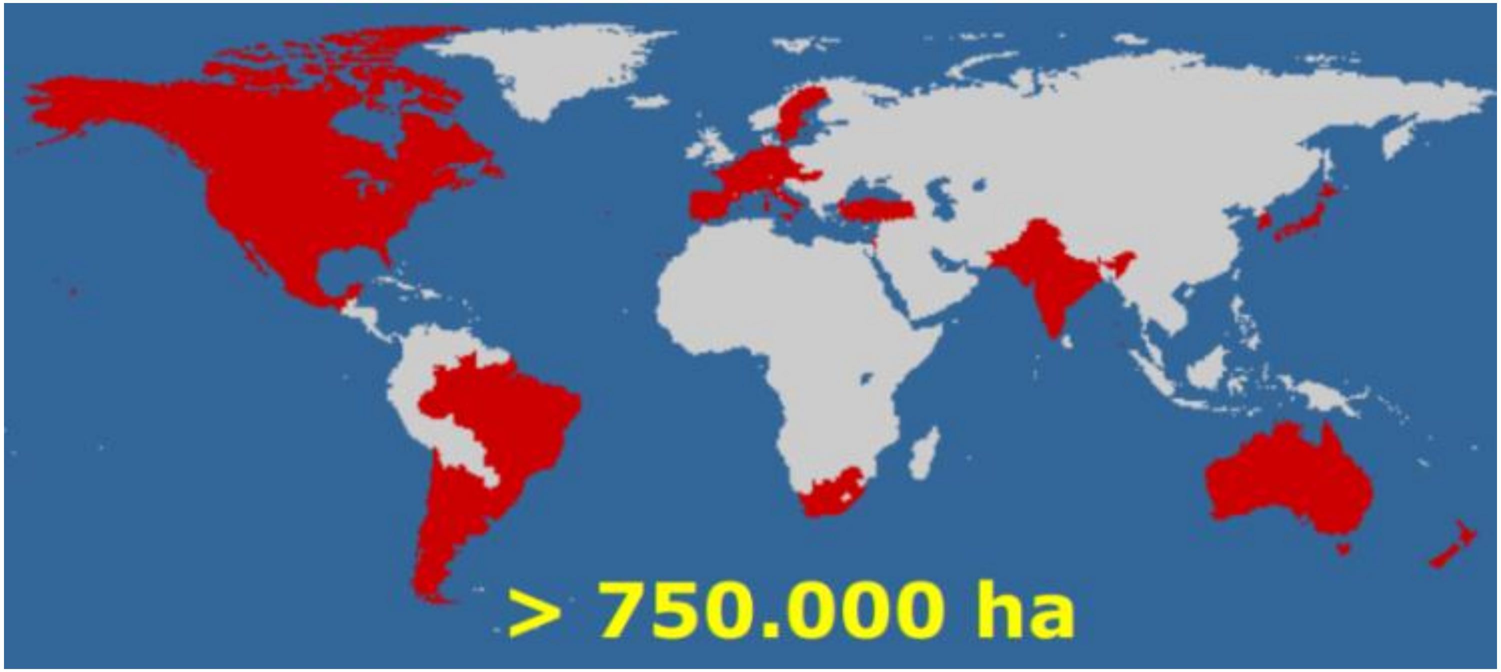
Market Sizes

Approximate word wide market size
€, ex works

- **Agro-chemicals market** (€100-140 bn)
  - **Fertilizers, others** (ac€100bn)
  - **Traditional pesticides** (€25–30bn)
    - **Herbicides** (€12–13bn)
    - **Fungicides** (€5–7bn)
    - **Insecticides** (€8–9bn)
  - **Biological products** (€1bn)
    - **Microbials** (€200-300m)
      - **Bacteria**(€100-160m)
      - **Virus**(€30-50m)
      - **Funghi** (€100-130m)
    - **Macrobials** (€200-250m)
    - **Biorationals** (€350-400m)
      - **Naturals** (€150-200m)
      - **Semiochemicals** (€150-200m)
  - **Physical methods** (ac €50m)
    - **Traps**
    - **Sound, etc**
    - **Heating/freezing**

Sources: Agrochemical & Biotech Corporations Spur Global Growth of Pesticides, June 2005
www.organicconsumers.org/foodsafety/biotechpesticides080805.cfm
www.biopesticideindustryalliance.org/marketinfo.php ,
Biological Control: Current and Future Market Demands, www.oardc.ohio-state.edu/mcspaddengardenerlab/Presentations/BMG_CSREESpres.pdf
Global Market for Agrochemicals, www.indiaprwire.com/pressrelease/chemical/2010012742159.htm
Annual Biocontrol Industry Meeting (ABIM) Lucerne, Switzerland – archive presentations 2006-2011

Sex Pheromones as Control Products



">750k ha now use pheromones in Mating Disruption control programmes" *IBMA 2009*

Commercial success in top fruit, stone fruit, vines, tomato, rice, cotton, forestry

Principally against lepidopteran pests

Sentomol™
Pest Management Solutions

Commercial Applications for Control Strategies

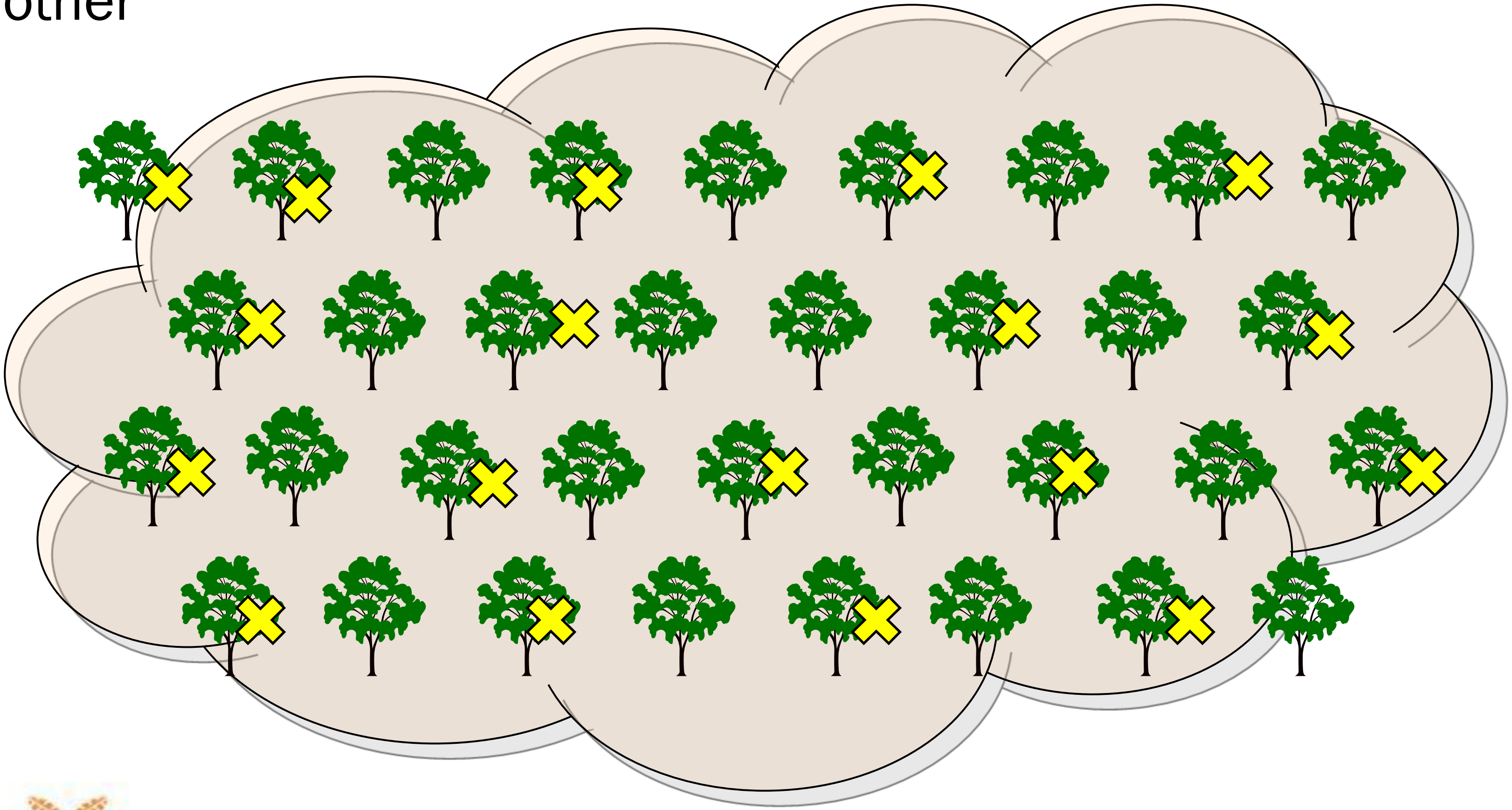
Mating Disruption sexual confusion,
auto-confusion,
false trail following

Mass Trapping

Attract & Kill

Concept of Mating Disruption

Dispenser products interfere with insects natural attraction to each other



Sentomol™
Pest Management Solutions

e.g. Sexual Confusion creates a cloud that masks natural scent trails

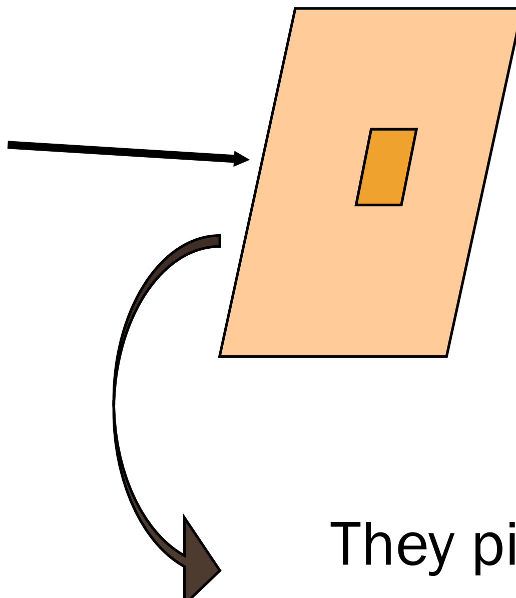
Current Mating Disruption Products

Reservoirs

Aerosols , Sprays
Gels & Powders

Concept of Attract & Kill

Insects are attracted to a target device coated with insecticide



They pick up a lethal dose of insecticide and die

IGR also used

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Current Attract & Kill Products

For Mediterannean Fruit Fly *Ceratitis capitata*

For Olive Fruit Fly *Dacus (Bactrocera) oleae*

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Concept of Mass Trapping

Large numbers of Insects (male & female) are attracted to a trap

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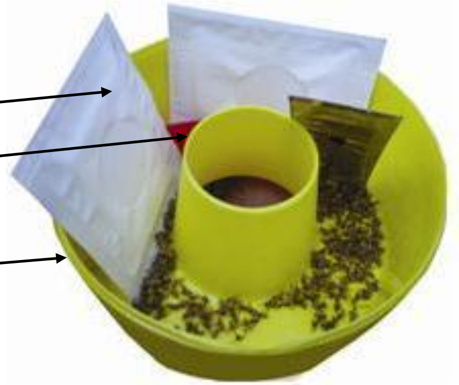
Current Mass Trapping Products

McPhail Trap (Fruit Fly)

Attractant
Killing Agent
Trap (various styles available)



Water Trap (*Tuta absoluta*)

Attractant
Killing Agent
Trap

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So What About Soft Fruit?

Commercial Potential for Soft Fruit

- High value crops
- Clean fruit “no residues” required
- Extended cropping
- Complex of pests present
- Monocultural production

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Soft Fruit Pests Under Investigation

	Monitoring	Control Potential
Raspberry Cane Midge *Resseliella theobaldi*	✓	?
Raspberry Beetle *Byturus tomentosus*	✓	✓
Strawberry Blossom Weevil *Anthronomus rubi*	✓	?
European Tarnished Plant Bug *Lygus rugulipennis*	✓	?
Blackcurrant Leaf Midge *Dasineura tetensi*	✓	?
Blackberry Leaf Midge *Dasineura plicatrix*	✓	?
Common Green Capsid Trap *Lygus pabulinus*	✓	?
Western Flower Thrips *Frankliniella occidentalis*	✓	?

Ref: http://www.hdc.org.uk

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NB: None of the above are moths

Raspberry Beetle Monitoring Trap

Raspberry Beetle *Byturus tomentosus*

SF 74 Integrated pest and disease management for high quality raspberry production

- Para pheromone attractive to male and female beetles
- White vanes simulate colour of Raspberry flower
- Excluder used to avoid catching bees
- Apply at 50/ha
- Threshold of 5 beetles per trap
- Potential to reduce populations with time

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Midge Monitoring Traps

Raspberry Cane Midge (Resseliella theobaldi)

Defra project HH34124SSF

SF 74 Integrated pest and disease management for high quality raspberry production

- Sex pheromone
- Delta trap

  Red colour catches less beneficial insects
- Threshold of 30 midges per trap
- MD trials with gel ongoing

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Midge Monitoring Traps

Blackberry Leaf Midge *Dasineura plicatrix*

SF 117 - Sex pheromone trap for monitoring blackberry leaf midge

- Sex pheromone
- White or Red Delta
  Red colour catches less beneficials
- Season long trapping
- 2 traps / ha

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Midge Monitoring Traps

Blackcurrant Leaf Midge *Dasineura tetensi*

Hortlink 01105 Developing biocontrol methods and their integration in sustainable pest and disease management in blackcurrant production

- Male & female sex pheromones
- looking for better ways of exploiting the sex pheromone and new selective insecticides for control.
- Traps in development
- Thresholds being set

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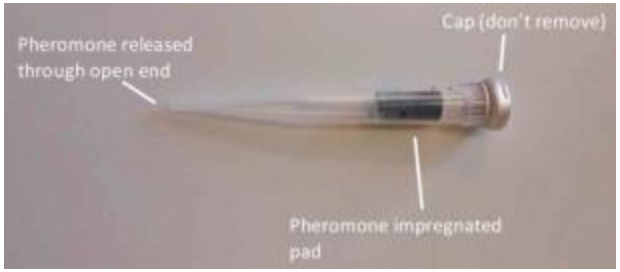
European Tarnished Plant Bug Monitoring Trap

European Tarnished Plant Bug *Lygus rugulipennis*

Defra HH1939SSF : *Pheromones of strawberry blossom weevil and European tarnished plant bug for monitoring and control in strawberry crops*

- Green Vane (White is repellent)
- Trap secured at ground level
- Traps give 4 weeks warning
- Threshold 10 bugs/week or rapid increase



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Strawberry Blossom Weevil Monitoring Trap

Strawberry Blossom Weevil *Anthronomus rubi*

*Defra HH1939SSF **:** Pheromones of strawberry blossom weevil and European tarnished plant bug for monitoring and control in strawberry crops*

SF94 - Minimising pesticide residues in strawberry through integrated pest, disease and environmental management crop

European Union, CORE Organic II , Softpest Multitrap: Management of strawberry blossom weevil and European tarnished plant bug in organic strawberry and raspberry using semiochemical traps.

- Complex 4 component aggregation pheromone
- Adapted Funnel Trap – not optimised
- 36 in 1 Ha in grid format or 25/ha large plots
- Work ongoing – possibly smaller trap required and same trap for ETPB & SWB

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WFT on Strawberries

Enhancing Sticky Trap Catch

SF 120 - Biological, semiochemical and selected chemical management for insecticide resistant western flower thrips on protected strawberry

Lurem thrips attractant is a kairomone in a controlled release dispenser (Koppert)

Thripline$_{ams}$ contains a synthetic version of a sexual aggregation pheromone for Western Flower Thrips, *Frankliniella occidentalis*. The natural pheromone is produced by males of *F. occidentalis* and attracts both males and females into mating aggregations. (Syngenta Bioline)

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Other Work

Vine Weevil

SF HNS 127 CS - Characterising vine weevil aggregation pheromone for use in traps at soft fruit and nursery sites, JHI

There is evidence that adult weevils produce a volatile aggregation pheromone which has to be identified and which could be incorporated into lure-and-kill traps, such as sticky traps. Still needed is to characterise the pheromone's chemical components, how the weevils generate it and the distance over which it attracts the adults.

Blueberry Gall Midge

Project SF126 Blueberry Gall Midge: Sex Pheromone monitoring and control with insecticides, EMR

The overall aim of this project is to develop a sex pheromone monitoring trap for blueberry gall midge and methods of using it for monitoring and timing insecticides for control.

Market Trends

3 Drivers: Resistance, Registration and Residues

The GLOBAL G.A.P standard is primarily designed to reassure consumers about how food is produced on the farm by minimising detrimental environmental impacts of farming operations, reducing the use of chemical inputs and ensuring a responsible approach to worker health and safety as well as animal welfare.

Greenpeace Germany Report 2007

- Found illegal pesticides
- Found MRL levels exceeded

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Thank You

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