An Integrated Pest management Strategy for pollen beetle in oilseed rape: Are we nearly there yet?

Sam Cook
Rothamsted Research, UK

ROTHAMSTED RESEARCH

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Integrated Pest Management (IPM) for pollen beetle in oilseed rape

ROTHAMSTED RESEARCH

William Shakespeare, 1564 - 1616

To B(rassicogethes), or not to B(rassicogethes): that's the question;

Whether 'tis nobler in the mind to suffer the slings and arrows of outrageous fortune, Or to take arms against a sea of troubles, And by opposing end them? (Hamlet)

Should we accept this or fight it? Preliminary re-examination of genus-level taxonomy of the pollen beetle subfamily Meligethinae (Coleoptera: Nitidulidae) Audisio 2009, 2014, 2015

Who cares?
'' A rose by any other name would smell as sweet' (Romeo & Juliet)

This is unnecessary over splitting of the genus and will lead to confusion (and Romeo & Juliet didn't end well!)

Integrated Pest Management (IPM) for pollen beetle in oilseed rape

William Shakespeare, 1564 - 1616

The name change has not been accepted by National Biodiversity network NHM (UK) BUT term becoming more widely accepted (EPPO included).

So, do I have to accept this? Do *we* accept this??

If so then I'm extremely sad to announce the demise of *Meligethes aeneus* – but perhaps we'll have more luck controlling *Brassiocogethes aeneus*?!

Integrated Pest Management (IPM)

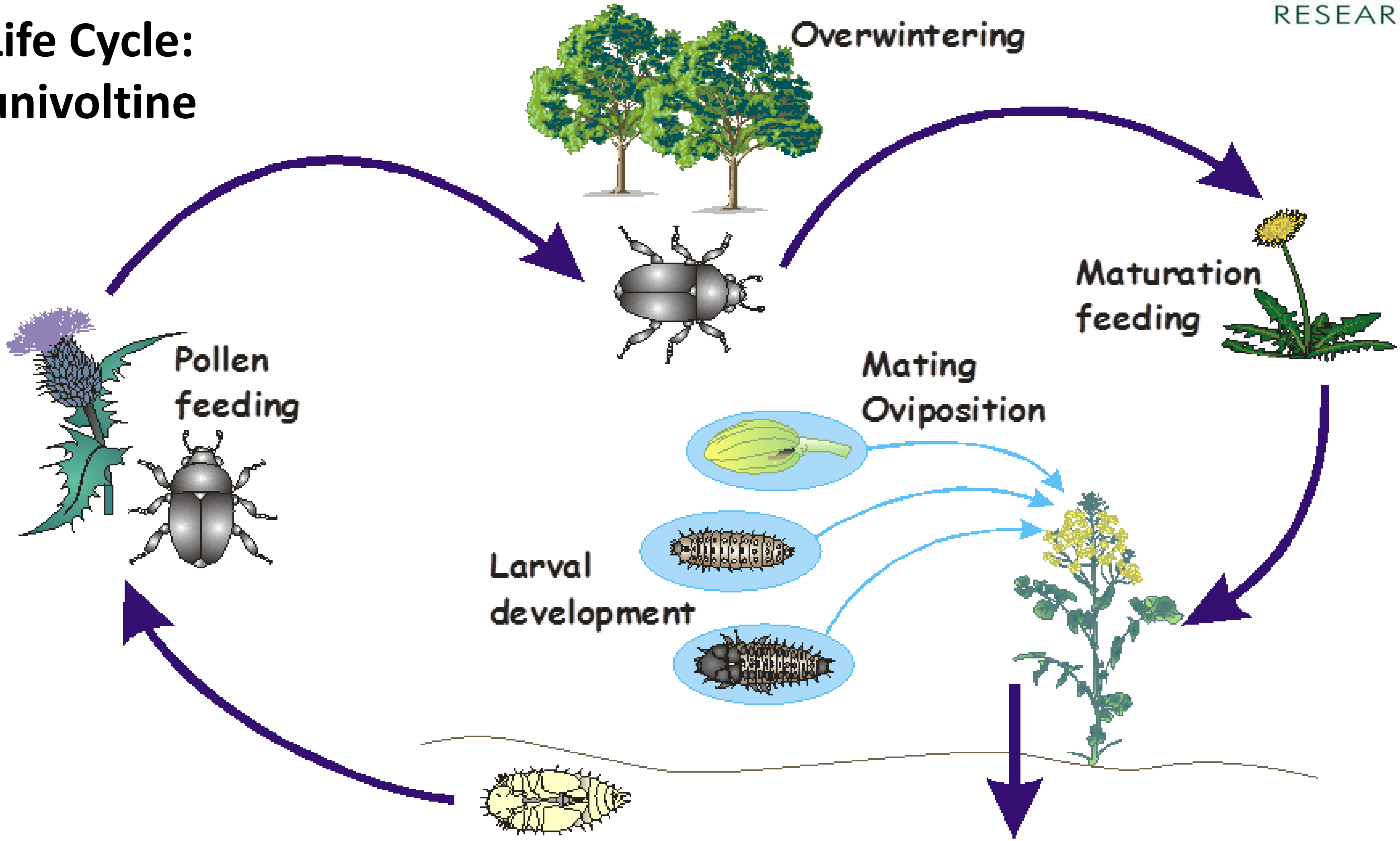
- IPM is an effective and environmentally sensitive approach to pest management that relies on a combination practices (including the judicious use of pesticides)

- 4 usual steps in IPM programmes:

1. Set action threshold
2. Monitor pest density & assess risk
3. Prevention – cultural methods e.g. crop rotation, use of pest-resistant cultivars, semiochemical e.g. pheromone repellents, habitat diversification intercropping, trap cropping
4. Control – mechanical (e.g. trapping), biological, conservation biocontrol, botanical insecticides, synthetic pesticides

Pollen beetle (*Brassicogethes /Meligethes aeneus*)

Life Cycle: univoltine



Pollen beetle (*Brassicogethes /Meligethes aeneus*)

Damage

- Adult feeding damage at bud stage causes abscission ‘blind stalks’

Pollen beetle (*Meligethes aeneus*)

Damage

- Adult feeding damage at bud stage causes abscission 'blind stalks'
- Pyrethroid resistance widespread across Europe
- Loss of control resulted in complete loss of 30,000ha (€22-25 M) in Germany 2006
- Indoxacarb, neonicotinoids (thiacloprid acetamiprid) & Pymetrozine currently viable alternatives

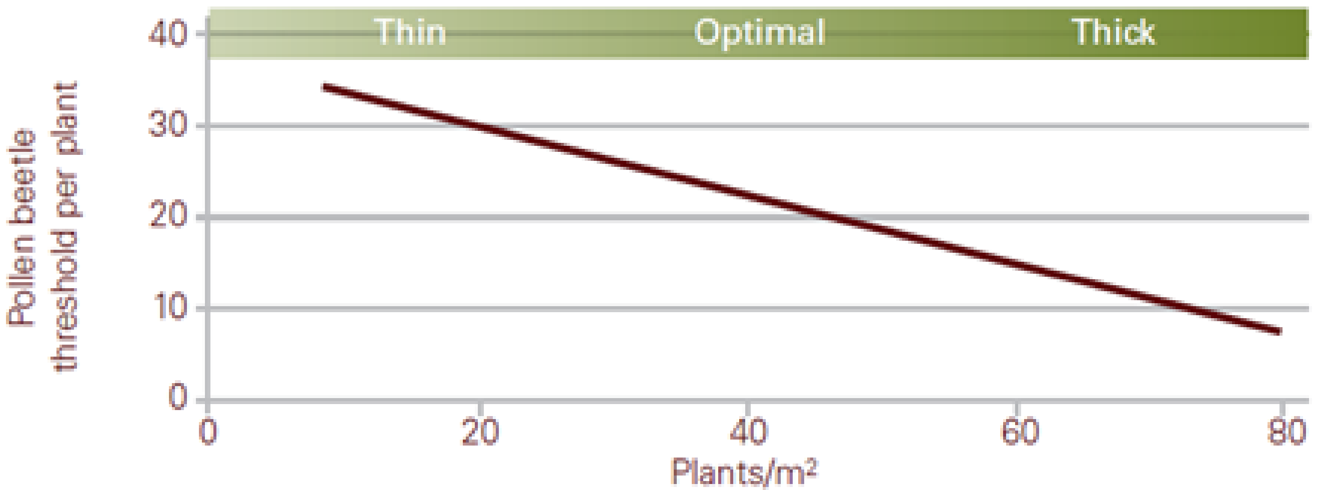
1. Set Action Thresholds

E.g. Revaluation of threshold for pollen beetle (UK)

AHDB Project 495 (Ellis & Berry, 2014)

Previous to 2012 UK threshold 15 beetles/plant or 5 for backward crops (GS 50-61)

- Logic: 1) calculate the number of flowers that can be lost by plants to pollen beetles and still produce maximum yield (1 beetle damages 9 buds/season)
- 2) The number of 'excess flowers' could be predicted by # plants/m^2 at the bud stage. Crops with fewer plants/m^2 had more excess flowers than more dense crops



1. Set Action Thresholds

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Threshold for pollen beetle (UK) now based on plant density as well as number of pollen beetles/plant

Revised control thresholds for winter and spring oilseed rape

If there are less than 30 plants/m^2	the threshold is 25 pollen beetles per plant
If there are 30–50 plants/m^2	the threshold is 18 pollen beetles per plant
If there are 50–70 plants/m^2	the threshold is 11 pollen beetles per plant
If there are more than 70 plants/m^2	the threshold is 7 pollen beetles per plant

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Photo © Alan Dewar, Dewar Crop Protection

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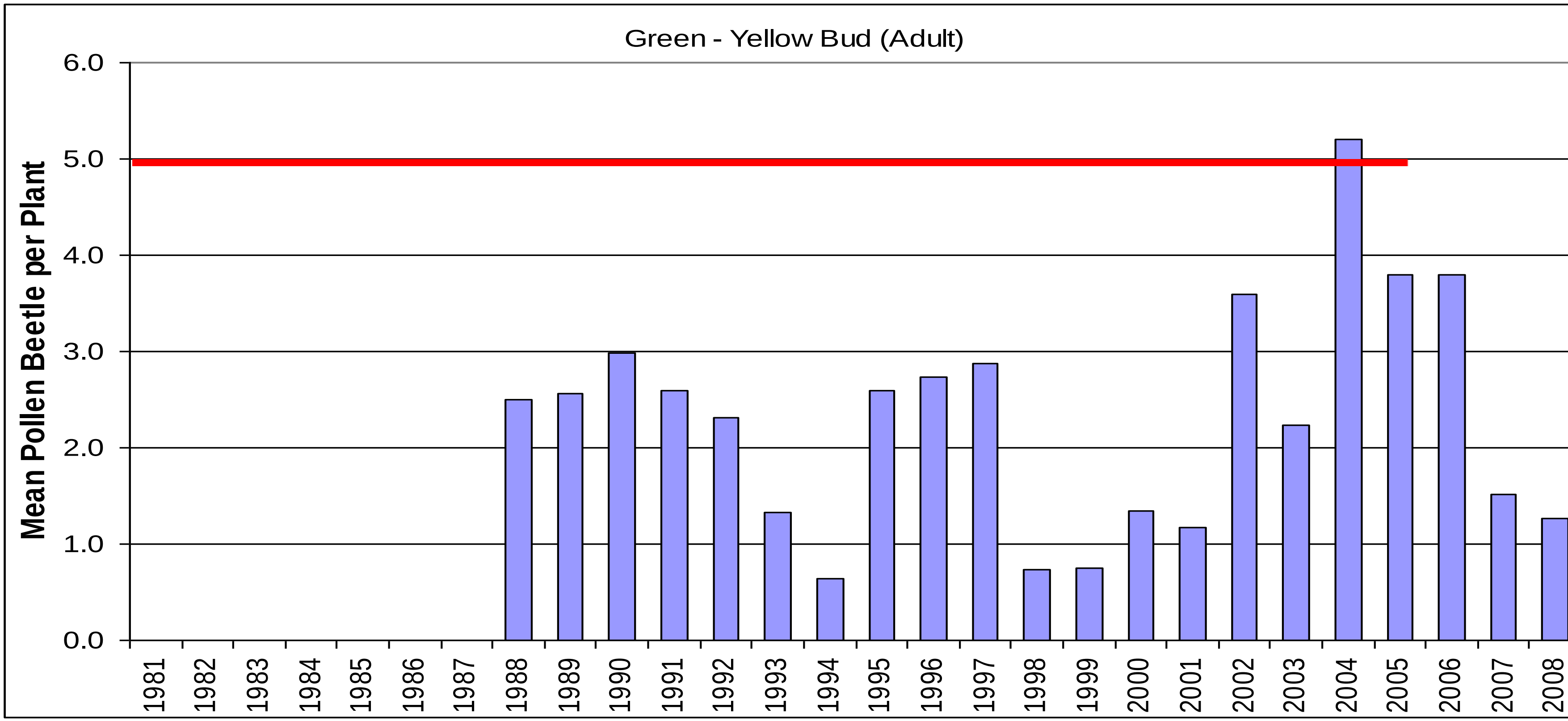
1. Set action thresholds - Pyrethroid use in UK

ROTHAMSTED RESEARCH

Pollen beetle populations are usually below UK spray thresholds (15 beetles/plant)
- only rarely reach threshold for backward crops (5 beetles/plant)



Defra data - collected through FERA's CropMonitor project

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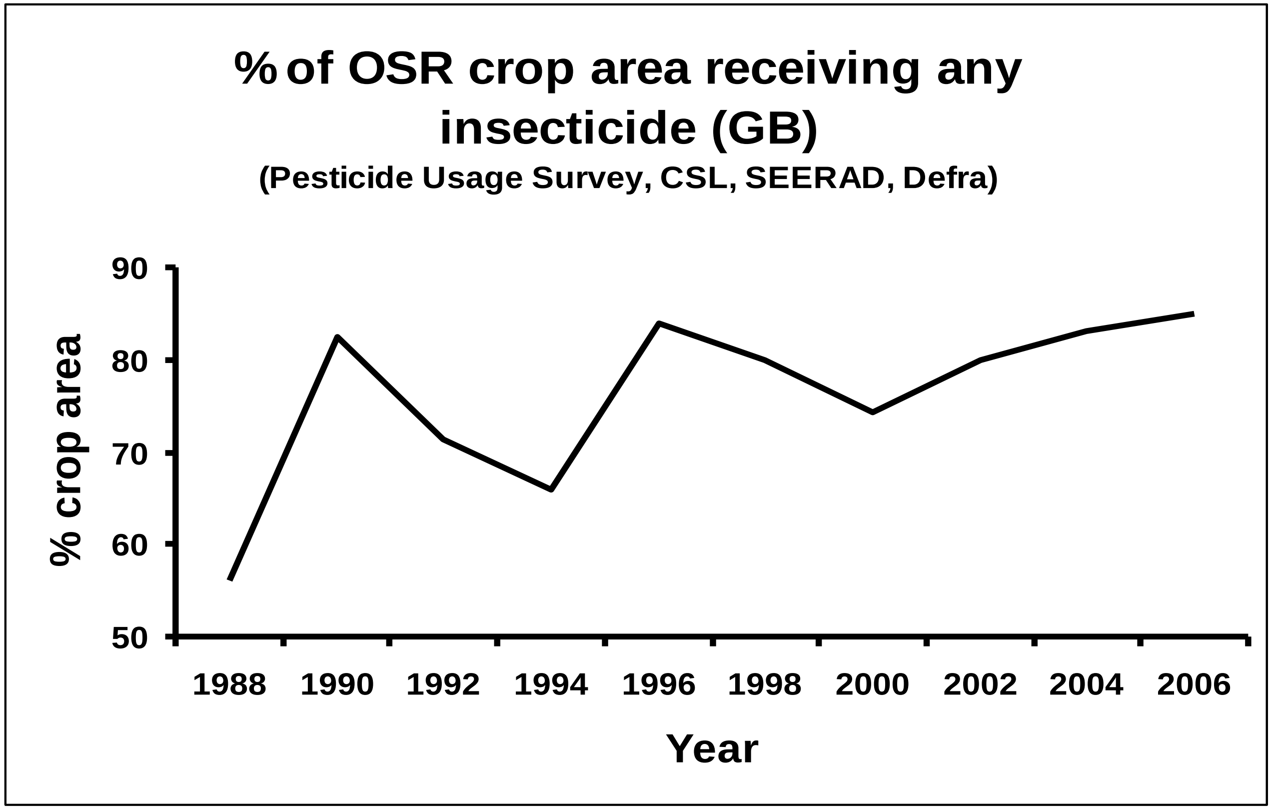
1. Set action thresholds - Pyrethroid use in UK

…But spring insecticide use is increasing (main target: pollen beetle)!

So thresholds not being used.. Why not?



2. Monitor pest density & assess risk

Advice:

- Crops at risk during green-yellow bud phase
- Risk of immigration on dry days when temperatures > 15 °C
- Pollen beetle spray threshold = 15/plant (average)
- Pest sampling protocol: '…10 plants sampled along a 30m transect across the field. Each transect should start at the headland and go diagonally across the field, choosing a plant at random every couple of metres'

2. Monitor pest density & assess risk

- Monitoring procedure is time consuming
- Pollen beetle immigration occurs over 2-6 week period

A baited monitoring trap will help growers & advisers to more easily and more accurately identify when spray thresholds have been breached than by plant scouting methods

2. Monitor pest density & assess risk

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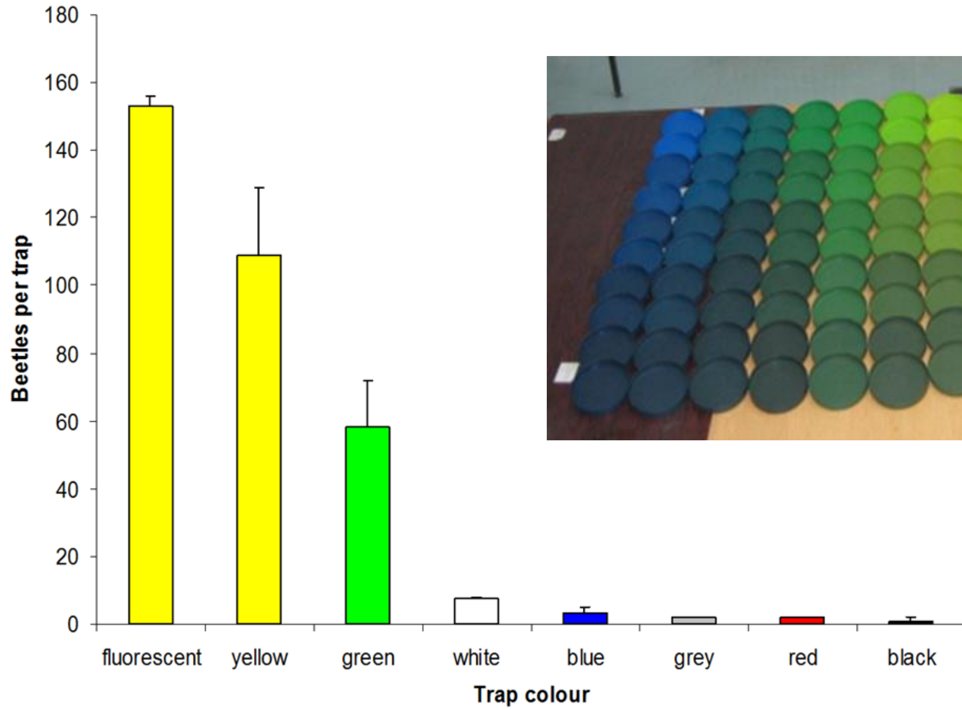
Monitoring methods : *Developing a monitoring trap for pollen beetle*

colour



Cook, Skellern, Döring & Pickett (2013) Arthropod-Plant Interactions 7:249–258

Döring, Skellern, Watts & Cook (2012) Phys. Ent. 37:360-368

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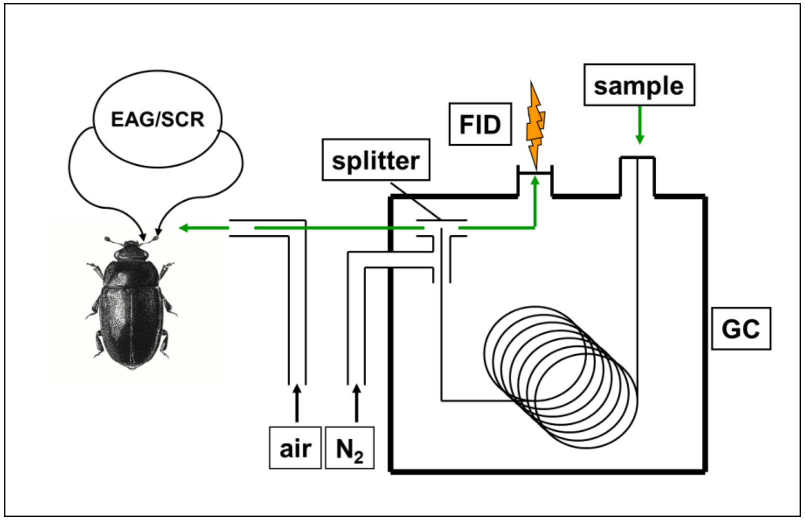
HSE Health and Safety Executive
Chemicals Regulation Directorate Pesticides

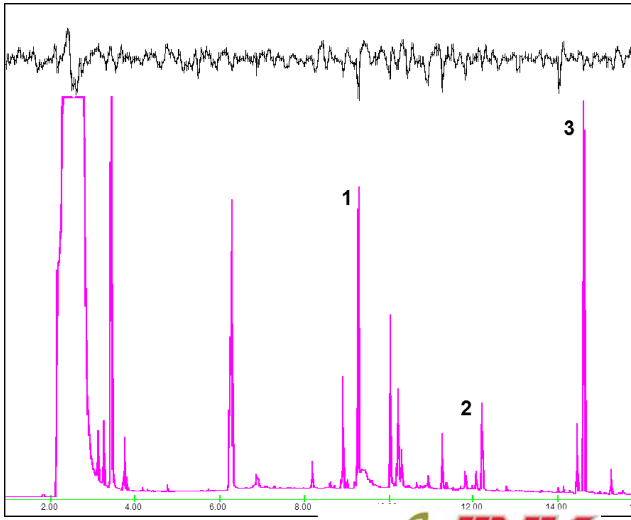
2. Monitor pest density & assess risk

Monitoring methods : *Developing a monitoring trap for pollen beetle*

Volatile lure

- Lure derived from OSR host plant volatiles (in the absence of pheromones)





- 15 electrophysiologically active volatiles identified

2. Monitor pest density & assess risk

Monitoring methods : *Developing a monitoring trap for pollen beetle*

- In replicated field experiments 2008-2011, Phenylacetaldehyde performed most consistently and was chosen for further development as the lure for the field trap

2. Monitor pest density & assess risk

Monitoring methods : *Developing a monitoring trap for pollen beetle*

Spring 2013 - Commercially available from Oecos www.oecos.co.uk

- Good indication of when beetles are moving but not currently adequately calibrated to allow threshold determination ☹

- Best to site traps facing upwind but located downwind of prevailing wind (usually NE side of field) most effective

Skellern, Welham, Watts & Cook (2017) Agriculture, Ecosystems & Environment 24: pp.150-159 ...

2. Monitor pest density & assess risk

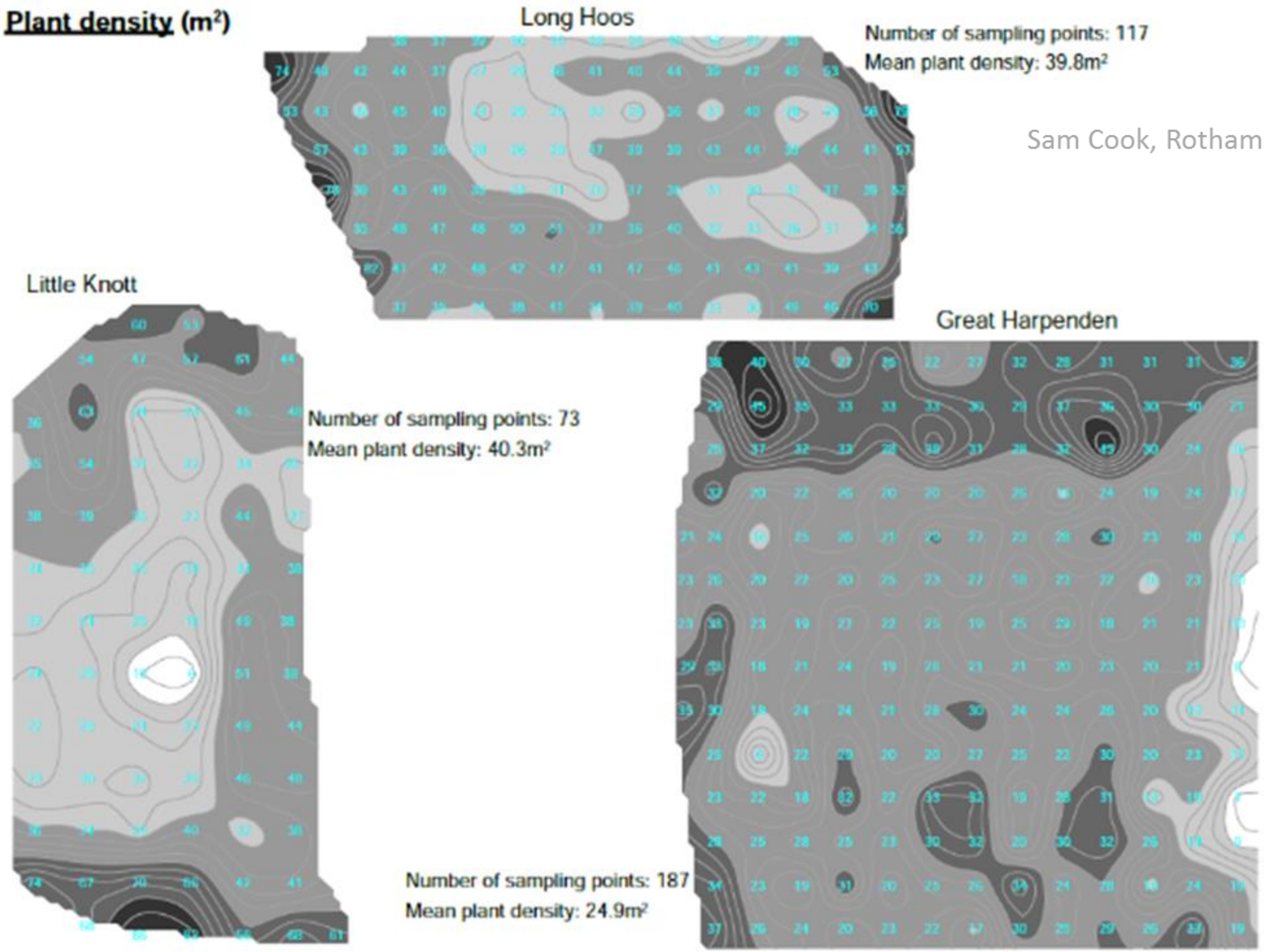
ROTHAMSTED RESEARCH

- Does it *really* matter where in the field the transect sampling is done?
- Need to understand:
- spatio-temporal abundance and distribution of pollen beetle
- \- how this relates to plant density and crop growth stage

- 3 fields at Rothamsted divided into grid 16 x 16m
- 3 plants in each zone sampled 3/week 9 March – 27 April

2. Monitor pest density & assess risk

ROTHAMSTED RESEARCH



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2. Monitor pest density & assess risk

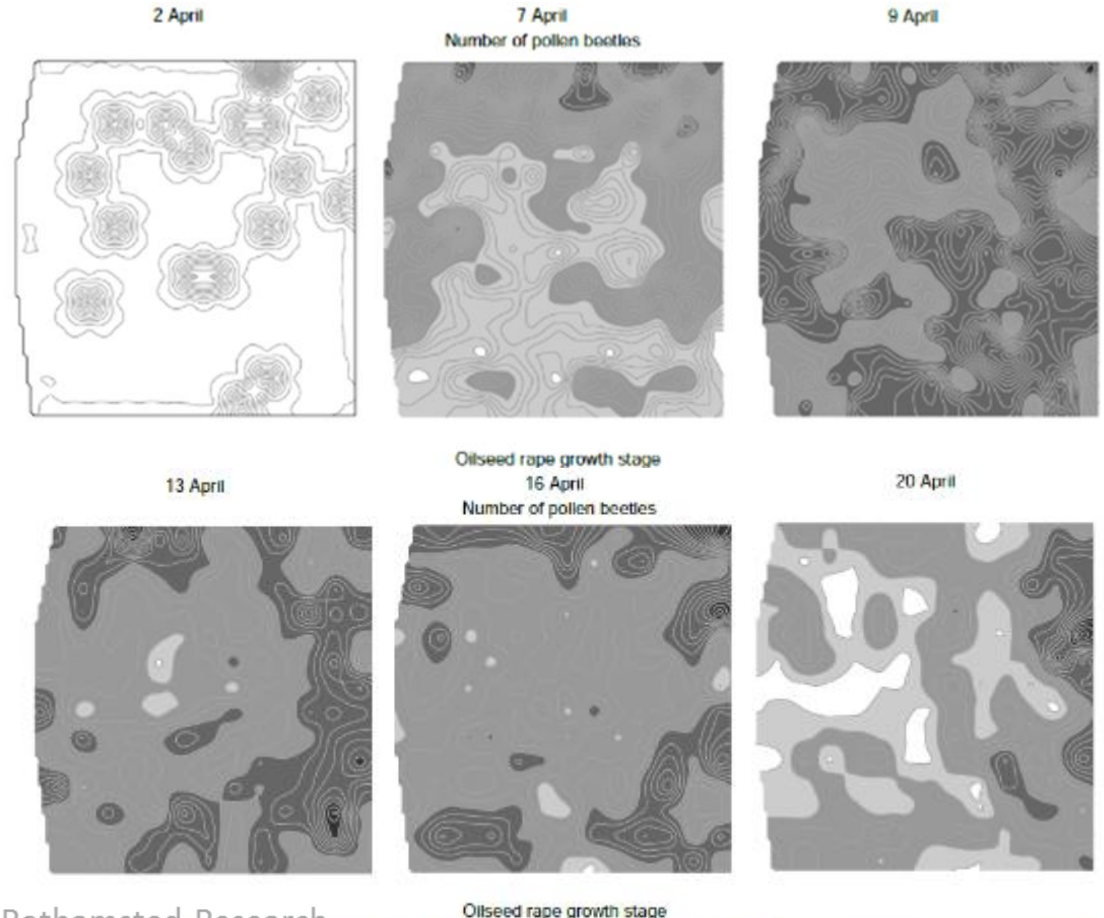
Table 22. Plant density (plants/m^2) and pollen beetle threshold (in parentheses) in field experiments on Rothamsted Farm, 2015

Field	Position	Plants/m^2 – Distance from crop edge: 1-10 m	10-20 m	20-30 m	Transect mean
Great Harpenden[1]	NE	27 (25)	33 (18)	36 (18)	32.0 (18)
	SE	22 (25)	26 (25)	25 (25)	24.3 (25)
	SW	27 (25)	25 (25)	30 (18)	27.3 (25)
	NW	22 (25)	32 (18)	32 (18)	28.7 (25)
	Whole field average				28.1 (25)
Long Hoos[2]	NE	29 (25)	6 (25)	44 (18)	26.3 (25)
	SE	61 (11)	11 (25)	38 (18)	36.7 (18)
	SW	30 (18)	11 (25)	39 (18)	26.7 (25)
	NW	58 (11)	10 (25)	36 (18)	34.7 (18)
	Whole field average				31.1 (18)
Little Knott 1[3]	NE	35 (18)	44 (18)	17 (25)	32.0 (18)
	SE	40 (18)	39 (18)	30 (18)	36.3 (18)
	SW	60 (11)	54 (11)	45 (18)	53.0 (11)
	NW	32 (18)	31 (18)	38 (18)	33.7 (18)
	Whole field average				38.8 (18)

- Plant density varies within field so threshold varies according to position of sample

2. Monitor pest density & assess risk

- Pollen beetle spatio-temporal abundance highly variable



2. **Monitor pest density** & assess risk

ROTHAMSTED RESEARCH

Real-timing monitoring of insect pests is needed!

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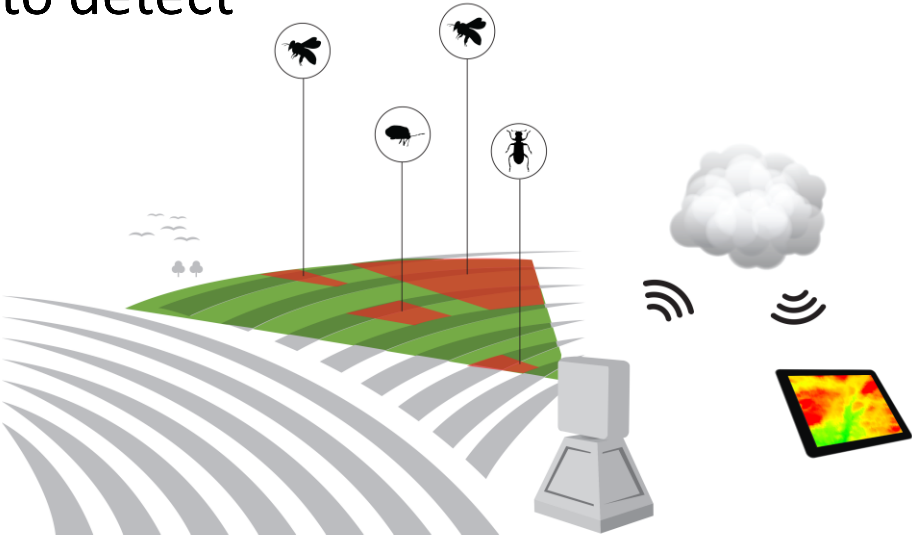
- Machine learning enables detection and recognition of insect species

- Camera traps being developed
- LIDAR (Light Detection and Ranging (LIDAR) 'laser' sensor technology being tested to detect OSR pests & beneficials



Digital Farming Solutions

FaunaPhotonics

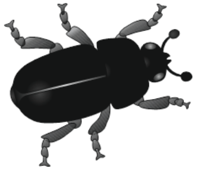
2. Monitor pest density & assess risk

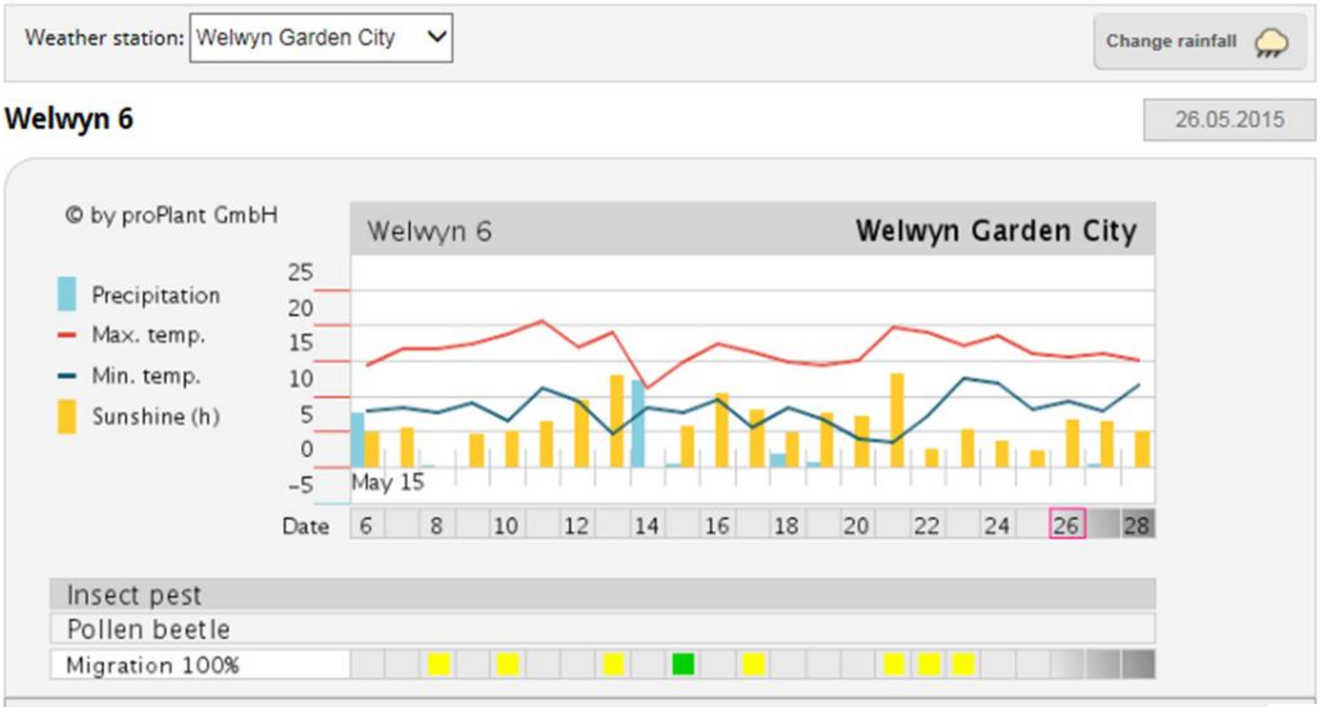
ROTHAMSTED RESEARCH

expert.com on-line risk assessment tool

for: pollen beetle

Predicts: start of migration, peaks in migration, end of migration





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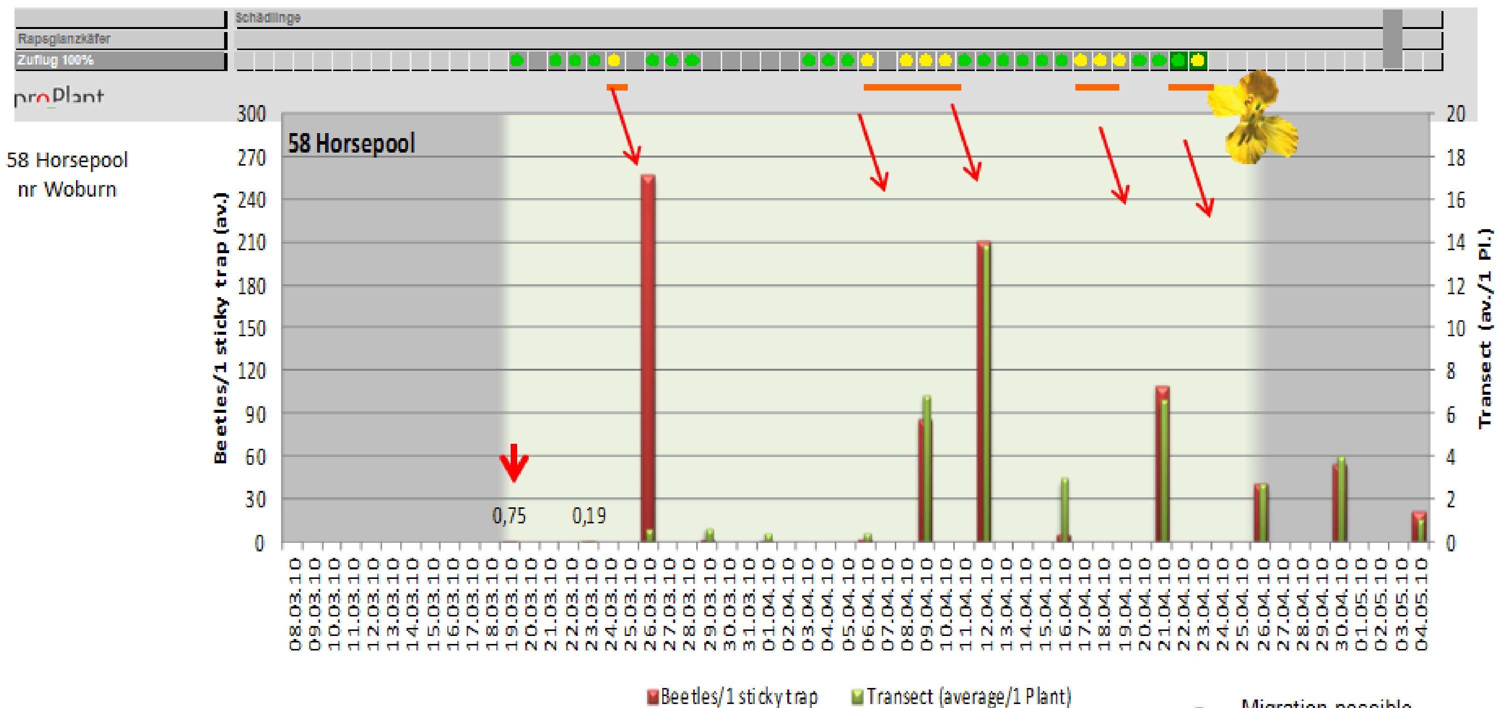
2. Monitor pest density & assess risk

ROTHAMSTED RESEARCH

- Trapping data from 178 crops across UK over 4 years
- proPlant can accurately forecast start, peaks (risk periods) and end of immigration;
- **Focussing monitoring effort to when it is most needed, reducing it by half cf. rule based advice**



Migration possible

Good conditions for migration

Optimal conditions for migration

Ferguson et al.& Cook , (2016) Pest Management Science 72:609-617

Digital Farming Solutions

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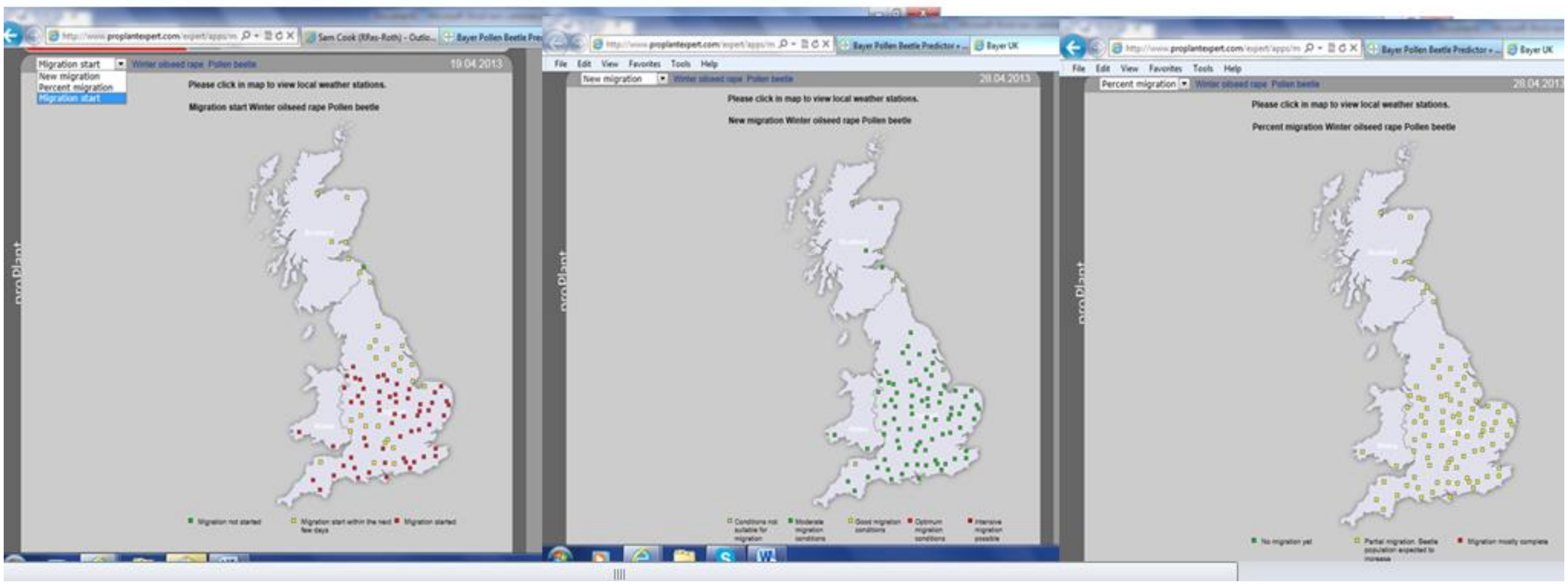
2. Monitor pest density & assess risk

ROTHAMSTED RESEARCH

ProPlant tool now available free to UK growers via Bayer Pollen Beetle Predictor

www.bayercropscience.co.uk/ Bayer CropScience

Immigration start | Immigration risk | % completion



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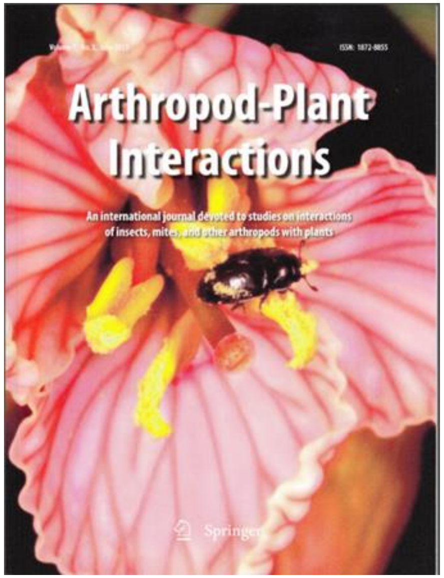
3. Prevention

Cultural methods

- Crop Management

Reviewed by Skellern & Cook - coming soon in special issue on Pollen beetle in Arthropod-Plant Interactions



3. Prevention

Cultural methods

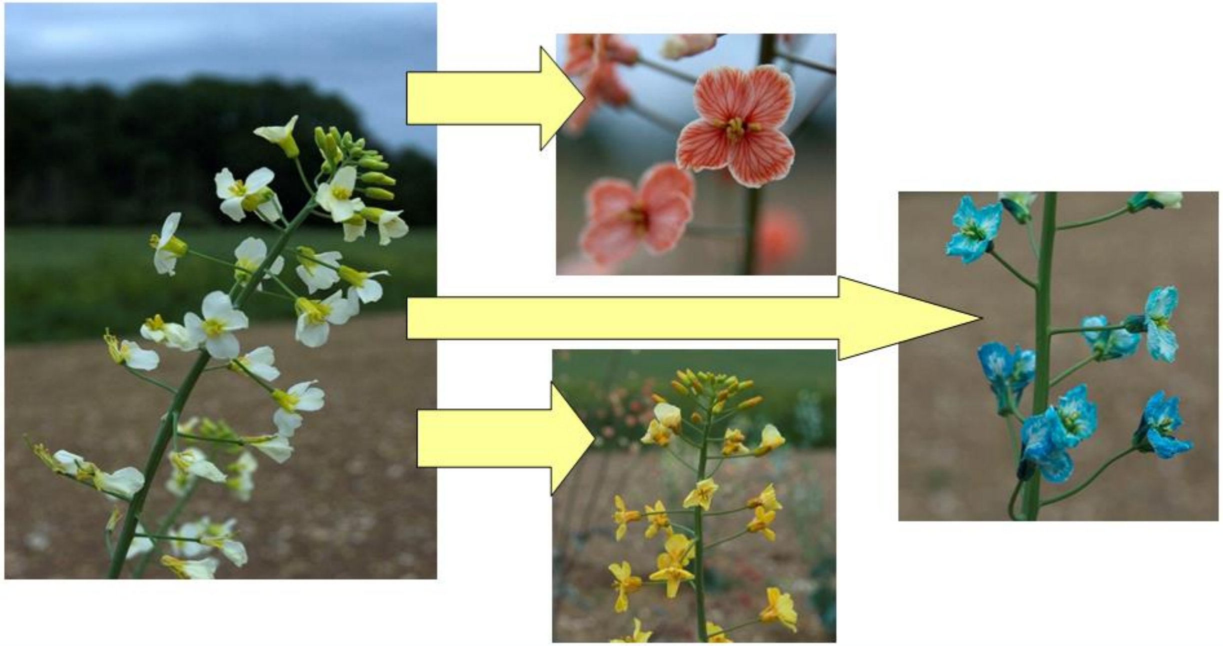
- Use of pest-resistant cultivars

In research pipeline - Reviewed by Hervé & Cortesero (2016) APIS 6 : 463-475

3. Prevention: Use of pest resistant cultivars

Manipulation of petal colour – red oilseed rape

- Pollen beetles are attracted to 'yellow'; Cultivars with petal colour other than yellow are less attractive! Cook et al (2013) Arthropod-Plant Interactions 7:249–258



3. Prevention: Use of pest resistant cultivars

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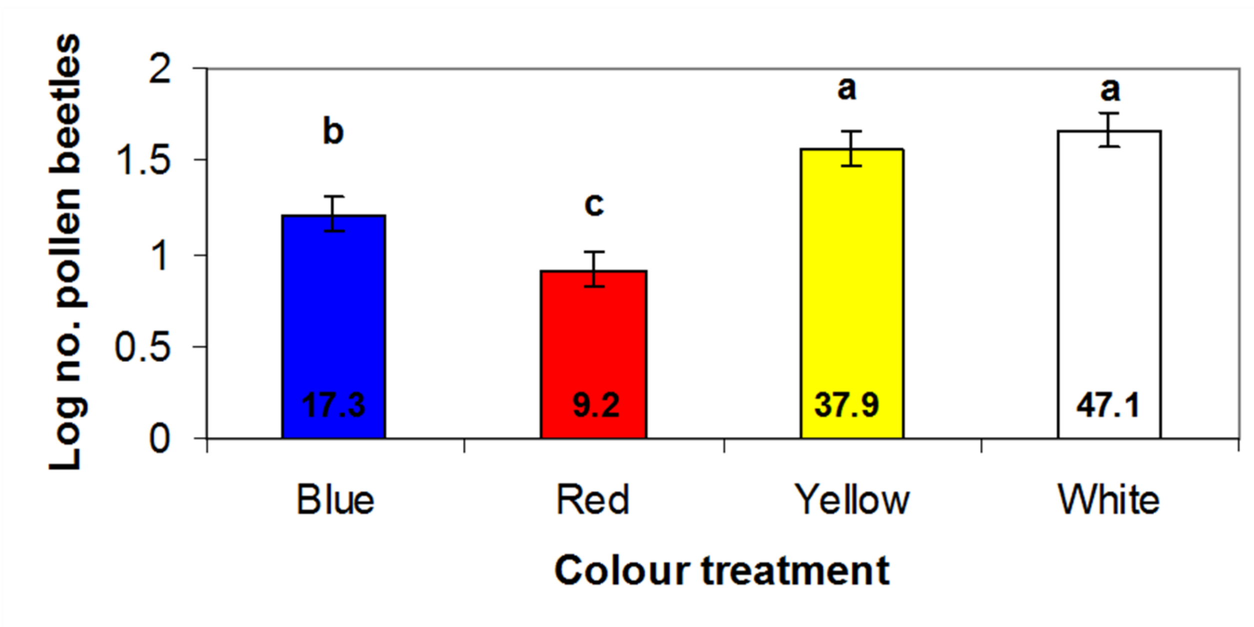

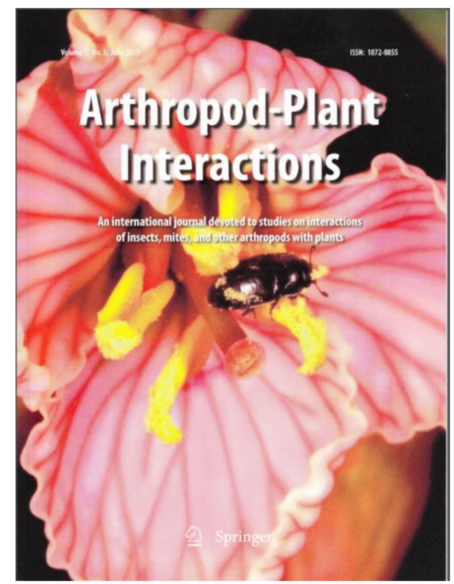

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3. Prevention: Use of pest resistant cultivars

Reduction of attractive plant volatiles

- Attracted to host plant volatiles including isothiocyanates (breakdown products of glucosinolates)

Alkenyl GS → 3-butenyl isothiocyanate

Indolyl GS do not catabolise to form stable ITC

low % alkenyl GS
high% indolyl GS

high % alkenyl GS
low % indolyl GS

Cook et al (2006) Ent. Exp. Appl. 119:221-9

3. Prevention: Habitat diversification

Cultural methods

- Habitat diversification

Reviewed by Skellern & Cook coming soon in special issue on Pollen beetle in Arthropod-Plant Interactions

Trap cropping

3. Prevention: Habitat diversification- **trap cropping**

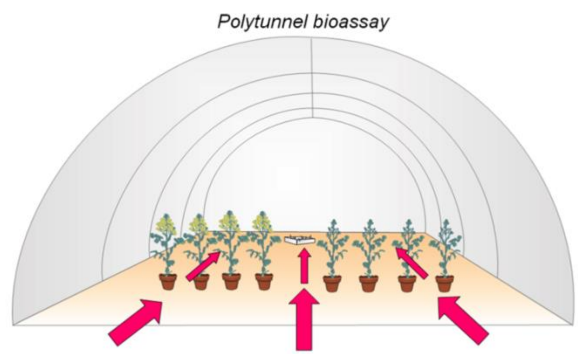
Cook et al., 2006; *Ent. Exp. Appl. 119:221-9*

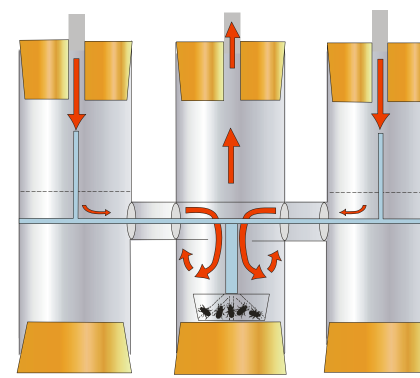
Cook et al., 2007 Arthropod-Plant Interactions 1:57-67

Turnip rape (*Brassica rapa*) trap crop

More attractive than oilseed rape for pollen beetles

- early flowering nature
- more attractive scent (e.g. phenylacetaldehyde)





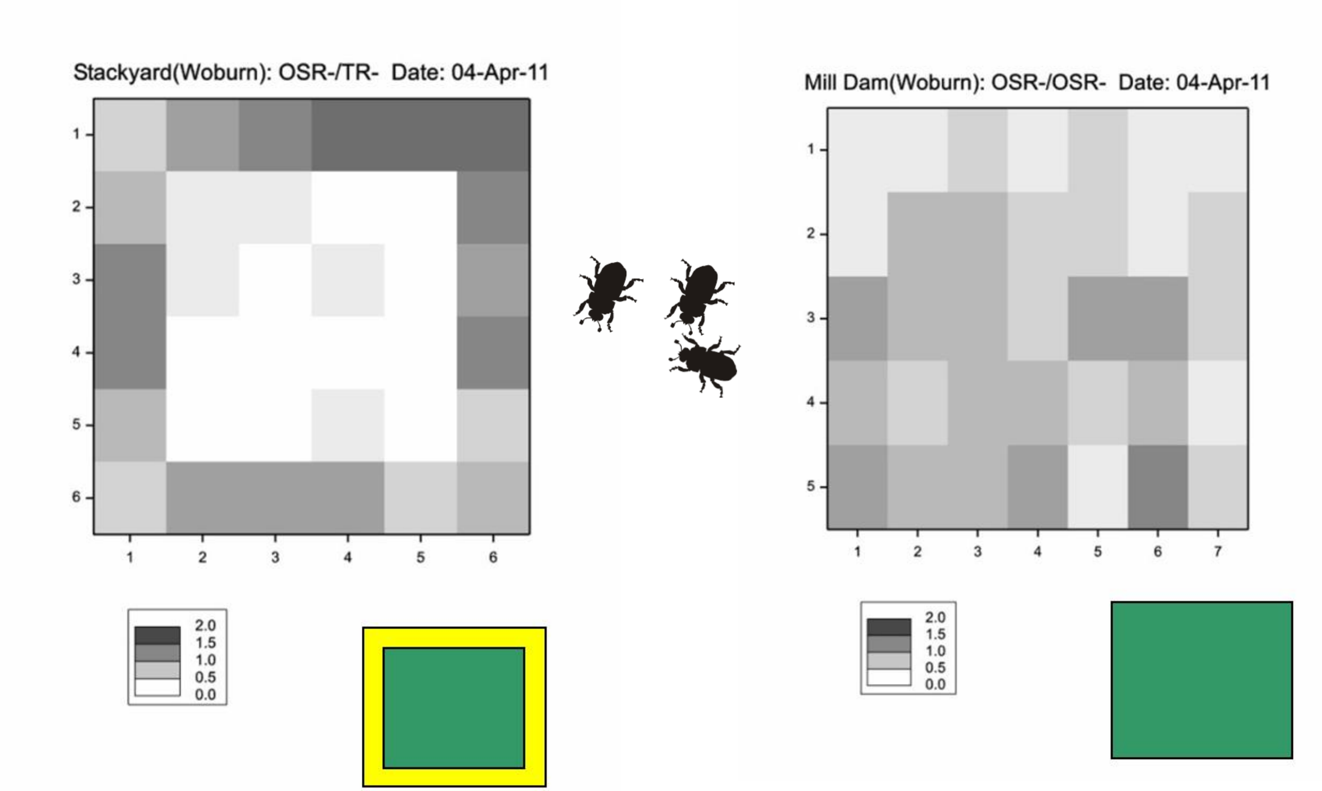
3. Prevention: Habitat diversification (intercropping, cover crops, mixed cropping, **trap cropping**)

Replicated field plots

Pollen beetles can be reduced to below spray thresholds in plots with early flowering trap crops

3. Prevention: Habitat diversification (intercropping, cover crops, mixed cropping, **trap cropping**)

ROTHAMSTED RESEARCH



**Whole field experiments successful … ** But cost:benefit analysis revealed current system NOT currently economically viable for conventional growers (UK) Cook et al (*in prep*)

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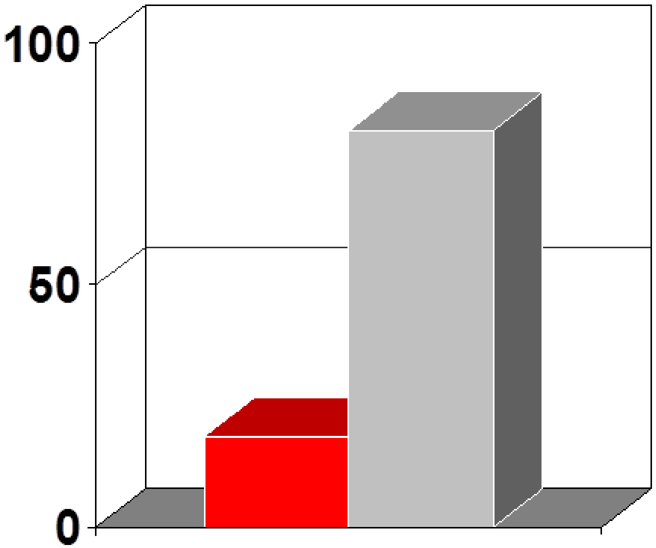
3. Prevention: Use of semiochemicals

- **Non-host volatiles as repellents** e.g. *Lavendula angustifolia*

Essential oil



Mauchline et al., 2005. *Ent. Exp. Appl* 114: 181-188.
Mauchline, Cook, Powell & Osborne (2013) *Ent. Exp. Appl* 146:313-320.
Cook & Mauchline *in prep*

Successful at field trial stage; limitations are cost and formulation

4. Control

- Mechanical e.g. trapping (commercialized)

http://www.csalomontraps.com/

4. Control: Bio-insecticides

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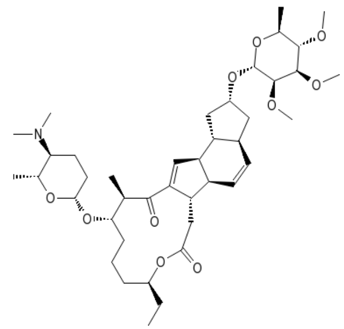
Commercialized

Spinosad insecticide active via contact/ingestion based on chemical compounds found in the bacterial species *Saccharopolyspora spinose*



(not in EU)

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4. Control: Bio-insecticides

In research pipeline

- Entomopathogenic fungi

e.g. *Metarhizium anisopliae, Beauveria bassiana*

- Pathogenic nematodes

e.g. *Steinernema feltiae*

4. Control: Botanical insecticides

Commercialized
Pyrethrum

Research pipeline:
Neem

Carum carvi
Thymus vulgaris
Pavela (2011) Industrial Crops and Products 34:888-892

CARE!
Many are broad spectrum!

4. Control: Conservation biocontrol

The pest

The parasitoid

Meligethes aeneus

Phradis interstitialis

Tersilochus heterocerus

- 80% biocontrol
- Overwinter as cocoons in soil; susceptible to tillage

Sam Cook, Rothamsted Research

4. Control: Conservation biocontrol

Conservation biocontrol of parasitoids of OSR pests via field margins designed to deliver biocontrol:

Inclusion of
Brassica napus **subsp. Biennis Forage rape**

Good to support populations of parasitoids of pollen beetles, seed weevils and pod midge

Skellern & Cook et al., Submitted

Yes we're nearly there! (but not quite....)

1. Set action threshold ✓ ✓
2. Monitor pest density ✓ & assess risk ✓
3. Prevention(✓)
4. Control (✓)

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pure

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HSE Health and Safety Executive
Chemicals Regulation Directorate Pesticides

IOBC
OILB

Working Group Integrated Control in Oilseed Crops

17th Biannual Meeting

September 2018, Zagreb, Croatia (17-19th)

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WG ICOC

International Organization for Biological and Integrated Control of Noxious Animals and Plants West Palaearctic Regional Section (WPRS)