NEW- Integrated Pest Management Strategies for cabbage stem flea beetle

Dr Sam(antha) M. Cook

Section Lead: Next-Gen IPM

Cabbage Stem Flea Beetle (CSFB) *Psylliodes chrysocephala*
"Two pests for the price of one"

@SamCook_IPM

Adult feeding threatens crop establishment

Larval feeding weakens plant, damages growing point, increases susceptibility to disease

Cabbage Stem Flea Beetle (CSFB) *Psylliodes chrysocephala*

Huge damage potential of adult feeding!

@SamCook_IPM

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Seedgrowth.bayer.com

theguardian
Winner of the Pulitzer prize

Neonicotinoid ban hit UK farmers hard

Bugs devour rapeseed crop in Britain as EU ban on pesticide to save bees comes into force

Leaves on a young shoot of rapeseed oil plant eaten by bugs. Photograph: Louise Gray

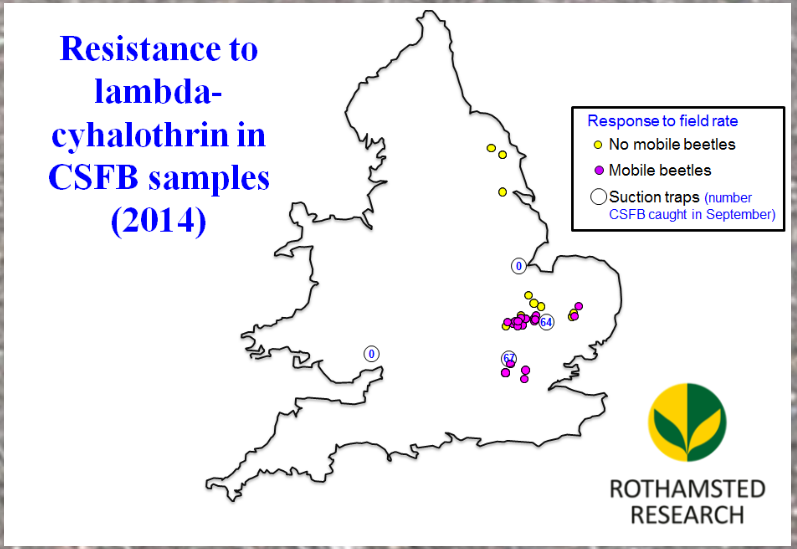
2014 c.5 % crop lost nationally; (70%) in East / South-East

- Pyrethroid resistance confirmed in Germany

  Zimmer et al., 2014 PBP 108:1-7

- Pyrethroid resistance in UK

  Steve Foster et al - AHDB Project 214–0019



Cabbage Stem Flea Beetle (CSFB) *Psylliodes chrysocephala*

Huge damage potential of adult feeding!

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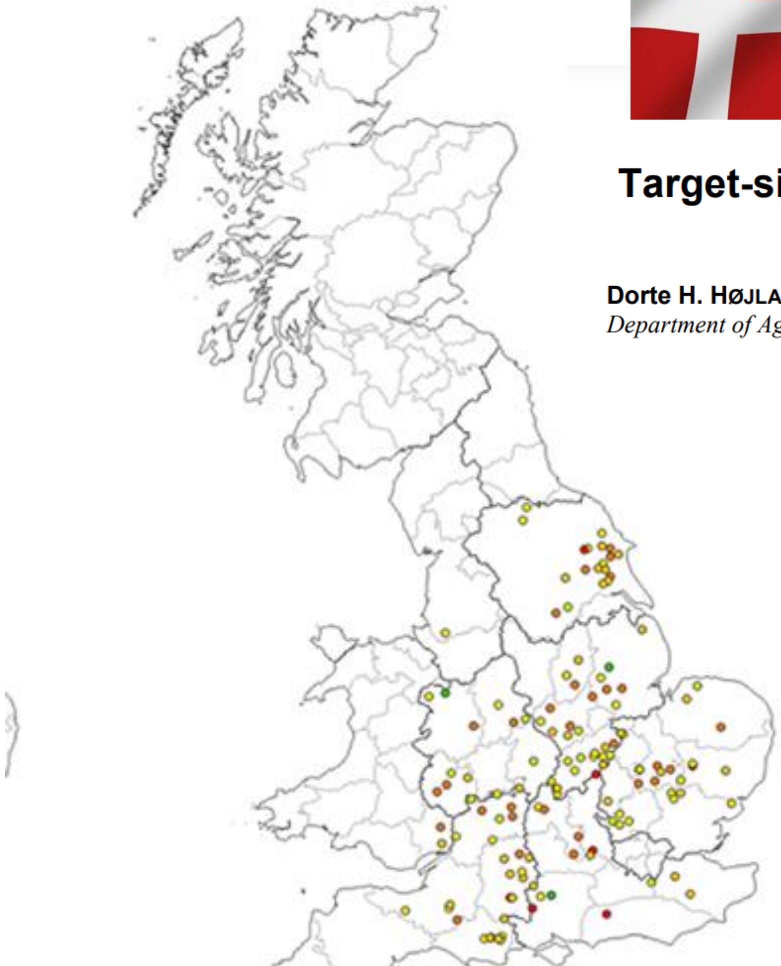
Pyrethroid resistance in CSFB



Bulletin of Insectology ***71*** *(1): 45-49, 2018*
ISSN 1721-8861

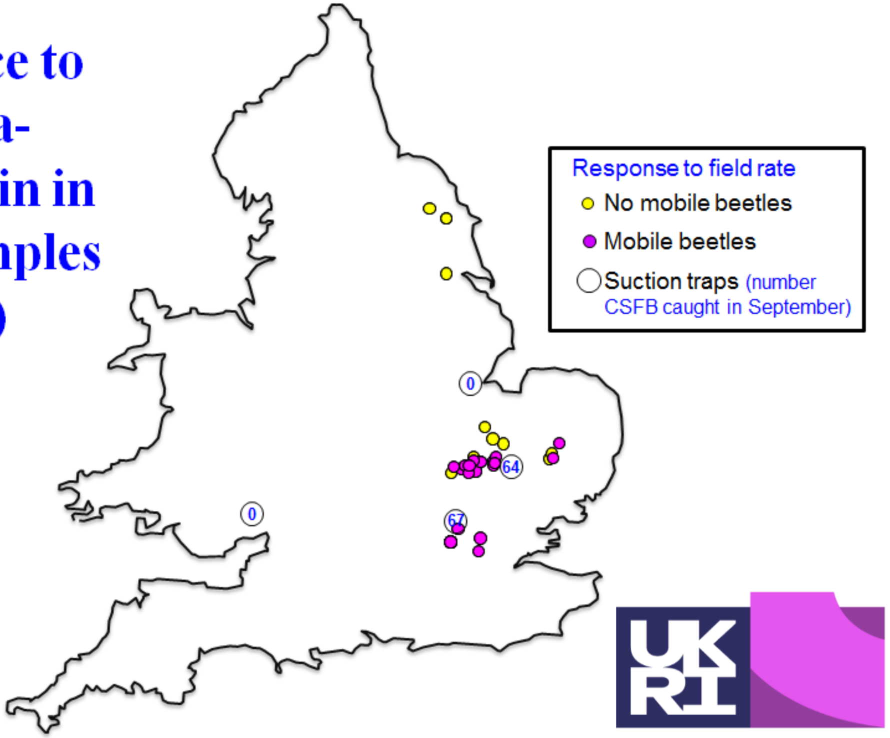
Target-site and metabolic resistance against λ-cyhalothrin in cabbage stem flea beetles in Denmark

Dorte H. HØJLAND, Michael KRISTENSEN
Department of Agroecology, Aarhus University, Slagelse, Denmark

2019

Willis et al (2020) *Crop Protection* 138: 105316

Resistance to lambda-cyhalothrin in CSFB samples (2014)



Control failure of CSFB (& contradictory EU policies) responsible for fast decline in OSR cropping

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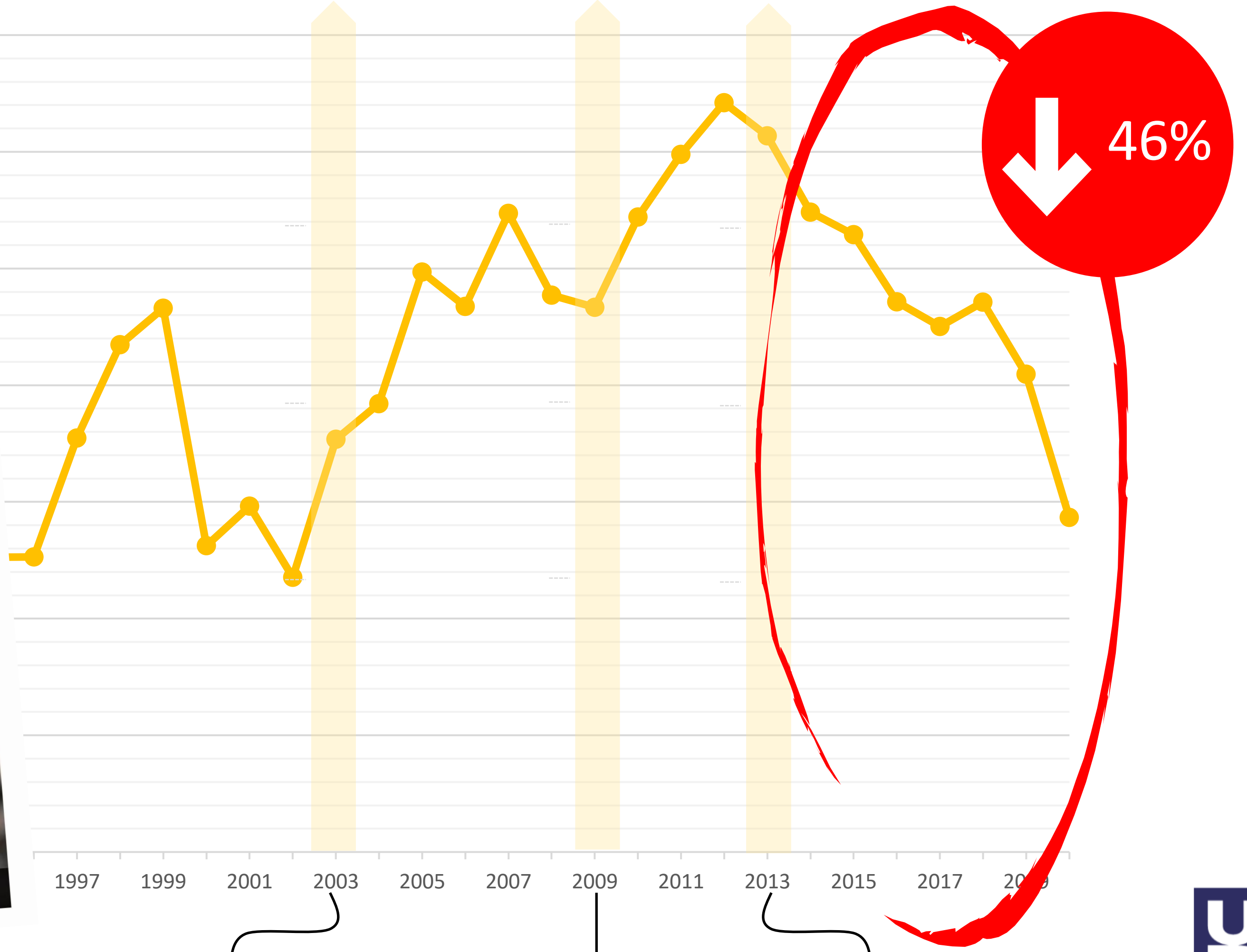
GCB-BIOENERGY
BIOPRODUCTS FOR A SUSTAINABLE BIOECONOMY

OPINION | Open Access

How contradictory EU policies led to the development of a pest: The story of oilseed rape and the cabbage stem flea beetle

Patricia A. Ortega-Ramos, Samantha M. Cook, Alice L. Mauchline

First published: 07 January 2022 | https://doi.org/10.1111/gcbb.12922



Directives
Biofuels policy (2003/03/EC)
Energy Taxation(2003/96/EC)

Directives
Renewable Energy (2009/28/EC)
Fuel Quality (2009/30/EC)
Sustainable Use of Pesticides package

Regulation
Neonicotinoid ban
(2013/485)

UKRI

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@BeetlePatry

Integrated Pest Management Strategies for CSFB

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@SamCook_IPM

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- IPM is an environmentally sensitive approach to pest management that relies on a combination practices (*including the judicious use of pesticides*) using information on the life cycles of pests and their interaction with the environment

EPA United States Environmental Protection Agency

- 4 usual steps in IPM programmes:

1. **Set action threshold**
2. **Monitor pest density & Risk assessment**
3. **Prevention** – cultural methods e.g. crop rotation, use of pest-resistant cultivars, habitat diversification (e.g. companion planting); semiochemicals (e.g. pheromone repellents)
4. **Control** – population reduction via: mechanical methods (e.g. mass trapping), inundative biological control, conservation biocontrol & bio/botanical insecticides or synthetic pesticides ***as a last resort***

Integrated Pest Management Strategies for CSFB

@BeetlePatry
@SamCook_IPM

ROTHAMSTED RESEARCH

- IPM is an environmentally sensitive approach to pest management that relies on a combination practices (*including the judicious use of pesticides*) using information on the life cycles of pests and their interaction with the environment

EPA United States Environmental Protection Agency

- Can be insecticide-based:

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

1

With the new draft Sustainable Use Regulation proposing that IPM strategies for all main crop/pest combinations become mandatory in each Member State, **ecologically-based IPM strategies are a <u>need</u> not an option!**

Life cycle

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@SamCook_IPM

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Received: 13 August 2021 | Revised: 18 November 2021 | Accepted: 30 November 2021
DOI: 10.1111/gcbb.12918

GCB-BIOENERGY WILEY

REVIEW ARTICLE

Integrated pest management strategies for cabbage stem flea beetle (*Psylliodes chrysocephala*) in oilseed rape

Patricia A. Ortega-Ramos[1,2] | Duncan J. Coston[1,2] | Gaëtan Seimandi-Corda[1] | Alice L. Mauchline[2] | Samantha M. Cook[1]

- CSFB is univoltine (1 generation/year)

UKRI

1. Action thresholds

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Available!

Pest		UK threshold	
	CSFB	25% leaf area eaten	5 larvae /plant
		AHDB	av. 96 adults/ yellow water trap

Thresholds based on responses to insecticides – not physiological

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Lawes Agricultural Trust

Coston et al (*in prep*)

- Testing OSR response to leaf area injury and infestation with CSFB:
- Year 1 examined simulated leaf area injury at various levels (0, **25%**, 50%, 90%)
- Year 2 combined simulated leaf area injury (0, **25%**, 90%) with controlled larval infection (0, 1, **5** or 25 / plant)

1. Action thresholds

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- High leaf area injury (90% removal) did *not* impact the productivity of OSR

  → more research needed to understand crop loss in field

- Negative yield responses seen when 25 CSFB larvae (but not <5) were introduced:

  - Plants were shorter, produced less flowers & pods with lower oil content than other treatments

→ Larval threshold might be too low (?)… but between 5-25 larvae *are* damaging!

❗ Importance of developing strategies for both adults & larvae❗

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Coston et al (*in prep*)

2. Monitoring - adults

Available!

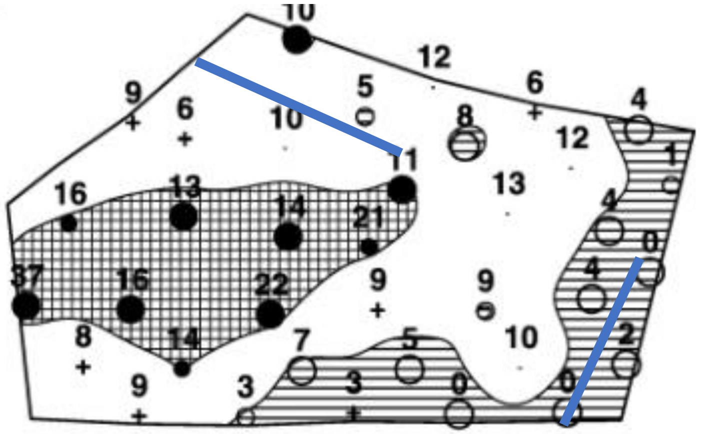
Pest		UK threshold
	CSFB	25% leaf area eaten

- Assess % feeding damage to leaves from 25 plants in transect into crop

Physically demanding, time consuming

25%
Difficult to determine quickly (subjective)

Future-proofing solution?



(A) Total female *P. chrysocephala* distribution

2. Monitoring - larvae

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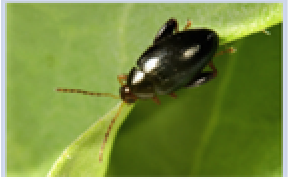
Available!

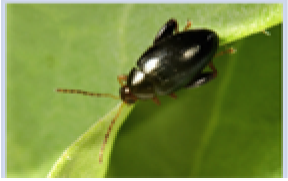
Pest		UK threshold	
	CSFB	25% leaf area eaten	5 larvae /plant

- Count larvae in plant petioles and stems (from at least 25 plants /field) threshold = average 5/plant

Requires identification skills

2. Monitoring - larvae

Available!

Pest		UK threshold	
	CSFB	25% leaf area eaten	5 larvae /plant
			av. 96 adults/ yellow water trap

- Count larvae in plant petioles and stems (from at least 25 plants /field) threshold = average 5/plant
- Run yellow water traps weekly from sowing to end October

Requires identification skills

2. Monitoring

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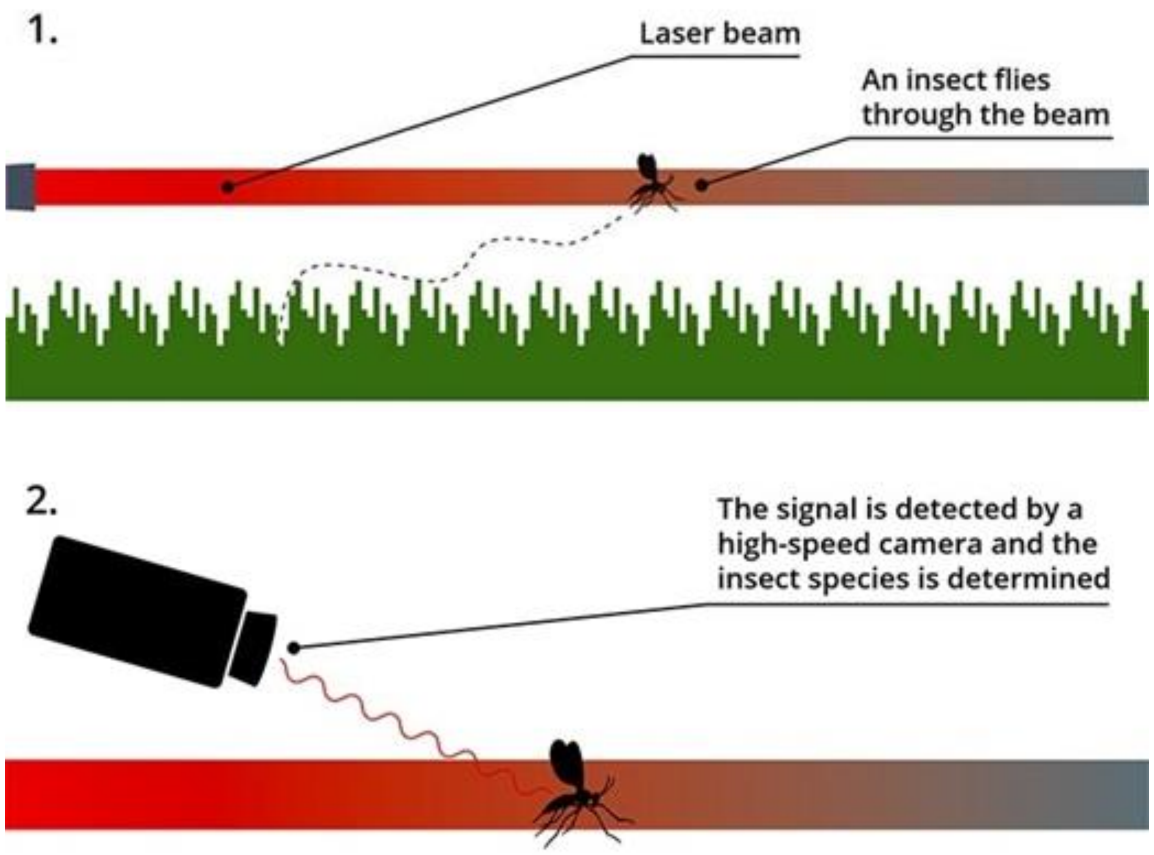
Investigating Pheromones of CSFB for monitoring trap

- Evidence for production of male-produced sex pheromone Bartlet et al (1994) Phys. Ent. 19: 241–250)
  - Male-specific volatiles observed

- Testing responses in the field

2. Monitoring

Potential of optical sensors for real-time monitoring of pest *and beneficial insects*



2. Monitoring

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Potential of optical sensors for real-time monitoring of pest and beneficial insects

Create database library of traces for known species & machine learning for identification algorithms

Kirkeby, Rhydmer, Cook et al., (2021) Scientific Reports 11(1): 1555

CSFB main target; distinguish from *Phyllotreta*

80-95% accuracy

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2. Monitoring

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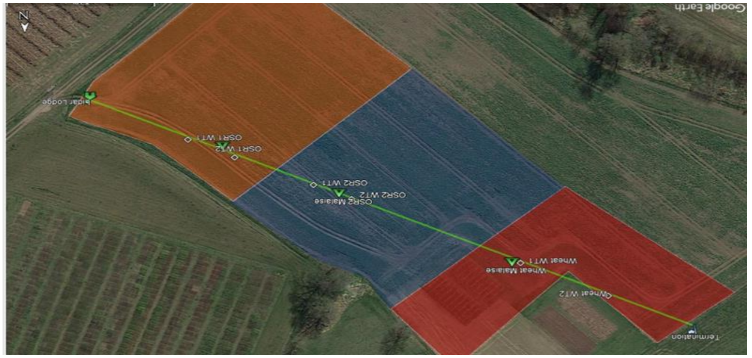
Potential of optical sensors for real-time monitoring of pest and beneficial insects

- Activity and abundance of insects detected by sensor and assigned to CSFB correlates with trap catches in the field



Cook *et al* in prep

BASF We create chemistry

Digital Farming Solutions

FaunaPhotonics

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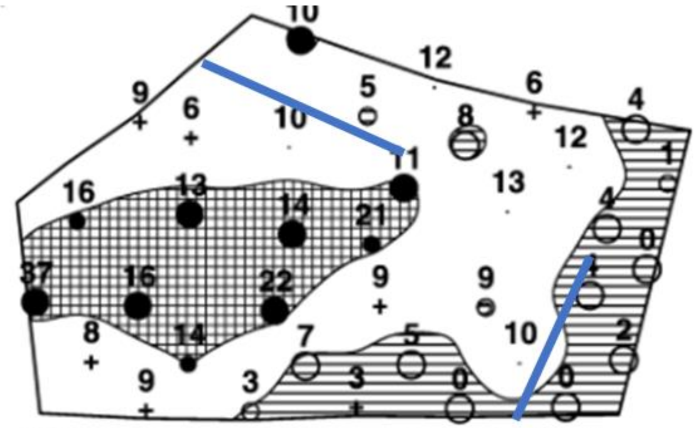
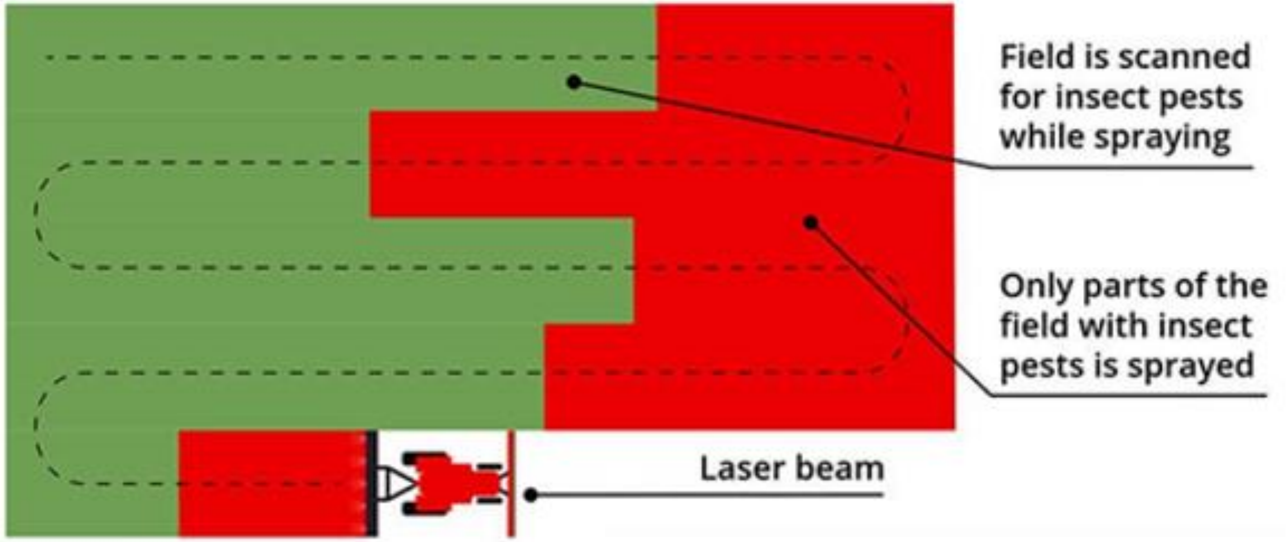
2. Monitoring

Potential of optical sensors for real-time monitoring of pest and beneficial insects

Vision of the future: tractor mounted apparatus that sprays only areas where pests density exceeds threshold (& beneficial density is low)



(A) Total female *P. chrysocephala* distribution



Cook *et al* in prep

3. Prevention - Rotation

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- CSFB infestation greater in new crops sown next to fields with OSR as previous crop Williams and Carden (1961); Alves et al. (2015)
- Longer rotations tend to result in increased OSR yield (Zheng et al. 2020),
- Best preceding crop:
  winter barley, Durham wheat,
  lentils

Terres Inovia
l'agronomie en mouvement

Current work: Rothamsted LSRE

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3. Prevention – Pest resistant cultivars

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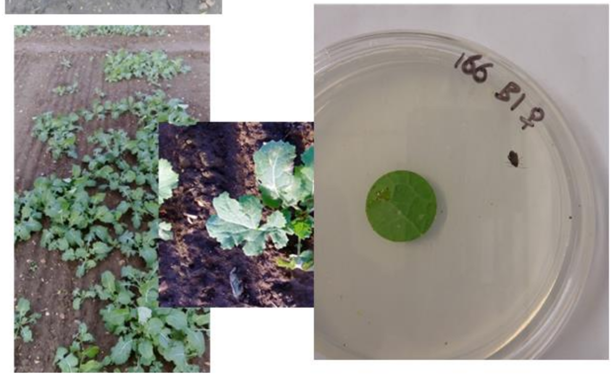
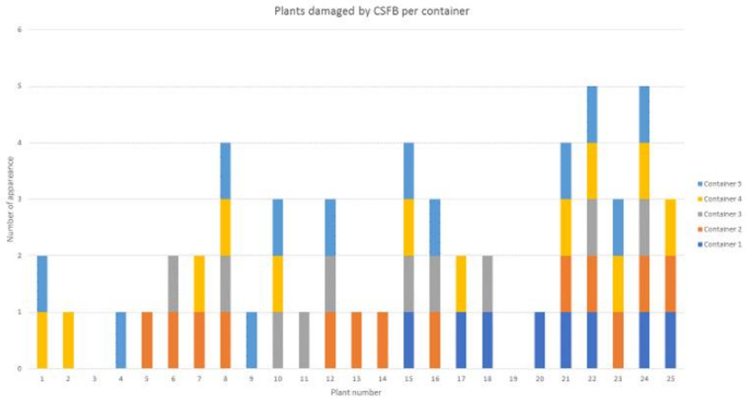
CSFB resistant cultivars – none available!

Variation in feeding responses observed in studies at RRes

OREGIN (Oilseed Rape Genetic Improvement Network)

- Field assessments of diversity sets
- Assessing effects of sucrose and metabolites on feeding





Breeding for Resistance to cabbage stem flea beetle BR2CSFB

Biotechnology and Biological Sciences Research Council

John Innes Centre

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FW | LATEST | KNOW HOW | MARKETS | DISCOVER | 2° Sutton

Philip Case

15 August 2021

More in

Arable | Crop management | Oilseed rape | Pest management

Recommended

Why urgent research is needed to fight flea beetles

UK research begins to develop flea beetle-resistant OSR varieties

© Tim Scrivener

Research teams in the UK have received significant funding to develop new varieties of oilseed rape which are resistant to cabbage stem flea beetle (CSFB).

Scientists from the John Innes Centre (JIC) and Rothamsted Research will work together with seven crop breeding companies as part of the project which aims to find solutions to one of the most significant crop pests, which can devastate OSR crops.

It is thanks to a £1.8m cash injection from a Biotechnology and Biological Sciences Research Council (BBSRC) partnership award.

3. Prevention – Companion planting

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Companion planting = the cultivation of different types of plants in close proximity so as to benefit each other

- Companion planting methods include e.g. intercropping, trap cropping, undersowing etc.

Ulrich Ebert

Being taken up in practise, but not supported by scientific study; not optimised

3. Prevention – Companion planting

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Intercropping = cultivation of more than one crop on the same piece of land at the same time

Peola = spring peas + OSR (canola) – Andrew Howard

The potential for companion cropping and intercropping on UK arable farms
A Nuffield Farming Scholarships Trust Report (2016)

NUFFIELD Farming Scholarships

Winter Peosr (?!)

Photo credits: Ulrich Ebert

Kompetenzzentrum Ökolandbau Niedersachsen GmbH

EcoStack

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3. Prevention – companion cropping

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Companion planting: Trap cropping

Trap crops = plants more attractive than the main crop used to divert pest pressure away from the crop

2005: Turnip rape trap crop borders significantly reduced no. CSFB larvae in OSR vs controls

Barari, Cook, Clark & Williams (2005) BioConrol 50: 69-86

2015-16: Turnip rape trap borders borders significantly reduced CSFB feeding in OSR vs controls

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University of Reading

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Duncan Coston

Coston (2020) PhD ; Coston et al., *in prep*

3. Prevention – companion plantig

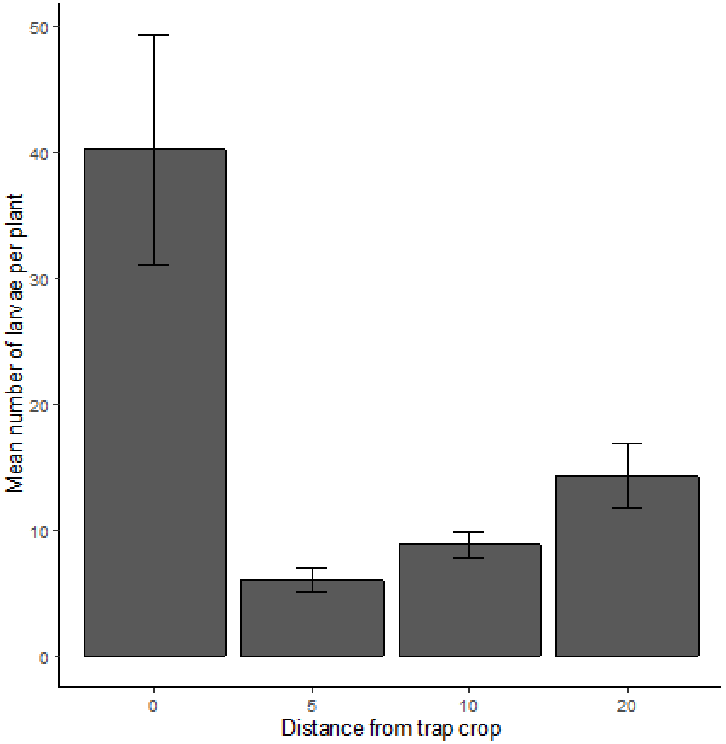
Companion planting: Trap cropping

2005: Turnip rape trap crop borders significantly reduced no. CSFB larvae in OSR vs controls

Barari, Cook, Clark & Williams (2005) BioConrol 50: 69-86

2015-16: Turnip rape trap borders borders significantly reduced CSFB feeding in OSR vs controls

2021-22 Turnip rape trap crop in-field strips significantly reduced CSFB larvae (RSBP Hope Farm)



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Grant Agreement no. 773554

3. Prevention – companion planting

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Nurse crop: a crop planted with another to shelter it from competition from weeds *(&/or pests)*

- Mixed brassicas/white mustard in Clearfield OSR strategy reduces feeding and larval infestation BUT timing of companion removal difficult Coston (2021) PhD ; Coston et al., *in prep*

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Fenugreek & vetch white mustard clovers OSR control

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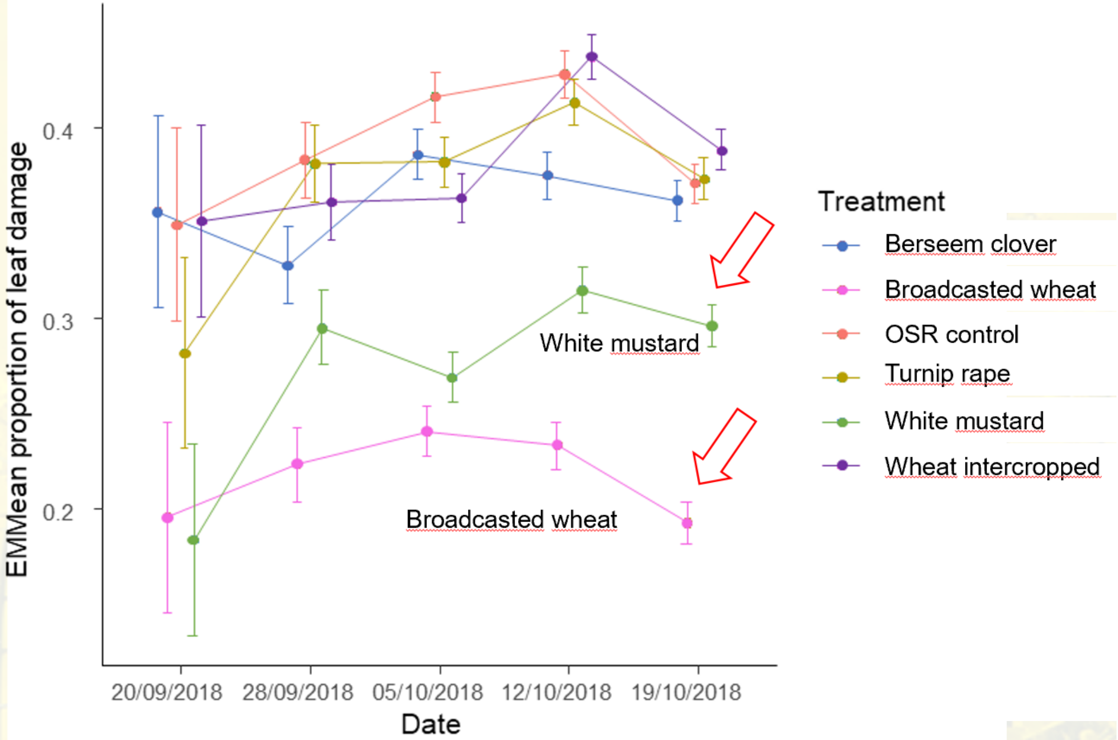
3. Prevention – companion planting

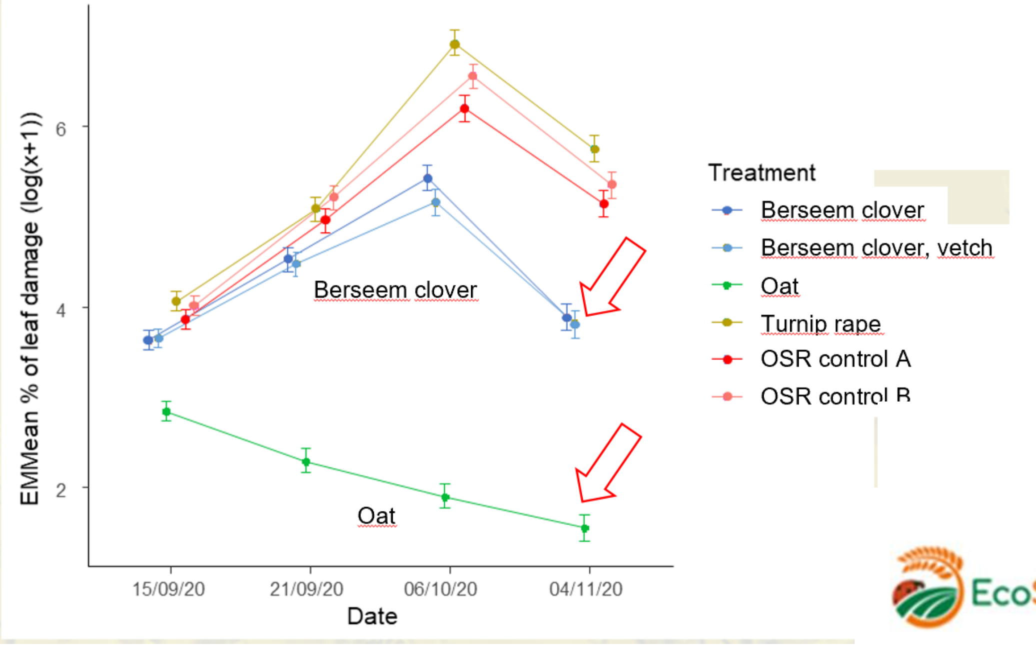
nurse crop: a crop/plants sown with another to shelter it from competition with weeds *(&/or pests)*

- Mixed brassicas/white mustard in Clearfield OSR strategy reduces feeding and larval infestation BUT timing of companion removal difficult Coston (2021) PhD ; Coston et al., *in prep*


Duncan Coston

- Undersowing with berseem clover, wheat/oats significantly reduces feeding damage & larval infestation (inconsistent)





Gaëtan Seimandi-Corda

Todd Jenkins

@SamCook_IPM

Grant Agreement no. 773554

3. Prevention – organic matter / fertilizer

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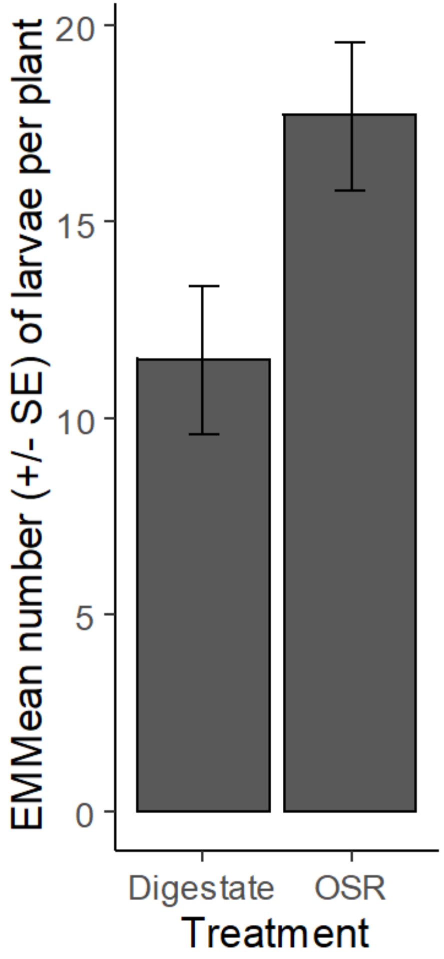
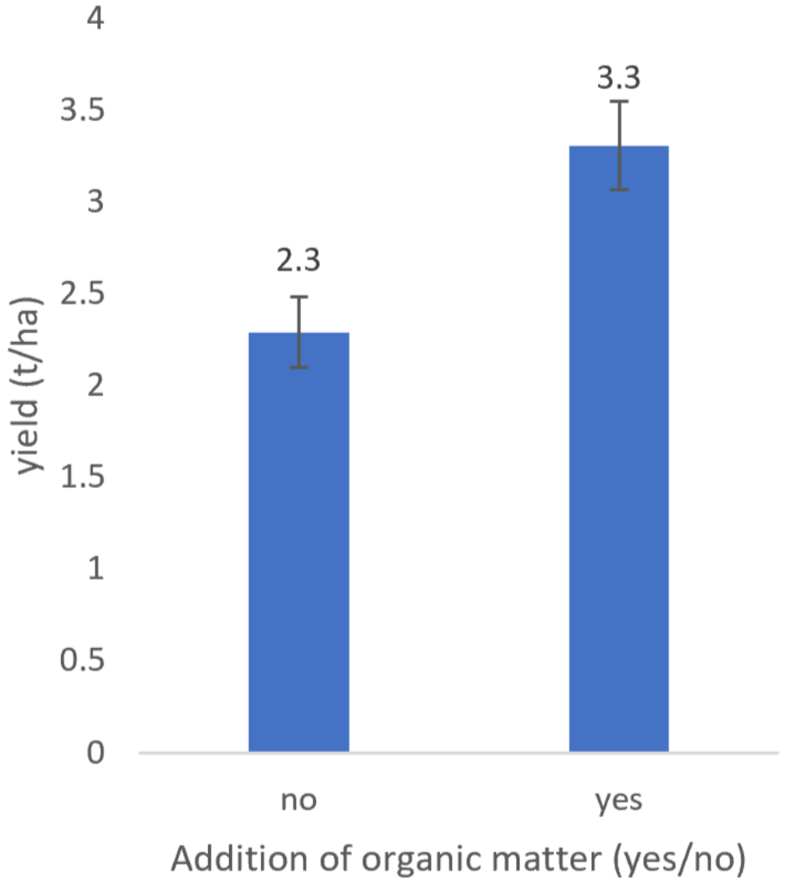
- Plants with more biomass (larger more leaves) more able to cope with larval infestation

  Addition of organic matter / biodigestate (Cross Farm, Harpenden 2020)



Georgina Bray (2021) BASIS report



4. Control – biopesticides

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New insecticides

Promising new approaches e.g. post-transcriptional gene silencing via RNA interference (RNAi), which prevents the manufacture of key proteins in insects, leading to death when ingested


MINI REVIEW article
Front. Agron., 10 December 2021 | https://doi.org/10.3389/fagro.2021.794312

Check for updates

RNAi Targets in Agricultural Pest Insects: Advancements, Knowledge Gaps, and IPM

Jonathan Willow[1,2*], Clauvis Nji Tizi Taning[2], Samantha M. Cook[3], Silva Sulg[1], Ana I. Silva[4], Guy Smagghe[2] and Eve Veromann[1]

https://www.frontiersin.org/articles/10.3389/fagro.2021.794312/full


Using insect-killing nematodes to control the cabbage stem flea beetle

Claire Hoarau, Heather Campbell, Tom Pope
Harper Adams University, Newport, Shropshire, TF10 8NB, UK
19303100@live.harper.ac.uk
@CSFB_Hoa

Take-home message

Nematodes are effective in controlling cabbage stem flea beetles in the lab, and the next step is to test them under field conditions to see if they would remain effective in commercial crops.

Biopesticides

entomopathogenic fungi → *Metarhizium anisopliae* and *Beauveria bassiana*

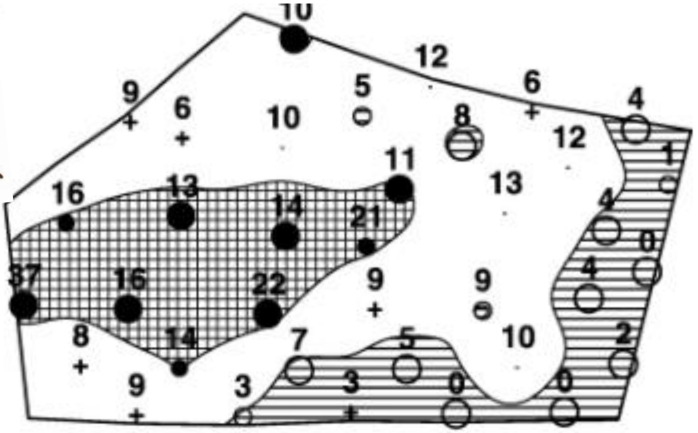
entomopathogenic nematodes → *Steinernema feltiae* tested along with *Heterorhabditis bacteriophora*

4. Control – biological control

Conservation Biological Control = Use of **agronomy** & **habitat management** methods to conserve the natural enemies of crop pests in the agri-environment to provide pest regulation

Predators

Carabid (ground) beetles: Spatial association & biocontrol potential of *Trechus quadristriatus*
(Warner et al., 2003 Ent Exp Appl 109:225-234)



(A) Total female *P. chrysocephala* distribution

2020-2023

- Role of predators in pest regulation and effect of companion crops

Comparison of pitfall trapping and camera trapping in the UK and Denmark

Rove beetles

Spiders

ground beetles

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4. Control – conservation biocontrol

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Parasitoids (attacking larval stage CSFB)

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c.20% (2005)

Tersilochus microgaster

Barari, Cook, Clark & Williams (2005) BioConrol 50: 69-86

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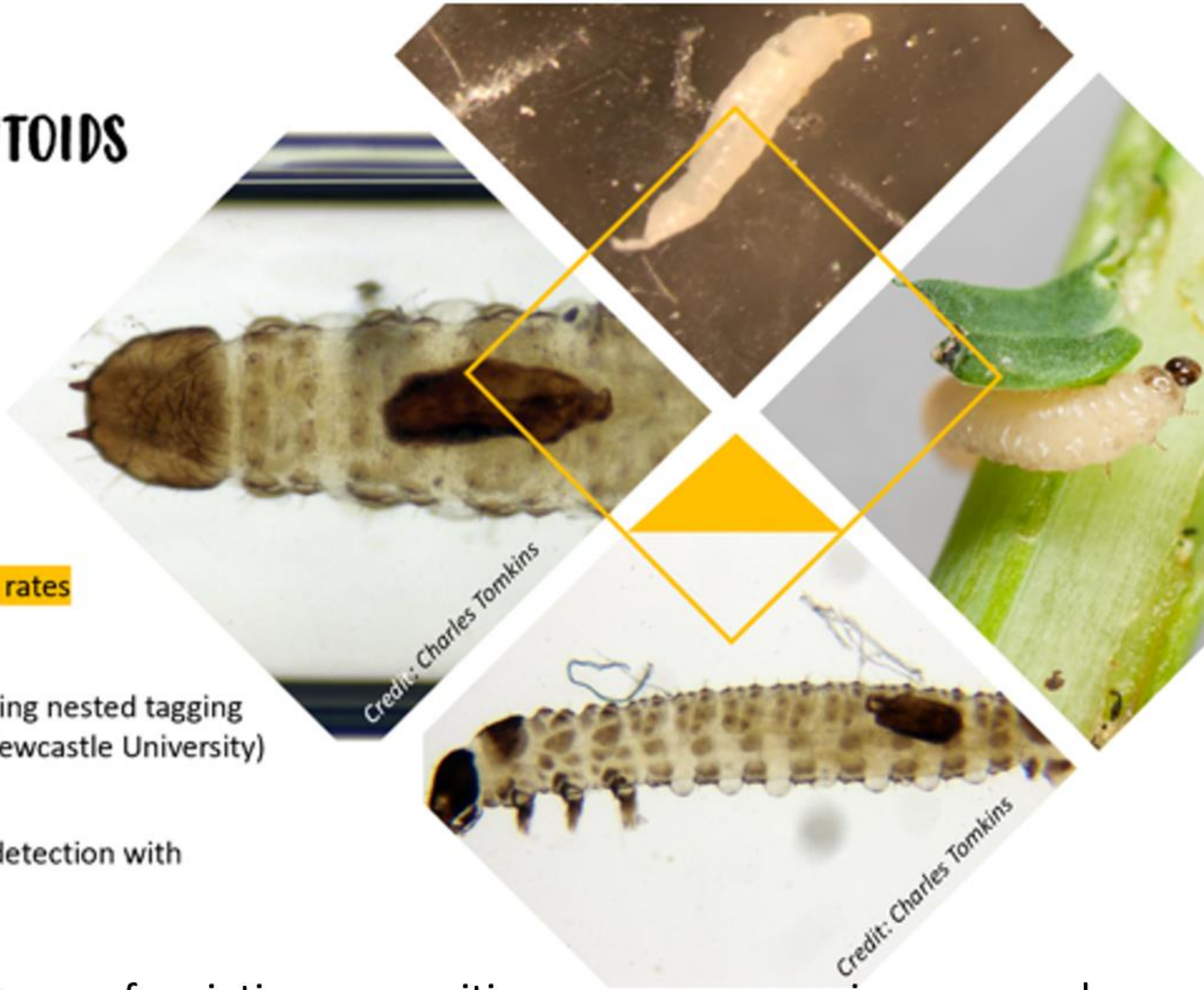
LARVAL PARASITOIDS

- Determining parasitism rates and distribution
- Parasitism detection using nested tagging DNA metabarcoding (Newcastle University)
- Comparing molecular detection with manual dissections



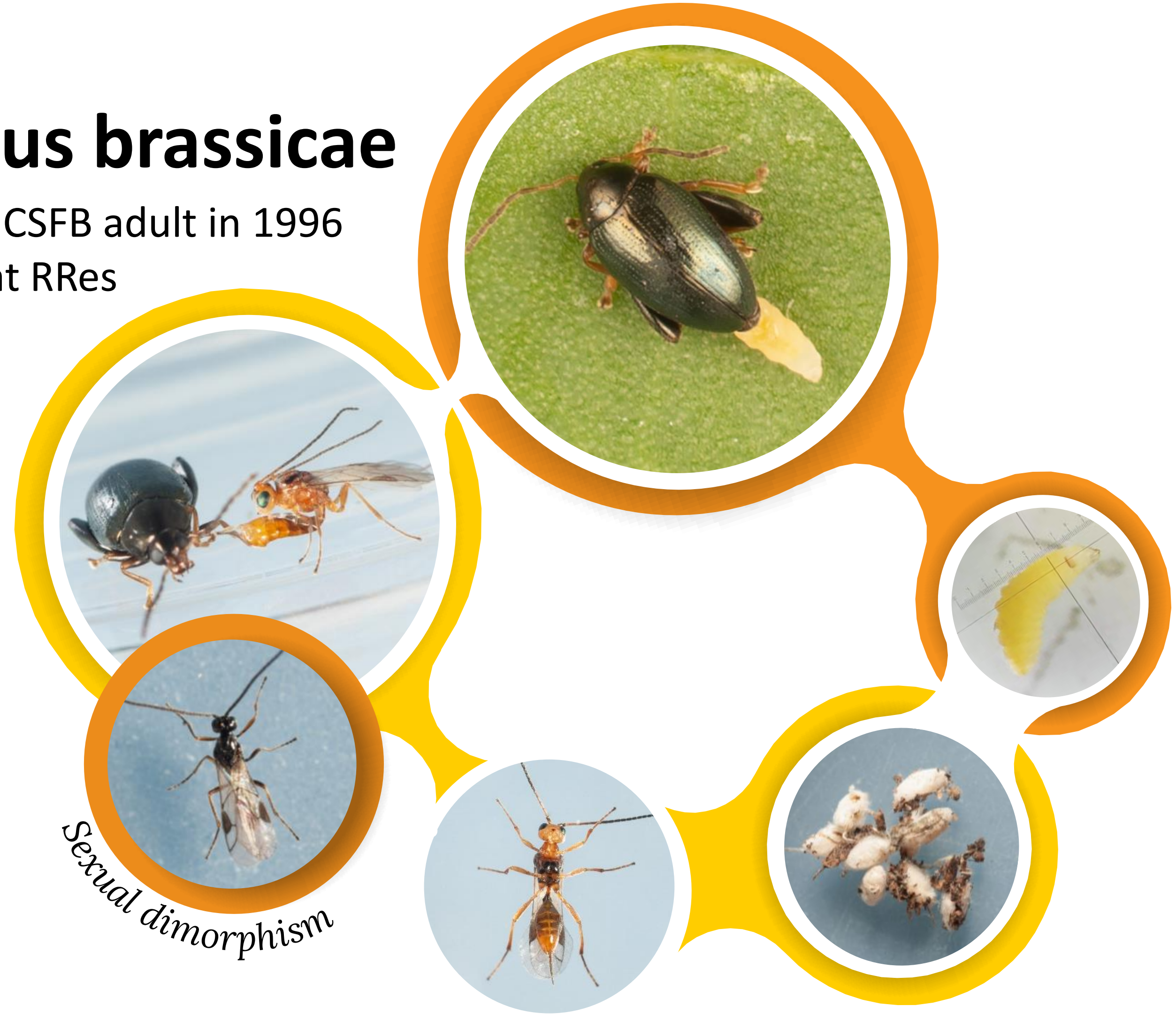
- Agronomical drivers of variation – parasitism more common in unsprayed crops

4. Control – conservation biocontrol

Parasitoids (attacking adult CSFB)

Microctonus brassicae

first reared from a CSFB adult in 1996 by A.W. Ferguson at RRes



First described in: Jordan et al (2020) Ent. Exp Appl 168:360-370

4. Control – conservation biocontrol

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@SamCook_IPM

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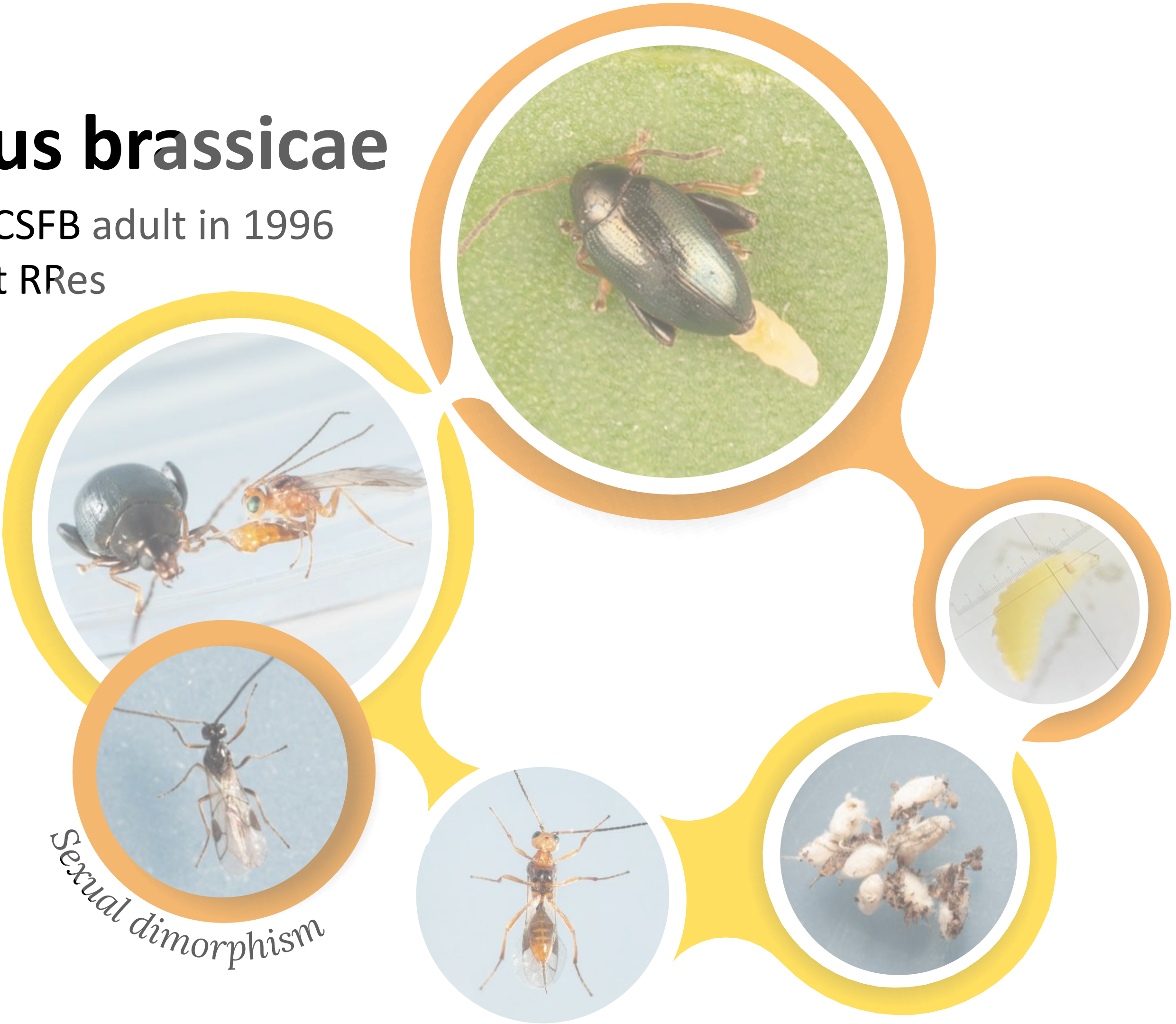
Parasitoids (attacking adult CSFB)

Microctonus brassicae

first reared from a CSFB adult in 1996 by A.W. Ferguson at RRes

Present in **96% of the fields studied**

Maximun parasitization rate 36%



fera The Food and Environment Research Agency

University of Reading

4. Control – conservation biocontrol

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@SamCook_IPM

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How can we support CSFB natural enemy populations?

Soil management

Both adult and larval parasitoids pupate in the soil; minimum tillage could improve survival?

Uncropped habitat

Provision of uncultivated habitat & pollen/nectar resources?

Pesticide use

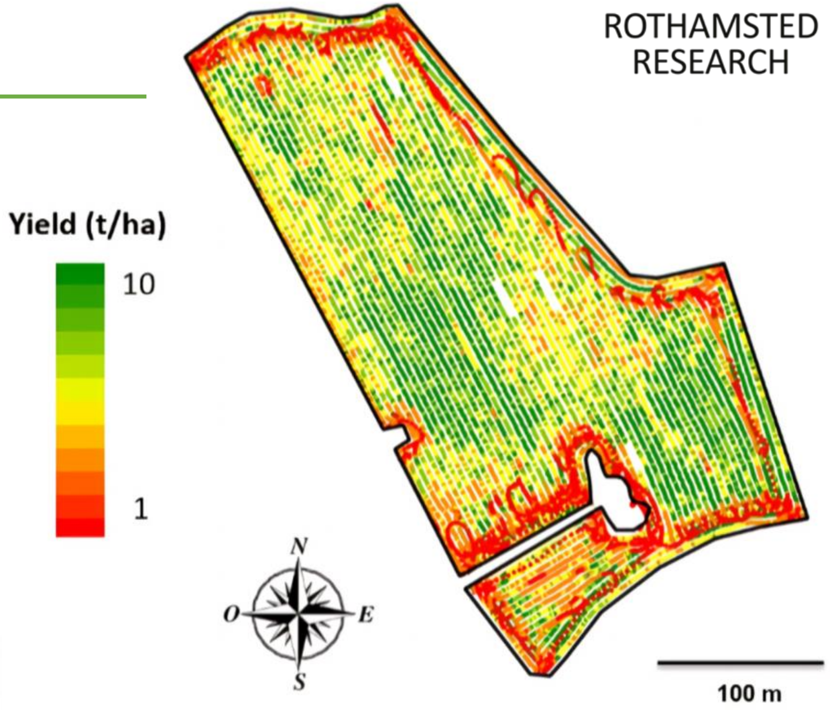
Susceptible to pyrethroids – spray only when necessary!

AgZero+
Towards sustainable, climate-neutral farming

Current work: Explore effects of off-crop habitats (field margins, hegderows, treelines) and the biodiversity they support) on crop yields

ROTHAMSTED RESEARCH

Can off-crop habitats mitigate yield decline at field edges?



- We will statistically relate yield variation within the field to adjacent field boundary features
  e.g. does a hedgerow - and the beneficial insects it supports - help to reduce yield decline compared to e.g. a forest?

- We need LOTS of GPS enabled yield monitor data (from any arable crop, any year, any place in EU)

- If you use a GPS enabled combine
  and are prepared to share your yield monitor data
  please get in touch! Sam.cook@rothamsted.ac.uk

- GDPR compliant! ALL data will be kept confidential, will be anonymised and will not be shared
- See our video at https://www.youtube.com/watch?v=wagwR7wW1fc&feature=youtu.be

EcoStack

In a future where fewer synthetic insecticides will be available, IPM strategies will be vital to providing a framework for sustainable pest management…

… and maintaining OSR as part of a healthy arable rotation!

Thank you for listening!

Tak fordi du lyttede!

Sam Cook & Patricia Ortega-Ramos
Rothamsted Research, Harpenden, Herts., AL5 2JQ

sam.cook@Rothamsted.ac.uk

Hassan Barari
Ingrid Williams
Suzanne Clark
Duncan Coston
Lin Field
Gaëtan Seimandi-Corda
Todd Jenkins
Fred Beaudoin
Mike Birkett
Jozsef Vuts
Alex Dye
Martin Torrance
Jenny Swain

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Simon Kightley

NIAB TAG

Tom Breeze
Simon Potts
Robbie Girling
Alice Mauchline

University of Reading

Larissa Collins

fera

Darren Evans
Kirsten Miller
Jordan Cuff

Newcastle University

Toke Høye

AARHUS UNIVERSITY

UKRI Biotechnology and Biological Sciences Research Council

Current work: Explore effects of off-crop habitats (field margins, hegderows, treelines) and the biodiversity they support) on crop yields

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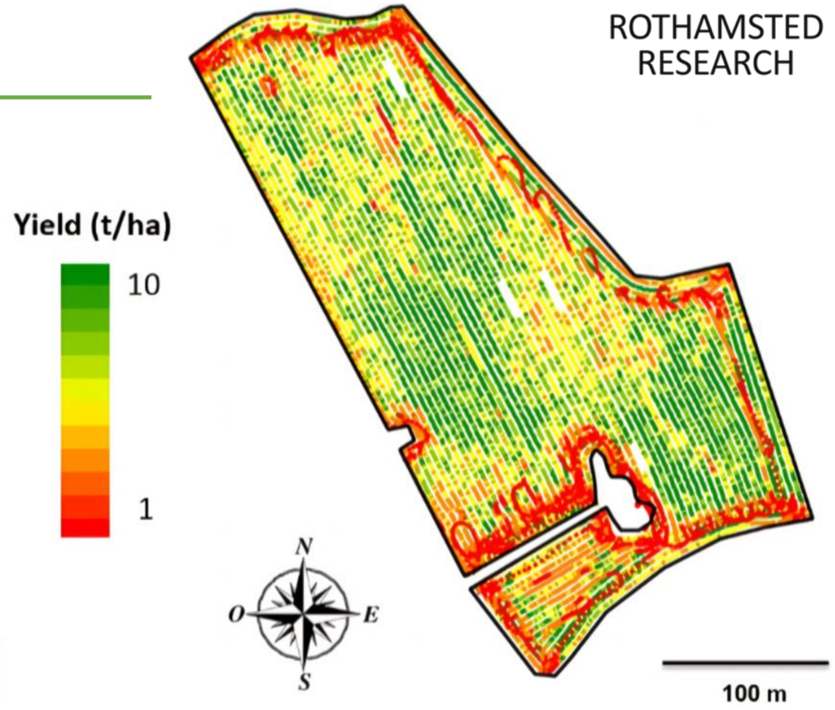

- We need LOTS of GPS enabled yield monitor data (from any arable crop, any year, any place in EU)

- If you use a GPS enabled combine
  and are prepared to share your yield monitor data
  please get in touch! Sam.cook@rothamsted.ac.uk

- GDPR compliant! ALL data will be kept confidential, will be anonymised and will not be shared
- See our video at https://www.youtube.com/watch?v=wagwR7wW1fc&feature=youtu.be

ROTHAMSTED RESEARCH

EcoStack