Integrated Pest Management Strategies for cabbage stem flea beetle

Sam Cook & Patricia Ortega-Ramos
Cabbage Stem Flea Beetle (CSFB) *Psylliodes chrysocephala*

Life cycle

Ortega-Ramos, P. A., Coston, D. J., Seimandi-Corda, G., Mauchline, A. L., & Cook, S. M. (2021). *Global Change Biology Bioenergy.*
Cabbage Stem Flea Beetle (CSFB) *Psylliodes chrysocephala*
“Two pests for the price of one”

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!

*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

*Resistance to lambda-cyhalothrin in CSFB samples (2014)*
CSFB (and contradictory EU policies) - responsible for the decline in OSR cropping

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

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UK FERA stats 2020
CSFB (and contradictory EU policies) - responsible for the decline in OSR cropping
CSFB (and contradictory EU policies) responsible for the decline in OSR cropping.

Flea beetle havoc leaves UK needing rapeseed imports.

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)
Integrated Pest Management Strategies for CSFB

• 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.

• 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; semiochemicals (e.g. pheromone repellents); habitat diversification (e.g. companion planting)
  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
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1. Action thresholds

| Pest     | UK threshold                  | Thresholds based on responses to insecticides – not physiological |
|----------|-------------------------------|-----------------------------------------------------------------|
| CSFB     | 25% leaf area eaten           | av. 96 adults/yellow water trap                                 |
|          | 5 larvae/plant                 |                                                                 |

- 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

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

more research needed to understand crop loss in field

• 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!

⚠️ Use early-sowing strategies to avoid adult damage with caution as these increase time for egg laying and larval development ⚠️
2. Monitoring - adults

| 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?
2. Monitoring - larvae

- 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

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

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

1. Laser beam
   An insect flies through the beam

2. The signal is detected by a high-speed camera and the insect species is determined
2. Monitoring

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

80-95% accuracy

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

CSFB main target; distinguish from *Phyllotreta*
2. Monitoring

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
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)

Cook et al in prep
3. Prevention

CSFB resistant cultivars
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)

UK research begins to develop flea beetle-resistant OSR varieties

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 = 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.
3. Prevention

**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) BioControl 50: 69-86

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

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

**Companion planting: Trap cropping**

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

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

2021-22 Turnip rape trap crop in-field strips significantly reduced CSFB larvae
3. Prevention

Companion planting: undersown ‘nurse’ plants

- Undersowing with mixed brassicas/white mustard in Clearfield OSR strategy reduces feeding and larval infestation
  BUT timing of companion removal difficult

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

nurse crop: a crop planted with another to shelter it from competition with weeds (\&/or pests)
3. Prevention

Companion planting: undersown ‘nurse’ plants

• Undersowing with mixed brassicas/white mustard in Clearfield OSR strategy reduces feeding and larval infestation BUT timing of companion removal difficult

• Undersowing with berseem clover, wheat/oats reduces adult damage and larval infestation (inconsistent – WHY? )
3. Prevention

- Longer rotations
- Minimum tillage
- Long stubble
- Organic matter / fertilizer
  - Plants with more biomass (larger more leaves) more able to cope with larval infestation
  - Addition of organic matter / biodigestate (Cross Farm, Harpenden 2020)
4. Control

**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.

[Image: Using insect-killing nematodes to control the cabbage stem flea beetle]

*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*

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

[Link: https://www.frontiersin.org/articles/10.3389/fagro.2021.794312/full]
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* and *Pterostichus madidus*  (Warner et al., 2003 Ent Exp Appl 109:225-234)

(A) Total female *P. chrysocephala* (B) *T. quadristriatus*, and (A) *P. madidus* distributions. Posted symbols and number indicate sampling position and the number of beetles trapped in the pitfall trap at each sample location, respectively.
4. 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

EcoStack project (2020 – 2023)

- Role of predators in pest regulation
- Effect of companion crops
- Comparison of pitfall and camera trapping in the UK and Denmark

Grant Agreement no. 773554
4. Control

Parasitoids

**Tersilochus tripartitus**
60% parasitization rate
(Aubert et al., 1958)

**Tersilochus microgaster**
7.7% parasitization (Barari et al., 2005)

**Microctonus melanopus**
Low incidence
(Jourdheuil, 1960)

**Microctonus brassicae**
First reared from CSFB in Rothamsted 1996
(Ferguson)

Others

Misdentification!
4. Control

Parasitoids (attacking CSFB larvae)

Determining **parasitism rates** and **distribution** using nested tagging DNA metabarcoding

Up to **33% parasitisation rate** detected

**Tersilochus microgaster** sequence detected
4. Control

Parasitoids (attacking adult CSFB)

**Microctonus brassicae**

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

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

Parasitoids (attacking adult CSFB)

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4. Control

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

Maximum parasitization rate 36%

Sexual dimorphism
4. Control

How can we support CSFB natural enemy populations?

Soil management
Both adult and larval parasitoids pupate in the soil; minimum tillage can improve survival

Field margins
Provision of uncultivated habitat & pollen/nectar resources?

Pesticide use
Susceptible to pyrethroids – spray only when necessary!
4. Control

How can we support CSFB natural enemy populations?

Temporal succession of parasitoid emergence

Pesticide use
Susceptible to pyrethroids – spray only when necessary!
Summary of IPM strategies for CSFB

1. Set action threshold

Action thresholds must be based on scientific studies, consider the variation in crop tolerance, control efficacy, insecticide cost, crop value and presence and abundance of natural enemies.

Sensor-based automatic identification of adults in real time. Identification, synthesis of attractant semiochemicals could improve monitoring efficacy.

2. Monitor pest density & risk assessment

3. Prevention – cultural methods

Further work is required to understand the trade-offs between crop establishment and larval damage and adult migration; effect of stubble length; the efficacy of nurse and trap crop species.

3. Prevention – cultural methods

No information on the natural enemies' distribution, control potential and impacts of landscape and management factors. Few or no effective synthetic insecticides available.

4. Control methods

@BeetlePatry
@SamCook_IPM
Moving forward into IPM

In a future where fewer synthetic insecticides will be available and their use less profitable...

IPM strategies will be vital to providing a framework for sustainable pest management

There is a need for further research to produce the scientific advances necessary for the development and commercialization of tools and techniques needed to make IPM a reality.

Also, to facilitate the successful adoption of IPM techniques, farmers need to be incentivized to adopt IPM - farmers’ needs should be better considered.
Thank you for listening!

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