Biopesticides for disease and insect pest management

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We need durable, sustainable IPM systems (within IFM) for all crops.

- EU Farm 2 Fork, 50% pesticide reduction, promoting IPM.
- COP15, 50% reduction in harmful effects of pesticides.

Over reliance on conventional pesticides.

We lack IPM tools.

- Many IPM tools are not being used to their full potential.

We lack a holistic science of IPM.

Regulatory, political, economic & technical barriers too!
PART 1: DEVELOPING MANAGEMENT TOOLS FOR BIOPESTICIDES.

PART 2: UNDERSTANDING INTERACTIONS IN IPM – THE CENTRAL ROLE OF PLANT GENOTYPE.
(1) Getting the best out of biopesticides / bioprotectants

- AHDB AMBER project (Warwick, ADAS, Silsoe, consultants).
- **Application & Management of Biopesticides for Efficacy & Reliability** – PE, PO, HNS crops.
- Develop generic management tools and practices to improve performance.
Biopesticides work well if used carefully in IPM: bioinsecticides 2nd line of defence to predators / parasitoids; biofungicides alternate with conventional fungicides

- Increasing number of products on the market.
- Only licensed products can be used: these products must show efficacy in registration trials.

- In growers’ hands – a mixed picture:
  - Some work well.
  - Others are poor / inconsistent.
  - Improve management practices: but exact reasons for suboptimal performance are often unclear.
We observed how growers used commercial microbial biopesticide products at crop scale.

**Benchmarking trials**

- Natural P&D outbreaks.
- Followed best practice guidelines.
- Compared to standard treatment if possible.

**6 growers**

(1 biopesticide, 1 P/D)

**5 licensed fungal BCA products**

- 7 crops (pepper, cucumber, 5 ornamentals)
- 3 pests (aphids, thrips, whitefly)
- 3 diseases (mildew, botrytis, root rots)

**Detailed information on biopesticide & grower performance**

*Product storage & viability; spray application; deposition on the crop; persistence; P/D control; environmental conditions; non-target effects; phytotoxicity.*
We observed how growers used commercial microbial biopesticide products at crop scale.

- Efficacy varied: some better than conventional pesticide; others did not work at all.

- Labels & guidance hard to follow. Lack of accessible information: (effective dose, persistence, environmental conditions, application etc.).

- Precision spray application needed:
  - Spray equipment not fit for purpose (1 exception).
  - Lack of evidence to optimize spray application (e.g. water volumes too high).
  - Not ‘winning the numbers game’: deliver effective dose, right place, right time.
  - Record efficacy data in a consistent way to enable meaningful analysis.
How can we move towards precision application?

- Optimize spraying (water volume).
- Develop models to test different application strategies in silico.
- Understand how the biopesticide ‘behaves’ (biofungicides persistence).
- Better data recording templates (pool grower information).
- Lots of knowledge exchange.
Spray application: amount deposited is sensitive to **water volume** even at constant dose

- Label recs for hort crops are up to 1500 L / ha.
- Inefficient, wasteful.
- Nominal constant dose application, amount of a.i. deposited on plants is actually sensitive to water volume.
- Lower volumes deposit more a.i. / leaf area. Spraying is faster, less waste.
- Increasing the concentration of a.i. on leaves increases efficacy.
- Water needed for activation?
- Biopesticides have an optimum water volume for efficacy - but companies don’t know what this is!

![Graph showing the relationship between water volume and amount deposited](image.png)

**Silsoe track sprayer experiments using tracer dyes (herbs, ornamentals, tomato)**
Precision application: a boxcar model of pest development to inform biopesticide use strategy

- Whitefly, aphids.
- Tracks the maturation of individuals to next life stage, reproduction & lifespan.
- Add in biopesticide mortality.
- **Test out biopesticide strategies in silico** (persistence, infection efficacy, speed of kill, frequency, pest population size).

**Effect of EPF speed of kill on whitefly growth (using dummy data)**

- Initial population size = 1000 adults.
- Sprayed on day 7, 14, 21, 28 and 35.
- All stages affected.
- Infection efficacy = 90%.
- Persistence = 5 days.
Powdery mildew control: Short survival on leaves of the obligate mycoparasite *Ampelomyces* in absence of its host

- Used to inform a smart decision support system.
- AI prediction of PM risk period from glasshouse environmental data.

Some growers assumed *Ampelomyces* was a preventative
Improving access to information

• Grower articles, talks, webinars - 9 crop sectors.

• Application workshops (> 100 growers / agronomists).

• Literature reviews to summarize how conditions affect performance (biofungicides).

• New data recording template for growers.
Biopesticides: ‘winning the numbers game’.

- Biopesticides need precision application, based on detailed understanding of their mode of action.
- Strategic thinking & funding for UK crop protection.

Other areas that require investment:

- Formulation.
- Mass production.
- Use in IPM systems.
A holistic science of IPM – interactions in the system

Biological crop protection: a ‘slow down / speed up’ strategy for aphid management on brassica

Creative commons
Aphids: Combining durable crop resistance with biocontrols

- *Myzus persicae* & *Brevicoryne brassicae* on Brassica crops.
- Partial (durable) host plant resistance.
- Conservation control with parasitoids.
- Plant defence activator cis-jasmone.
- Entomopathogenic fungi as a biopesticide.
Alter activity of aphids & their parasitoids with plant volatile cis-jasmone

Gene expression responses

Targeted plant breeding

Slow aphid development?

Identify partial resistance in Brassica

Interactions in the system
Key findings: putting crop genotype at the centre of IPM

1. Partial resistance in *B. oleracea*, *B. cretica*, *B. napus* – includes inbred lines

2. Resistance in *B. oleracea* is associated with upregulation of the SA pathway

3. Cis-jasmone activates parasitoid activity & affects aphid behaviour depending on plant genotype.

4. Natural populations of parasitoids are active in most field sites, giving opportunities to use them in conservation biological control.

5. Partially resistant plants make aphid nymphs susceptible to fungal biopesticides
Partial resistance to *Myzus* & *Brevicoryne* identified in vegetable brassicas (& *B. napus*). Confirmed in field cage experiments. Associated with reduced intrinsic rate of increase.

Backed up by field cage studies

Resistant -> Susceptible

16, 9, 15, 11, 12, 17
Partial resistance linked to the SA signalling pathway

- RNA seq: more DE genes in line 8 >> 9 at 2h & 6 h.
- Reversed at 24 h.

Concentrations of A: Jasmonic acid, B: Salicylic acid, C: Abscisic acid and D: GA4 from mass spec. leaf tissue of *Brassica oleracea*.

- 8= susceptible.
- 9 = resistant.
- 20 *Myzus* in clip cage for 24 h.
- Previous work identifies JA as the defence pathway – but have not worked with R vs S plants.
cis-Jasmone treatment increased parasitism (lab)

SBN = Samurai *Brassica napus*

EGBN = English Giant *Brassica napus*

TR = Turnip Rutabaga

Field trial

Aphid landing behaviour

군사

神	

X 50

Mean no. aphids on plant ± SE

Untreated

cis-jasmonate treated

ns

* 

OSR variety

Samurai

Temple
Brassica genotype makes aphid nymphs susceptible to fungal pathogen

- Strain 1.72 kills nymphs of *Myzus* & *Brevicoryne*.
- But strain 1.72 is no longer available as a commercial biopesticide.
- 433.99 is available as a product but does not normally kill nymphs.
- Partially resistant *B. oleraceae* – and *B. cretica* – make nymphs susceptible.
• Chemical pesticides

• Biocontrols

• Plant resistance

Physical, cultural, conservation, forecasting

• Future IPM:
  • Multi-trait crop improvements that work in synergy with biocontrols / bioprotectants.

• Holistic IPM science.

• We need a strategic plan for IPM.

Stenberg (2017). A conceptual framework for IPM. TiPS.
Thank you