Biopesticides for disease and insect pest management

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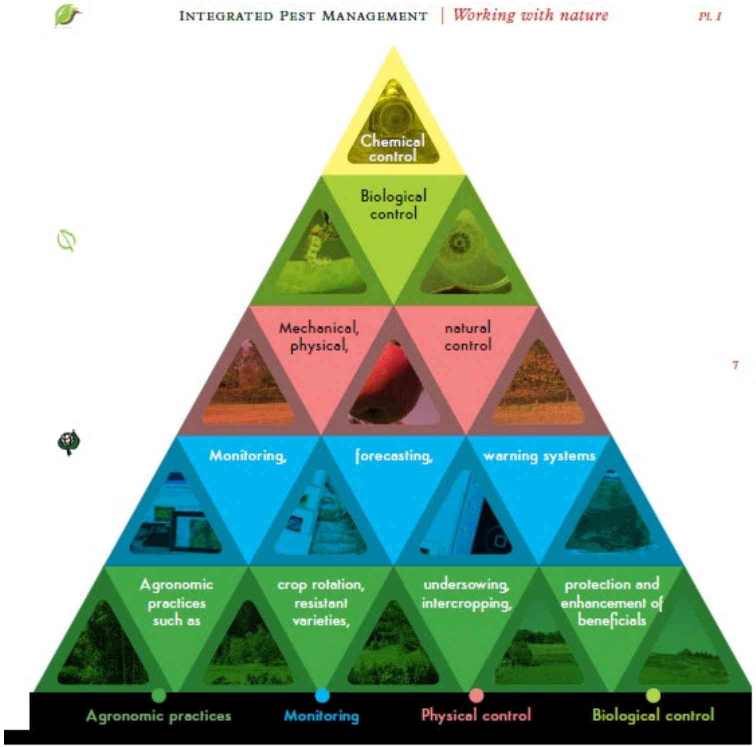


IBMA Global

background

- 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.

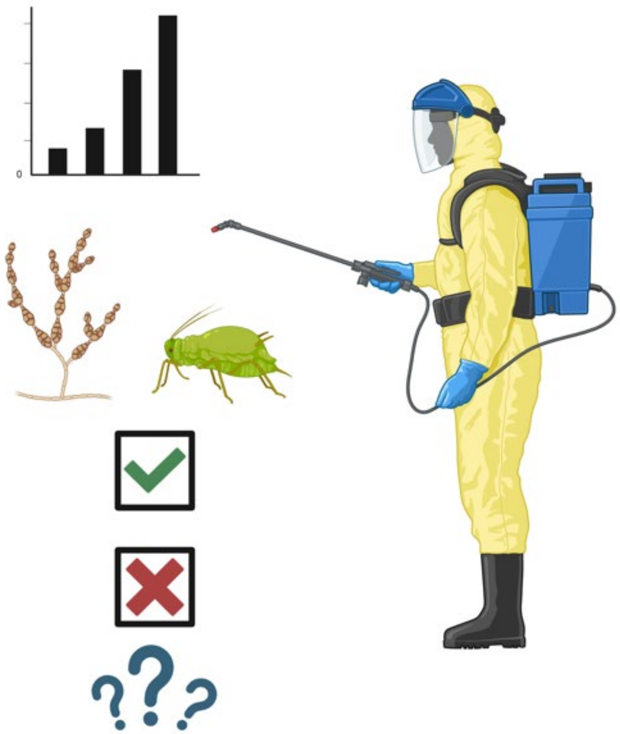
(1) Getting the best out of biopesticides / bioprotectants

- AHDB AMBER project (Warwick, ADAS, Silsoe, consultants).
- **A**pplication & **M**anagement of **B**iopesticides for **E**fficacy & **R**eliability – PE, PO, HNS crops.
- Biopesticides – living micro-organisms & natural products.
- Develop generic management tools and practices to improve performance.

Biopesticides work well if used carefully in IPM: bioinsecticides 2^{nd} 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.

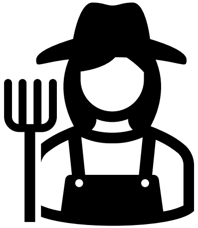


We observed how growers used commercial microbial biopesticide products at crop scale.

Benchmarking trials

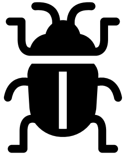
- Natural P&D outbreaks.
- Followed best practice guidelines.
- Compared to standard treatment if possible.

5 licensed fungal BCA products

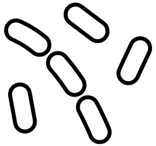


6 growers
(1 biopesticide, 1 P/D)

7 crops (pepper, cucumber, 5 ornamentals)



3 pests (aphids, thrips, whitefly)



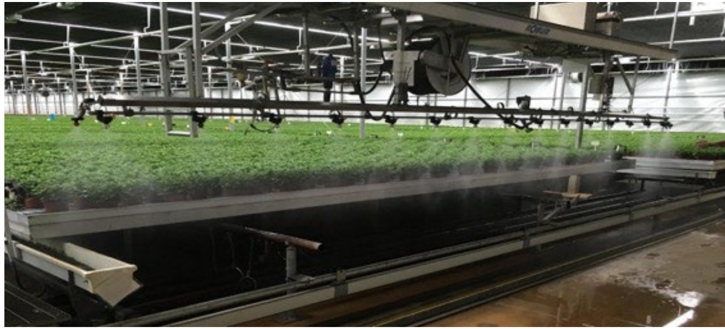
3 diseases (mildew, botrytis, root rots)

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.

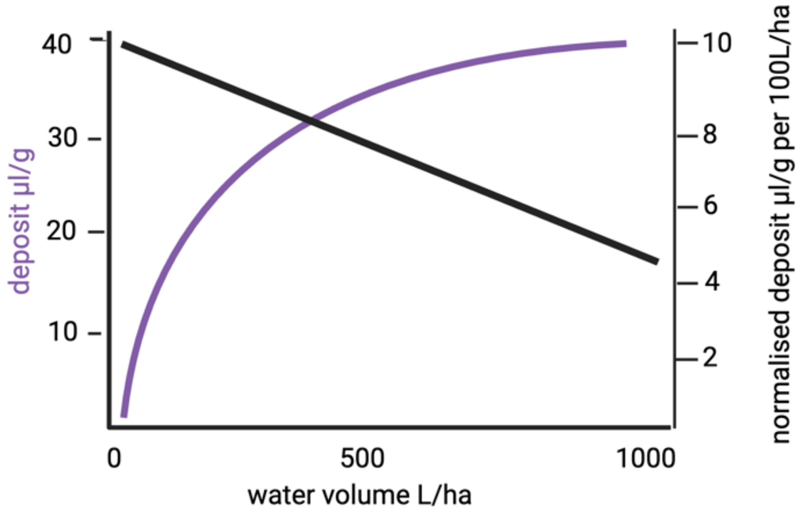
- Efficacy varied: some better than conventional pesticide; others did not work at all.
- Labels & guidance hard to follow. Lack of accessible information: (effective dose, persistence, environmental conditions, application etc.).
- Precision spray application needed:
- Spray equipment not fit for purpose (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.

<u>Spray application</u>: amount deposited is sensitive to <u>water volume</u> even at constant dose

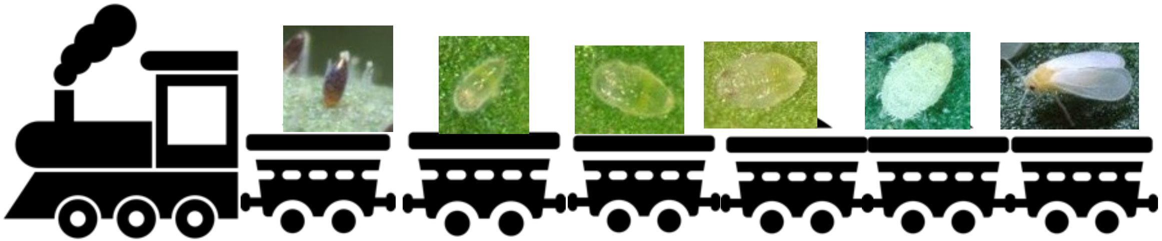


Silsoe track sprayer experiments using tracer dyes (herbs, ornamentals, tomato)

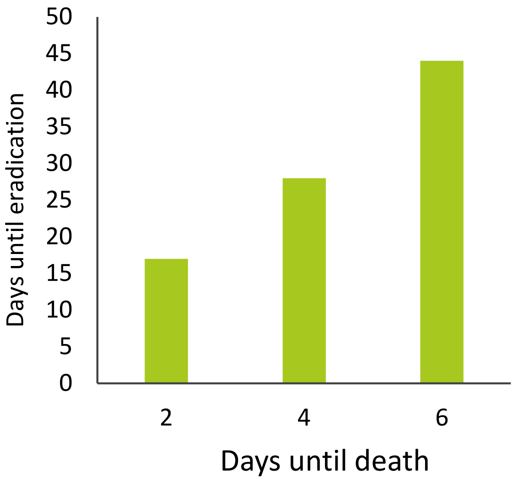
- Label recs for hort crops are up to 1500 L / ha.
- Inefficient, wasteful.
- Nominal constant dose application, amount of a.i. deposited on plants is actually sensitive to water volume.
- Lower volumes deposit more a.i. / leaf area. Spraying is faster, less waste.
- Increasing the concentration of a.i.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

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).

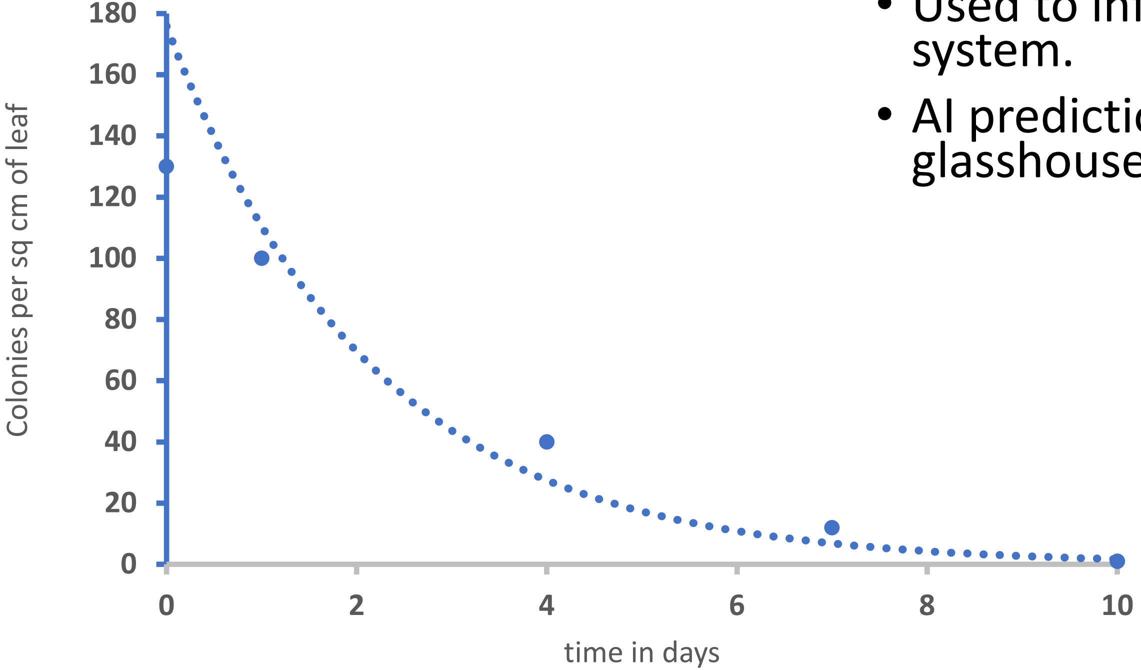


Effect of EPF speed of kill on whitefly growth (using dummy data)



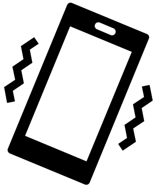
- Initial population size = 1000 adults.
- Sprayed on day 7, 14, 21, 28 and 35.
- All stages affected.
- Infection efficacy = 90%.
- Persistence = 5 days.

Powdery mildew control: Short survival on leaves of the obligate mycoparasite *Ampelomyces* in absence of its host



Some growers assumed *Ampelomyces* was a preventative

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



Narrow use window

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.

(2) A holistic science of IPM – interactions in the system

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

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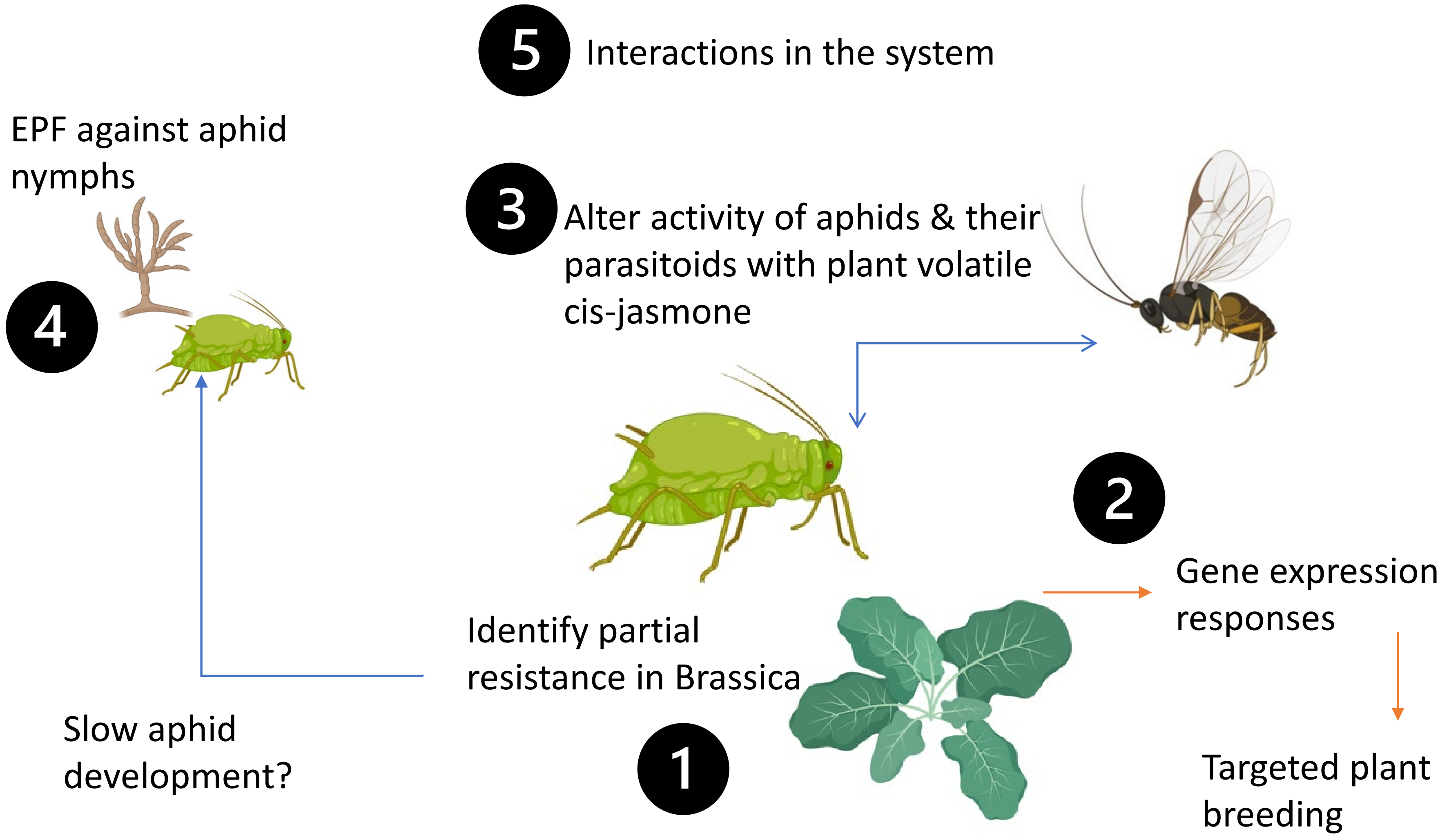
WARWICK THE UNIVERSITY OF WARWICK · Keele UNIVERSITY · Harper Adams University · Durham University · ADAS



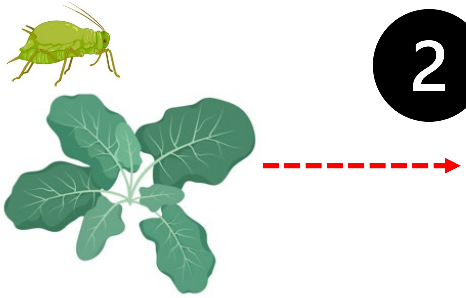

Aphids: Combining durable crop resistance with biocontrols

- *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.


5
Interactions in the system
EPF against aphid nymphs
4
3
Alter activity of aphids & their parasitoids with plant volatile cis-jasmone
2
Gene expression responses
Identify partial resistance in Brassica
Slow aphid development?
1
Targeted plant breeding

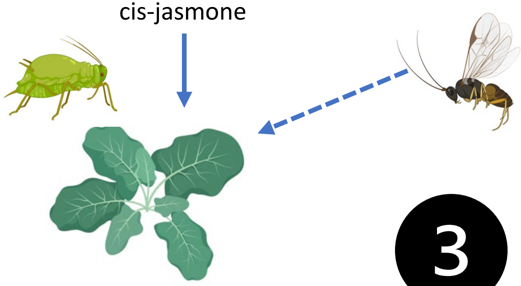
Key findings: putting crop genotype at the centre of IPM

1



2

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



3

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

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

5

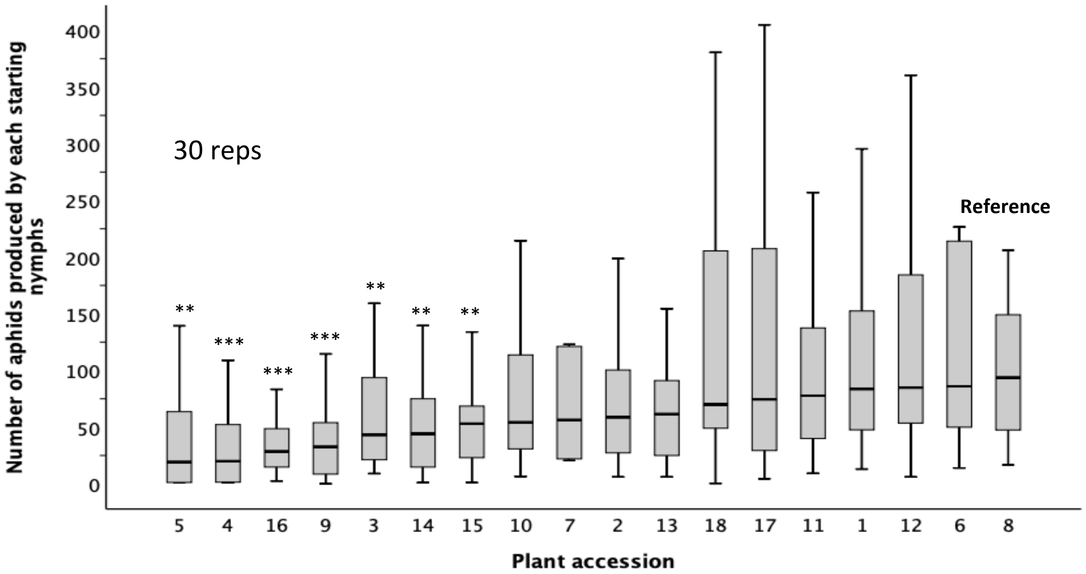
Partially resistant plants make aphid nymphs susceptible to fungal biopesticides

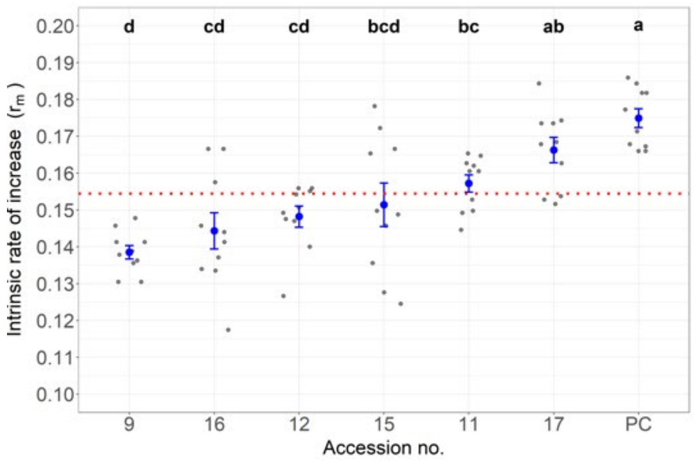
4

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

1

Partial resistance to *Myzus* & *Brevicoryne* identified in vegetable brassicas (& *B. napus*).
Confirmed in field cage experiments. Associated with reduced intrinsic rate of increase.



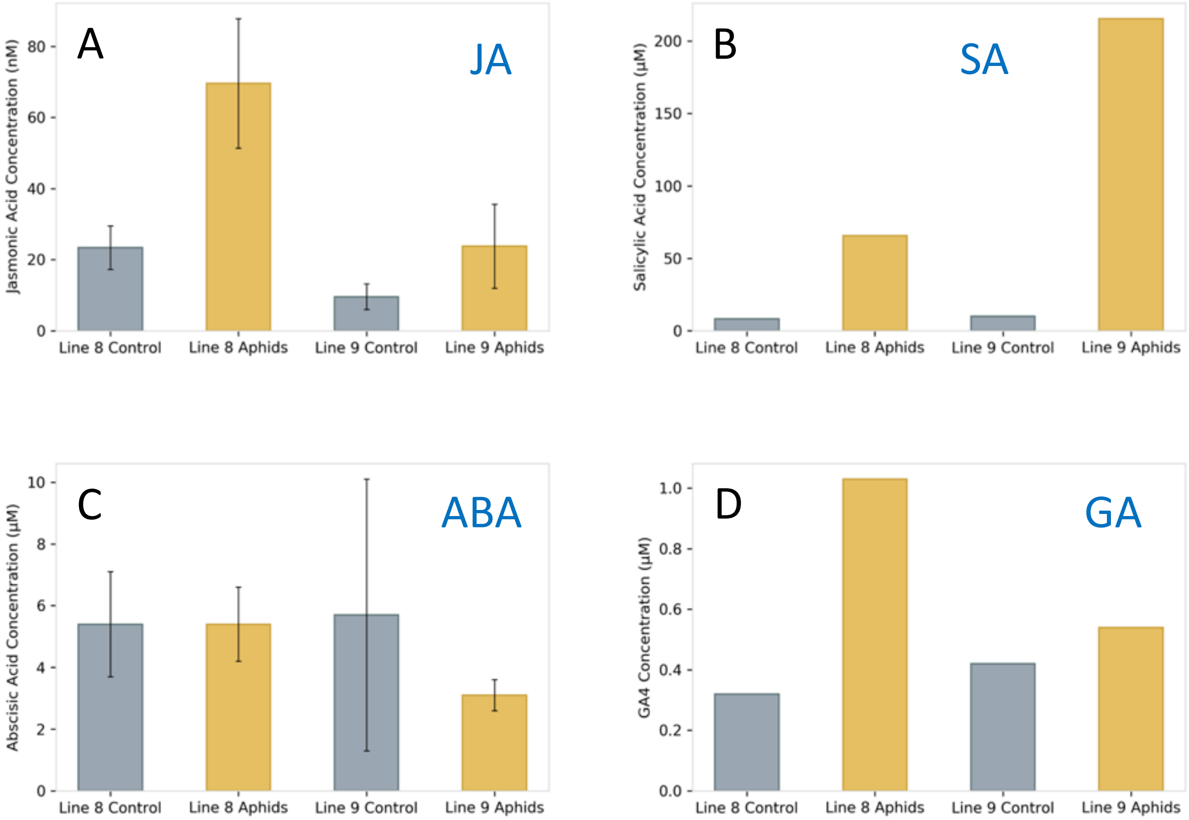


Resistant -> Susceptible
16, 9, 15, 11, 12, 17

Backed up by field cage studies

2 Partial resistance linked to the SA signalling pathway

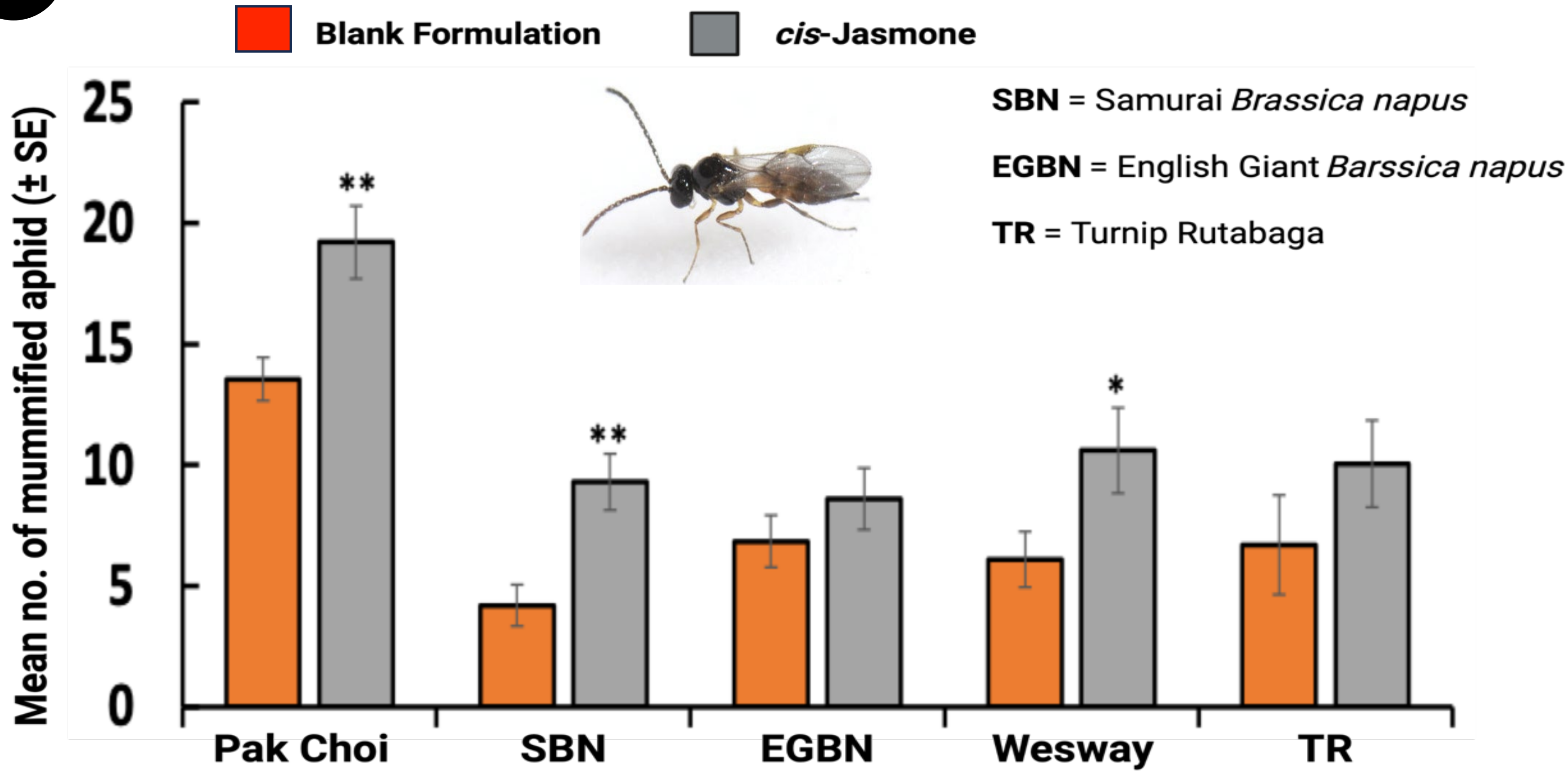
- RNA seq: more DE genes in line 8 >> 9 at 2h & 6 h.
- Reversed at 24 h.



- 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)

3



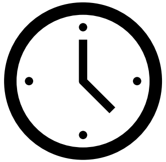
Ali et al. (2021) Frontiers in Plant Science 12: 711896

Keele University

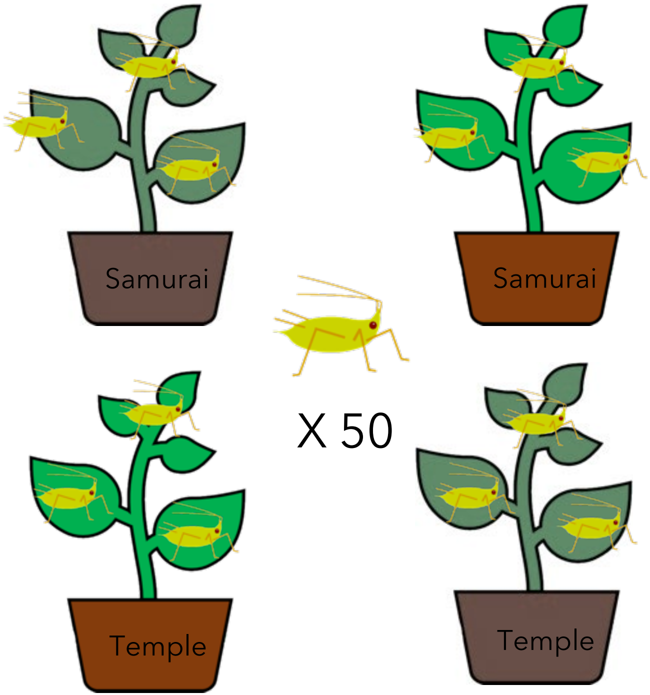
Field trial

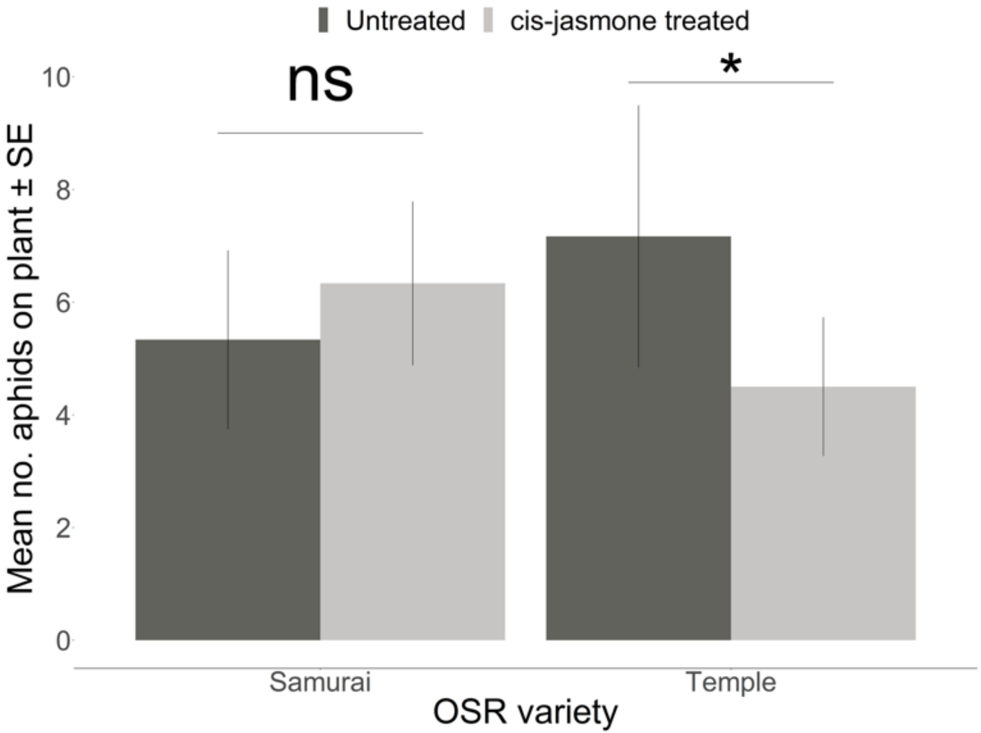
Aphid landing behaviour

24 hrs

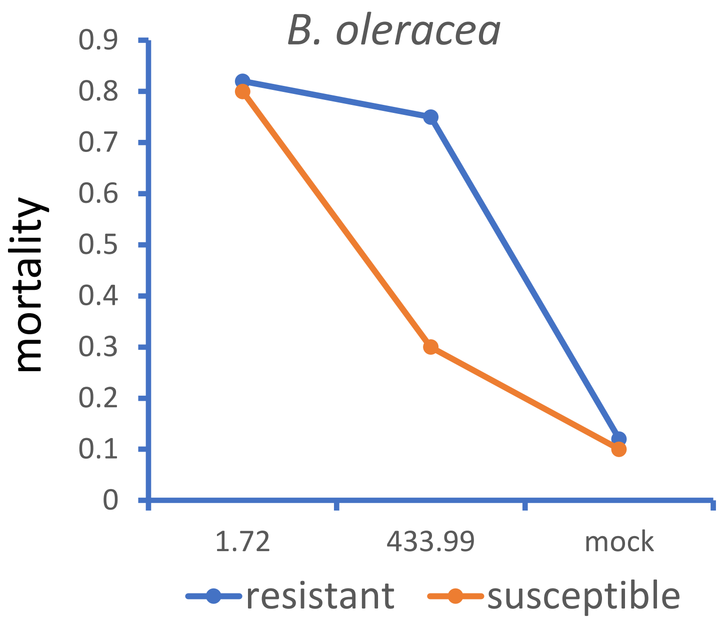


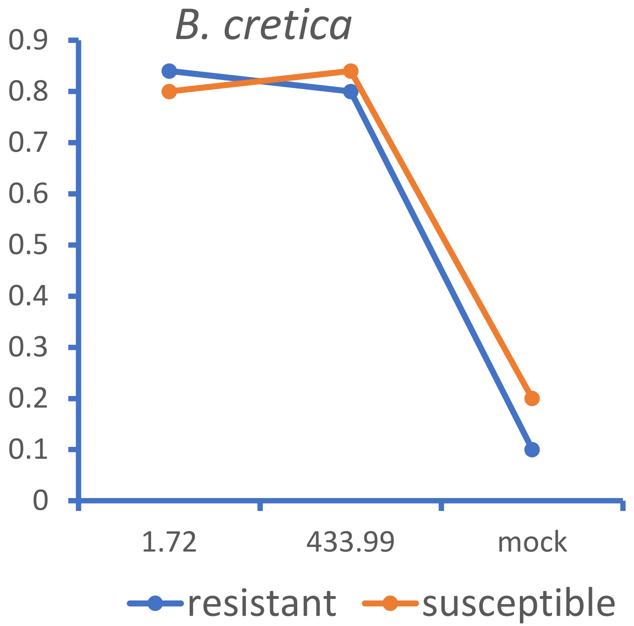
Harper Adams University



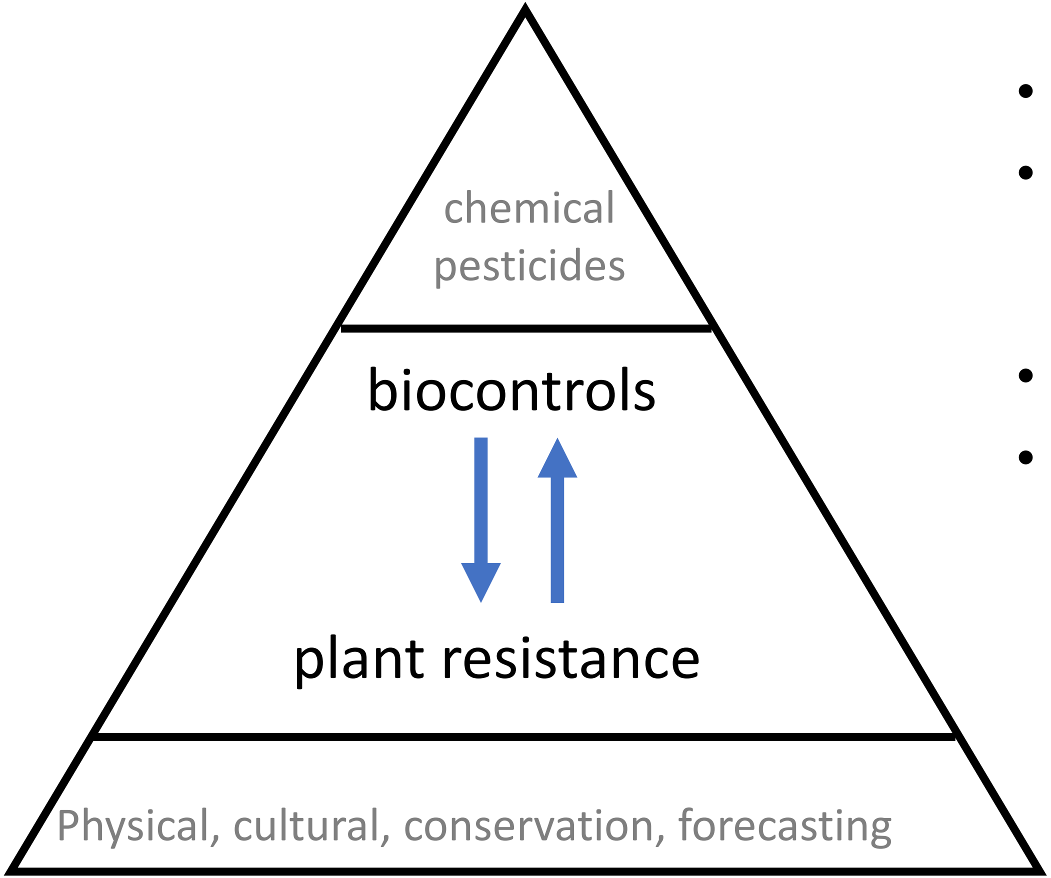


Brassica genotype makes aphid nymphs susceptible to fungal pathogen





- 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.



- 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