



AHDB / NIAB EMR

Tree Fruit Day

**Orchards Events Venue, Kent
27th February, 2020**



Technical Up-Date on Tree Fruit Research



Thursday 27 February 2020

10.00am – 3.40pm

The Orchards Events Venue, East Malling, Kent



The programme

10.00 *Arrive & coffee*

- 10.30 SmartHort – Update on strategic centres (Scott Raffle, AHDB)
- 10.45 Improving the efficacy of biopesticides – lessons from the Amber project (Dave Chandler, Warwick Crop Centre)
- 11.05 Introducing the new plum demonstration centre (Julien Lecourt, NIAB EMR)
- 11.20 An up-date on AHDB funded research into apple canker (Lucas Shuttleworth, NIAB EMR)
- 11.40 Harnessing endophytes as an aid to apple canker control (Matevz Papp-Rupar, NIAB EMR)
- 11.55 An investigation into new control methods for plum rust (Ruth D'Urban-Jackson, ADAS)
- 12.15 New research into the control of bacterial canker of cherry (Matevz Papp-Rupar, NIAB EMR)

12.35 *Lunch*

- 1.30 New approaches to apple powdery mildew control (Angela Berrie, NIAB EMR)
- 1.50 Up-date on two shield bug pests – a native and an invader, (Glen Powell, NIAB EMR)
- 2.10 *Anthonomus spilotus* – a climate change pest (Michelle Fountain, NIAB EMR)
- 2.25 Enhancing the ecology of newly planted orchards (Celine Silva, NIAB EMR)
- 2.40 SWD – The search for new repellents (Christina Conroy, NIAB EMR and Greenwich NRI)
- 2.55 SWD – Developing the use of bait sprays (Ralph Noble, Microbiotech)
- 3.10 SWD – Developing yeast attractants (Rory Jones, NIAB EMR and University of Lincoln)
- 3.25 SWD – Protecting natural enemies (Michelle Fountain, NIAB EMR)

3.40 *Tea and close*

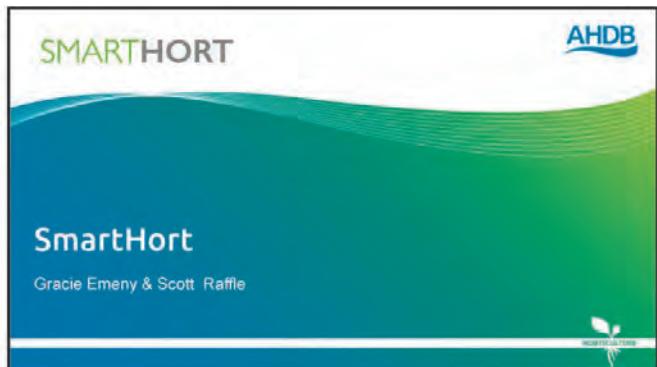
Contents

Subject and Speaker	Page
SmartHort – Update on strategic centres - Scott Raffle (AHDB)	1
Improving the efficacy of biopesticides – lessons from the Amber project - Dave Chandler (Warwick Crop Centre)	3
Introducing the new plum demonstration centre - Julien Lecourt (NIAB EMR) and Scott Raffle (AHDB)	13
An up-date on the AHDB funded research into apple canker - Lucas Shuttleworth (NIAB EMR)	21
Harnessing endophytes as an aid to apple canker control - Matevz Papp-Rupar (NIAB EMR)	26
An investigation into new control methods for plum rust - Ruth D'Urban-Jackson (ADAS)	32
New research into the control of bacterial canker of cherry - Matevz Papp-Rupar (NIAB EMR)	37
New approaches to apple powdery mildew control - Angela Berrie (NIAB EMR)	44
Up-date on two shield bug pests – a native and an invader - Glen Powell (NIAB EMR)	52
Anthonomus spilotus – a climate change pest - Michelle Fountain (NIAB EMR)	60
Enhancing the ecology of newly planted orchards - Celine Silva (NIAB EMR)	65
SWD – The search for new repellents - Christina Conroy (NIAB EMR and Greenwich NRI)	71
SWD – Developing the use of bait sprays - Ralph Noble (Microbiotech)	78
SWD – Developing yeast attractants - Rory Jones (NIAB EMR and University of Lincoln)	83
SWD – Protecting natural enemies - Michelle Fountain (NIAB EMR)	89

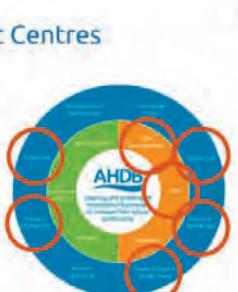


SmartHort – Update on strategic centres

Scott Raffle (AHDB)



SMARTHORT Strategic Centres



A circular diagram representing the SmartHort Strategic Centres. The center is labeled "AHDB" and "Strategic Centres". Around the center are four colored segments: green, orange, red, and blue. Each segment contains text related to the programme's objectives: "Launched in 2019", "Aiming to put Lean 'into practice'", "3 host sites. 4 workshops at each", "Live case studies", "Expert Lean consultant led", and "Farm Excellence Network".



SmartHort – Update on strategic centres

Scott Raffle (AHDB)

What are we covering?

- Background to Lean
- Value add/Non value add
- Process Mapping
- Waste Walks
- Activity Sampling
- Prioritisation Matrix
- Developing Action plan
- Continuous Improvement



Where are we now?

- 2 workshops at 2 sites complete
- 3 complete at Volmary
- 55 delegates from 22 businesses
- Attendees from across hort sectors
- 20% efficiency improvements projected



Process Area (or Waste Walk, Prioritisation and Action Plan)	Achievements reported at Volmary event 2
Stocking, Preparing Workshops or Organiser (10)	Created and tested that first cleaning of dried, bag was performed (standard). Devised visual standard for staff tasks. Volary office supports to standardise in portable cold store and ensure 6S source著 avoidance is fully present.
Meeting Process	Analysis looking at continuing process for pull-out prep, wind-up meeting and continue from previous meeting.
Lifting, Picking & Cleaning, Maths for Packing	Reducing packing unnecessary steps (pulling packed product only 10%). 20% of service improvements are a potential.
Clean Cleaning	Created visual standard for cleaning the same with less Additional quality benefit of not having much taping on field before it is delivered.
Transportation/Pallets	Reducing pallet unnecessary steps (pulling packed product only 10%). 20% of service improvements are a potential.

What happens next?

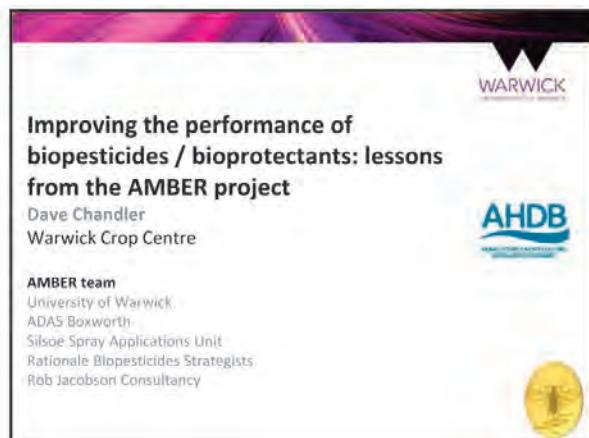
- Recruitment for next host sites starting soon
- Online 'how to guides'
- Arrange best practice visits outside of horticulture
- Year 1 case studies and report
- International study tour

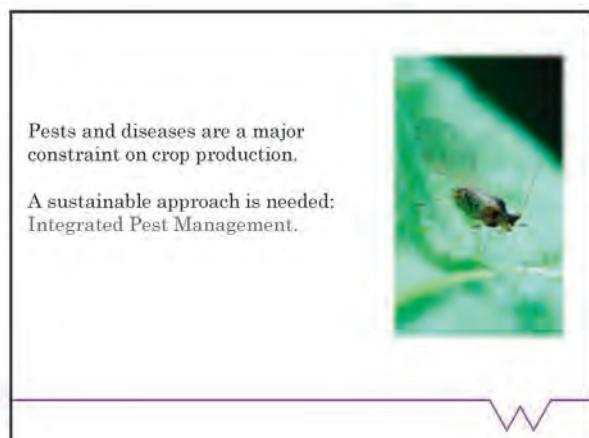


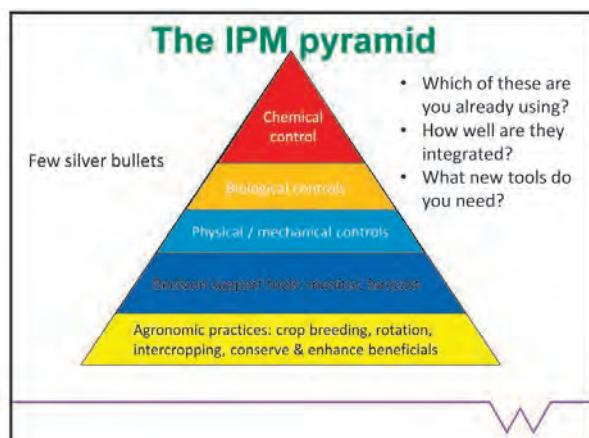
Interested in finding out more? Contact Grade on
grade.emery@ahdb.org.uk or 07975 233150

Improving the efficacy of biopesticides – lessons from the AMBER project

Dave Chandler (Warwick Crop Centre)







Improving the efficacy of biopesticides – lessons from the Amber project

Dave Chandler (Warwick Crop Centre)

Biopesticides / Bioprotectants

- Biological plant protection tools to help manage pests (invertebrates, weeds, plant pathogens).
- Living microbes, semiochemicals, plant extracts & other natural products.
- Originate from nature, or are nature-identical when synthesized. Formulated & packaged.
- Low impact on human health & environment.
- Varied modes of action.
 - Some may not directly kill the target (e.g. preventative biofungicides).
 - Hence term "bioprotectant" is now preferred by EU, IBMA.



- Human & environmental safety.
- EU approval inc. efficacy.
- Compatible with the IPM pyramid.
- Not silver bullets. Lower potency, some are slow acting.
- Many are contact acting.
- Less forgiving:
 - Good knowledge. Attention to detail.
 - Environmental conditions.



New substances coming on stream

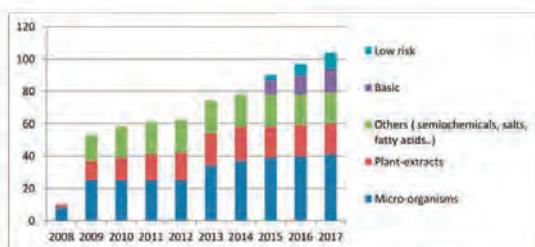
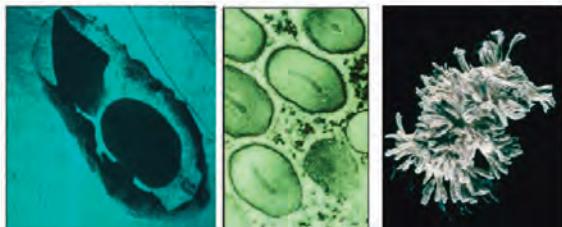


Figure 2: Increase in numbers of alternative substances approved by the EU

European Commission 2017

Improving the efficacy of biopesticides – lessons from the Amber project Dave Chandler (Warwick Crop Centre)

Insect pathogenic microbes



Biofungicides – preventative vs curative

Preventatives for Botrytis (but note MoA).

- *Bacillus amyloliquefaciens* QST 713 (Serenade): extracellular lipopeptides
- *Gliocladium catenulatum* J1446 (Prestop): colonizes plant surfaces, hyperparasite.

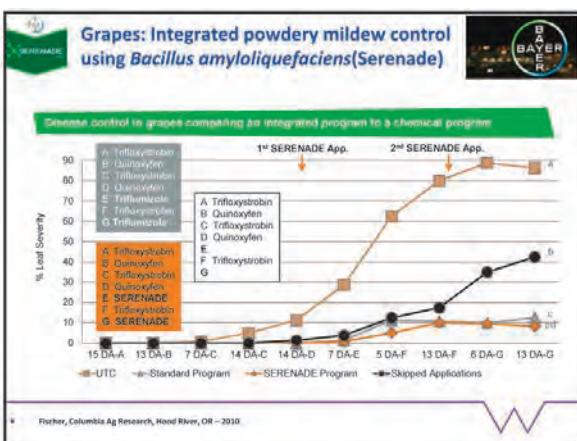
Curative for powdery mildew

- *Ampelomyces quisqualis* AQ10 - mycoparasite



Lallemand plant care

© Lallemand Plant Care 2010



Improving the efficacy of biopesticides – lessons from the Amber project

Dave Chandler (Warwick Crop Centre)

Mating behaviour disruption pheromone against moth pests



Can give 90 – 99% control depending on target species.
Can integrate with microbial biopesticides.

Biopesticides: UK experience in protected crops

- Growers want to use biopesticides. Increasingly important tool.
- Some products reliable. Others give inconsistent results.
- More knowledge needed with these new products.
- How to use in IPM on many different crop types?



The AMBER project

- Application & Management of Biopesticides for Efficacy and Reliability.
- PE, PO & HNS crops.
- Identify the reasons why biopesticides can be inconsistent.
- Develop management tools and practices that can improve performance.



Improving the efficacy of biopesticides – lessons from the Amber project

Dave Chandler (Warwick Crop Centre)

How do growers get on with biopesticides?

- Observed how growers used microbial biopesticides on commercial scale, following product guidelines (not efficacy trials).
 - Aphids, pepper.
 - WFT, chrysanthemum.
 - Whitefly, poinsettia.
 - Powdery mildew, cucumber.
 - Botrytis, cyclamen.
 - Root rots, Choisya & Dianthus.
- Data rich: Identify issues that were likely to affect biopesticide performance.
- Important qualitative information.



Chrysanthemum: Beauveria vs western flower thrips; automated horizontal boom.

WFT control same for Beauveria & nematodes. WFT v. low overall. Good application.



Organic pepper; Beauveria & Majestik vs aphids; semi-automated vertical boom.

Aphid population v. high at start (fast growth rate).

No control. High volume.



Improving the efficacy of biopesticides – lessons from the Amber project

Dave Chandler (Warwick Crop Centre)

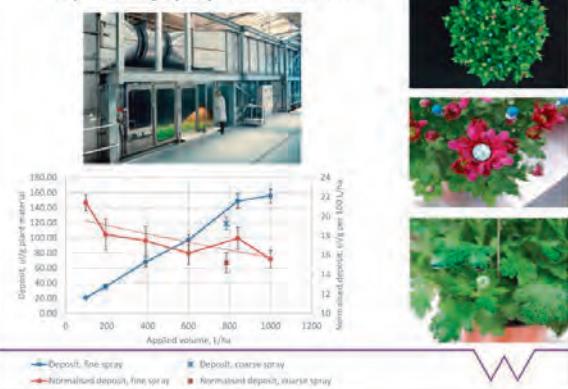
What did we observe?

- Benchmarked products varied in performance.
- Labels hard to follow: suppliers provide extra guidance.
- Issues with application:**
 - Water volumes high (run-off; inefficient), better attention to basics.
- Effective dose – how much product do you want on the plant, where & when?**

Working in 3 areas

- Making spray application more efficient.
- Biofungicide performance:** biofungicide persistence & integration with decision support system.
- Bioinsecticide performance:** how pest population growth rates influence biopesticide application strategy.

Optimising spray water volumes

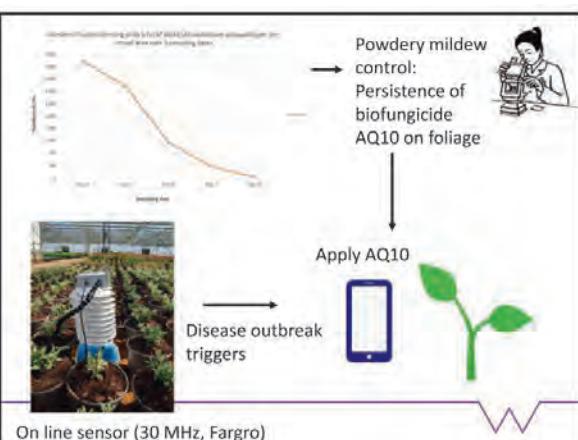
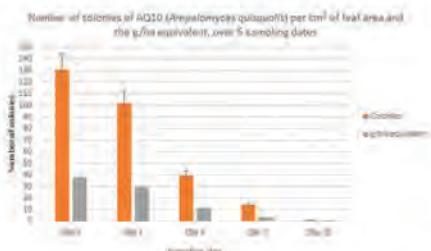


Improving the efficacy of biopesticides – lessons from the Amber project

Dave Chandler (Warwick Crop Centre)

Biofungicide persistence.

Ampelomyces - a mycoparasite - does not survive for long in the absence of host powdery mildew



A pest growth model to inform biopesticide application strategy

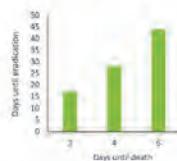
- Many biopesticides do not have an instantaneous speed of kill. Total mortality is often < 100%.
- Pests can grow and reproduce before death.
- How does this affect population growth? What is the best application strategy?

Improving the efficacy of biopesticides – lessons from the Amber project

Dave Chandler (Warwick Crop Centre)

Boxcar model of pest development: informs biopesticide use strategy in IPM

- Glasshouse whitefly & peach potato aphid.
- Tracks maturation of individuals & daily nymph production.
- Simulates control efficacy when kill is not instantaneous (persistence, mortality, speed of kill, frequency).



Effect of spray frequency on azadirachtin efficacy: model predictions for *Myzus*

Initial population size
= 1000 adults

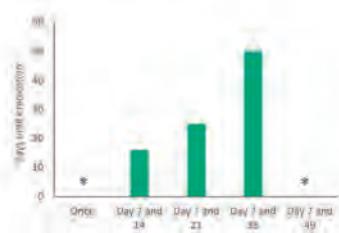
2 applications

All stages affected

Neem efficacy = 89%
Nymphs 79% adults

Persistence = 5 days

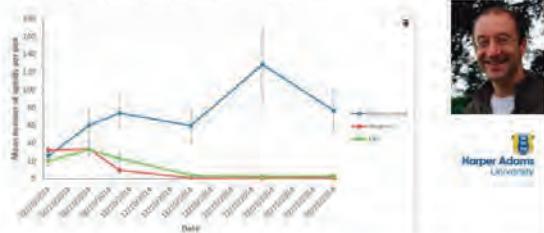
Time until death =
2 days (Nymph)
7 days (Adults)



* = Unable to eradicate. Pest population reaches 10m after 85 (once) and 124 days.

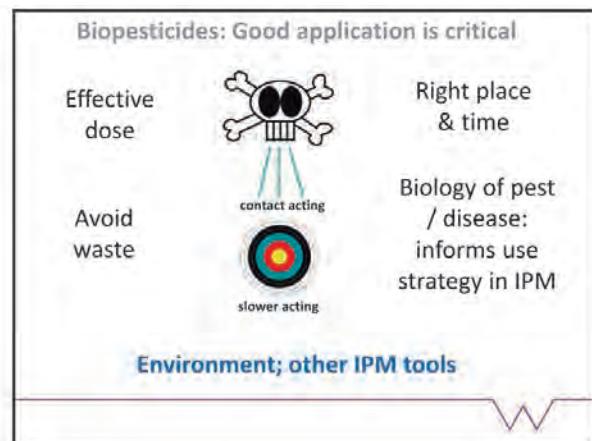
Validation of model – MOPS data 2014 *Myzus persicae* on pansy (Tom Pope): code 130 is NeemAzal

Treatments applied at 7 day intervals 3, 10, 17 October
after adding 1 aphid per plant 17/18 September



Improving the efficacy of biopesticides – lessons from the Amber project

Dave Chandler (Warwick Crop Centre)



The future: new biologically based products

- Microbes + metabolites:
 - Grandevo (Marrone): *Chromobacterium subtsugae* – whitefly, mites, caterpillars.
 - Requiem (Bayer) - terpenes
- RNAi mediated silencing of gene expression:
 - Exogenous dsRNA

Frontiers in Physiology, 7, 553

Wavy line at the bottom.

Future IPM: new technology & understanding

'Bio'-crop protection

IPM pyramid

Precision farming (sensing, spraying)

Decision support

Wavy line at the bottom.

Improving the efficacy of biopesticides – lessons from the Amber project

Dave Chandler (Warwick Crop Centre)

Netherlands '2030 plant protection vision' strategy document



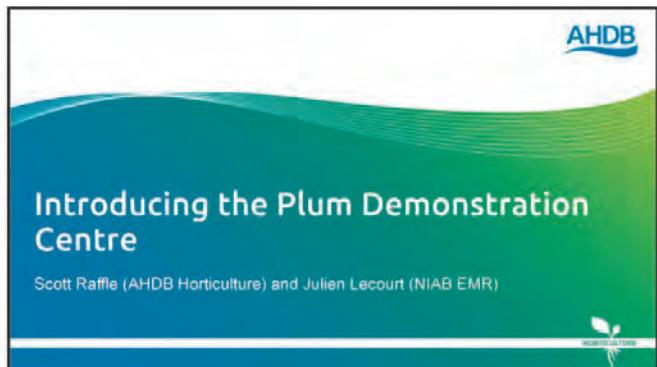
We need this too!

AMBER TEAM

- Dave Chandler¹, Jude Bennison², Clare Butler Ellis³, Andrew Lane³, Christine O'Sullivan³, Roma Gwynn⁴, Gill Prince¹, Rob Jacobson⁵, Sacha White², Dave Skirvin², Aoife O'Driscoll², Erika Wedgwood²

¹University of Warwick UK; ²RSK ADAS, Cambridge UK; ³Silsoe Spray Applications Unit, Silsoe UK; ⁴Rationale Biopesticides, Duns, Scotland UK; ⁵Rob Jacobson Consultancy Ltd, Bramham UK.

Introducing the new plum demonstration centre
Julien Lecourt (NIAB EMR) and Scott Raffle (AHDB)







Introducing the new plum demonstration centre Julien Lecourt (NIAB EMR) and Scott Raffle (AHDB)

Training systems

Replicated demonstration of Victoria on four different rootstocks with four training systems:

VVA1	Narrow A Frame
Pixy	Narrow Table Top
Wavit	Super Spindle
St. Julien A	Oblique

AHDB



Rootstocks

Performance of Victoria on four different rootstocks:

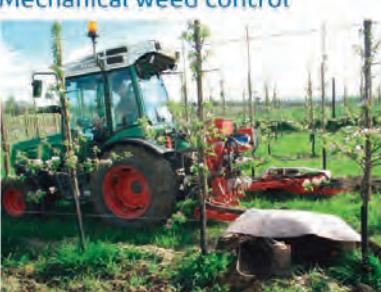
- VVA1
- Wageningen
- Wavit
- St. Julien A

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Mechanical weed control

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Introducing the new plum demonstration centre
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Protected v outdoor cropping



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New varieties

Replicated trial of 23 new varieties on Wavit rootstock



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New selections from NIAB EMR

Replicated comparison of two new selections from NIAB EMR grown on Wavit and St. Julien A

- P6-19
- P7-38



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Other variety demonstrations



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Great soils



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Launch at Fruit Focus 2019



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Introducing the new plum demonstration centre Julien Lecourt (NIAB EMR) and Scott Raffle (AHDB)

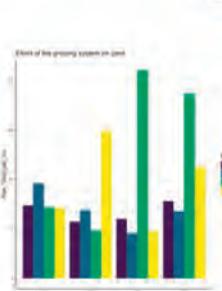
October open day



AHDB

Key results 2019 - Yields

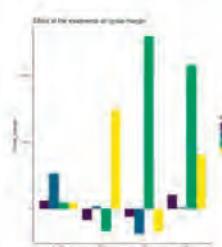
- The Oblique and Super Spindle systems on WA rootstock had the highest yields in 2019
- Narrow Table Top and Super Spindle on Wavit also performed well
- Over the past three years, the Super Spindle has produced the highest yields



AHDB

Key results 2019 – Gross margin

- The average gross margin for UK plums has been estimated at £250/ha/year
- Other tree fruit crops make considerably more
- The Oblique and Super Spindle on VVA and Narrow Table Top on Wavit have produced a higher gross margin than an average cherry crop



AHDB

Introducing the new plum demonstration centre Julien Lecourt (NIAB EMR) and Scott Raffle (AHDB)

Impact on fruit quality

- Training system x rootstock combination appears to have an impact on fruit quality
- Too early to draw conclusions
- Information will be gathered over several seasons



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New for 2020



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Weed control demonstrations



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Thinning demonstrations



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Comparison of top dressing v fertigation



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Earwig safe spray programmes



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Dedicated website for centre



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Communication and promotion



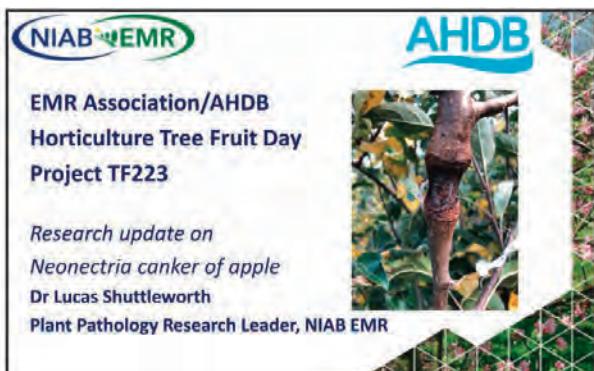
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Next open day – 3rd June 2020



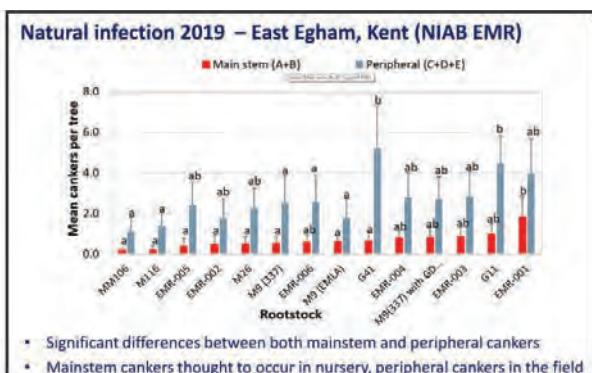
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An up-date on the AHDB funded research into apple canker
Lucas Shuttleworth (NIAB EMR)

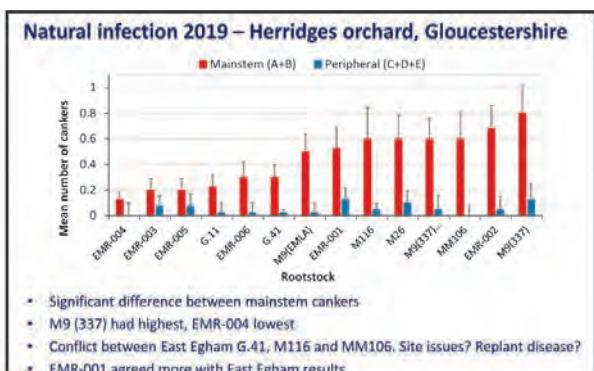
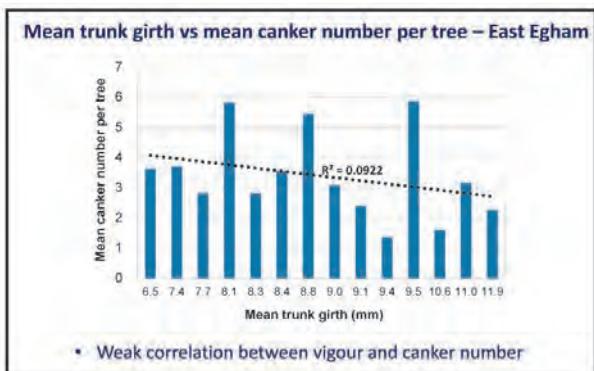
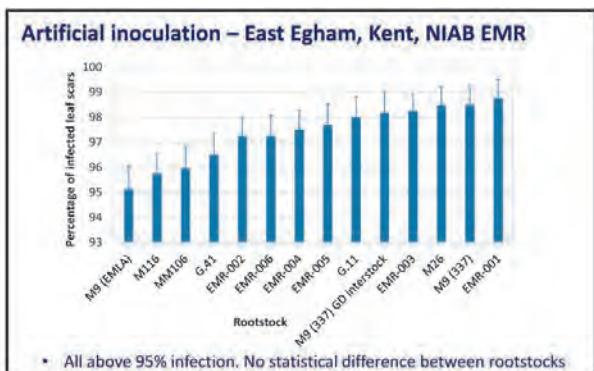


Objective 2. Rootstock experiments

- Rootstocks are known to confer resistance to pathogens such as *Neonectria ditissima*
- We evaluated resistance conferred by 14 commonly used and advanced rootstock selections from NIAB EMR and Geneva (USDA, Cornell University) breeding programmes
- Two methods: natural infection and artificial inoculation
- Two sites: 1. East Egham, Kent (NIAB EMR)
2. Herridges Orchard, Gloucestershire (ADAS)



An up-date on the AHDB funded research into apple canker
 Lucas Shuttleworth (NIAB EMR)



An up-date on the AHDB funded research into apple canker Lucas Shuttleworth (NIAB EMR)

Rootstock conclusions

- There was some conflict between East Egham and Herridges results
- May be due to apple replant disease, site issues, management (water stress, shallow ragstone layer at East Egham, not irrigated)
- No clear correlation between vigour and canker
- Work needs to be done on additional sites, ideally not previously planted with apple, to clarify effect of rootstock on canker

Objective 2.3 Soil amendments to reduce apple canker

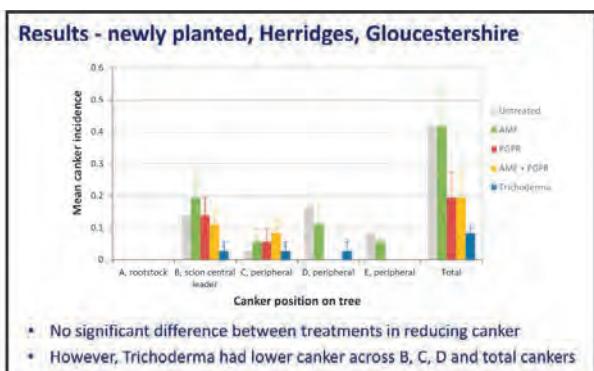
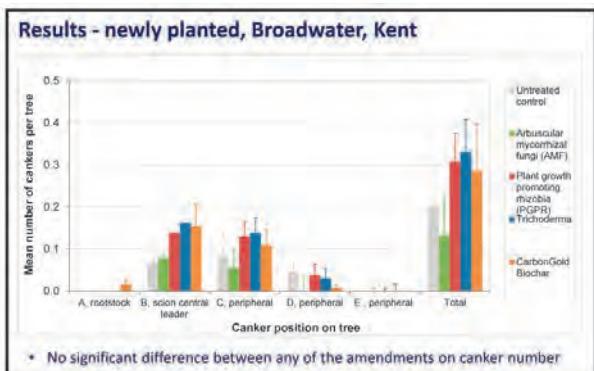
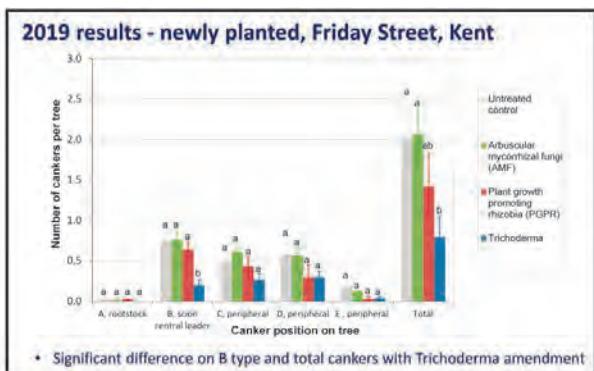
- *Neonectria ditissima* shown to infect apple trees in the nursery and remain asymptomatic
- Once planted, trees experience stress eg. drought, water-logging, replant disease, and the disease is expressed
- Biological soil amendments may improve tree health and establishment in the context of canker expression

Soil amendment experiments

- Four sites: 1. Newly planted orchards
 - Kent: Friday Street and Broadwater orchards
 - Gloucestershire: Herridges orchard
 - 2. Stoolbed experiment – Kent: East Egham only
- Treatments:
Newly planted orchards – Trichoderma, AMF, PGPR, CarbonGold (Broadwater only), AMF+PGPR (Herridges only)
- Stoolbeds* - Trichoderma, AMF, PGPR

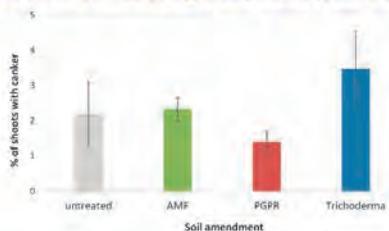


An up-date on the AHDB funded research into apple canker
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Stoolbed results - East Egham, Kent (NIAB EMR)



- No significant difference between amendments on canker
- Interestingly, Trichoderma had higher canker number, PGPR lowest
- This was opposite to 2018 stoolbed data

Soil amendment conclusions

- Trichoderma (Trianum G) is the most promising amendment from 2019 data and previous years data
- Amendments need to be used in an integrated disease management program incorporating several methods eg. cultivar selection – rootstock and scion, chemical and alternative controls (BCAs, elicitors)
- SCEPTREplus project will be looking at a number of these alternative products on reducing Neonectria canker

Acknowledgements

- AHDB and growers for funding
- Growers from Friday Street, Broadwater, and Herridges orchards for hosting experiments
- Rob Saville, Sonia Newman (ADAS), Tom Passey, Graham Caspell, Joyce Robinson, Jennifer Kingsnorth, Sarah Cohen



Harnessing endophytes as an aid to apple canker control

Matevz Papp-Rupar (NIAB EMR)

The poster features the NIAB EMR logo at the top left, followed by the title 'Harnessing endophytes to aid apple canker control'. Below the title is a subtitle: 'The role of endophytes in affecting European canker development on apple'. The AHDB logo is present, along with the text 'AHDB Tree Fruit Day 2020'. The authors listed are Matevz Papp-Rupar, Louisa Robinson-Boyer, Lucas Shuttleworth, Tom Passey, Leone Olivieri, Jennifer Kingsnorth, Sarah Cohen, Greg Deakin, and Xiangming Xu. Logos for Worldwide fruit, T&G, Adrian Scrivens Ltd, and Frank P Matthews are included. The background shows a photograph of apple blossoms.

The diagram illustrates the spectrum of interactions between plants and their environment. It shows a central tree with various arrows pointing outwards to different organisms and processes. A horizontal axis at the bottom represents the spectrum from 'Antagonism' (red) on the left to 'Mutualism' (green) on the right. Above this axis, arrows point from the tree to 'Pathogens' (disease-causing organisms), 'Mycorrhizas' (beneficial fungi), and 'Free-living and saprophytic' (non-pathogenic bacteria and fungi). Below the axis, arrows point from the tree to 'Benefit' (e.g., growth promotion, stress tolerance, defence induction) and 'Harm' (e.g., antagonism, competition, neutralism). The word 'Meta-organism' is also mentioned above the tree.

The diagram illustrates the interaction of endophytes with plant tissues. It shows a cross-section of a plant cell with various organelles. Endophytes are shown both within the intercellular spaces and within the plant cell itself. The diagram highlights 'Cross talk' between endophytes and the host plant, showing how they can promote growth, stress tolerance, and defence induction. It also shows how some endophytes can act as antagonists of pathogens. The diagram includes labels for 'Intercellular spaces', 'Plant Cell', 'Intra-cellular', 'Intra- and intercellular', 'Cross talk', and 'Cross talk & antagonism'.

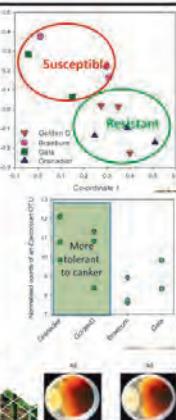
Harnessing endophytes as an aid to apple canker control

Matevz Papp-Rupar (NIAB EMR)

From preliminary data...

Are endophyte communities different in different apple cultivars?

- Small scale trial on 4 cultivars:
 - 2 resistant to canker: Golden D, Grenadier
 - 2 susceptible to canker: Gala, Braeburn
- DNA sequencing to characterise endophyte community revealed that:
 1. Trees from canker resistant cultivars harbour different endophyte communities
 2. Canker resistant cultivars had higher amount of *Epicoccum purpureescens* endophyte, a known fungal biocontrol agent against brown rot (*Monilinia*)
 3. *Epicoccum purpureescens* showed in vitro biocontrol potential against apple canker



Adding questions relevant to canker management:

- Can specific endophytes influence canker susceptibility of apple trees
 - Directly as biocontrol agents
 - Indirectly via inducing plant defence responses
- How does cold-storage duration affect endophyte composition, post-planting canker development and tree establishment?
- What else affects development of canker symptoms?
 - Physio-chemical characteristics of the soil?
 - Plant hormones?
 - Rhizosphere microbiota (Mycorrhizae and PGPRs)
 - Drought stress?



Overview of key project objectives

- WP1: To confirm the association of specific endophytes with cultivar or susceptibility / resistance to *N. ditissima*.
- WP2: To quantify biocontrol potential of specific endophytes in field conditions.
- WP3: To investigate whether endophytes induce host defence.
- WP4: To map genomic regions that control recruitment of specific endophytes and inform breeding
- WP5: To determine if canker expression and endophyte community are affected by soil microbiota and drought stress
- WP6: To determine the extent to which canker expression and endophyte community are influenced by planting date and biotic/abiotic factors of the planting site



Harnessing endophytes as an aid to apple canker control

Matevz Papp-Rupar (NIAB EMR)

WP1 results so far

- Is there an association of specific **endophytes** with cultivar and/or **susceptibility / resistance** to *N. ditissima*
- Two sites selected: Canterbury & Maidstone

A

Jack Skinner; Friday Street Farm, Planted: 22nd January 2018

Clive Chandler; Perry Farm, Wingham, Planted: 12th January 2018

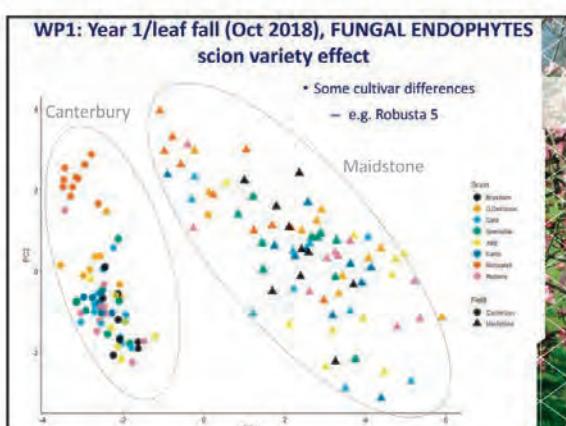
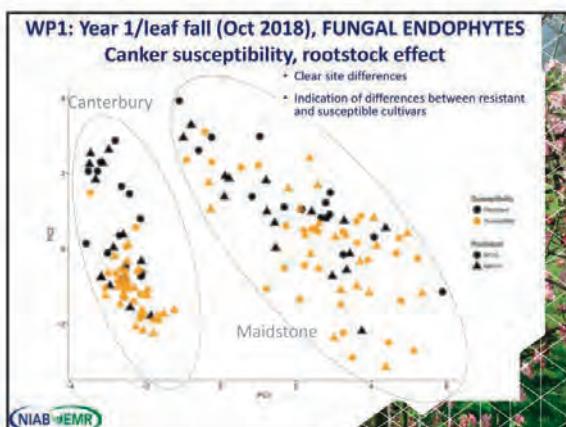
• 16 rootstock / scion combinations (15 trees per combination per site)

• DNA sequencing used to analyse MO communities in the leaf scars

Response to canker

	Scion	Rootstock
Resistant	Reinette Y, Ty, Worcester Pearmain	M26 M9 337
Susceptible	Gala, Bramley, Jazz, Kanzi, Roberts	M26 M9 337

NIAB EMR



Harnessing endophytes as an aid to apple canker control

Matevz Papp-Rupar (NIAB EMR)

WP2: Overview

Questions:

- Can we introduce biocontrol endophytes in the tree?
- If yes, do they protect against *N. ditissima* in field conditions?

Approach:

- Bulking up biocontrol fungi (*Epicoccum*)
- M9 rootstocks augmented with biocontrol spores in summer
 - spray / drench / spray + drench / water control
- Presence of biocontrol fungi assessed at leaf fall (DNA, isolation)
- Inoculation of leaf scars with *N. ditissima* spore suspension spray, rootstocks harvested, stored and planted
- Canker assessed the following summer

WP2: Results so far

Q: Can we introduce biocontrol endophytes in the tree?

A: Yes, at least temporarily.

- More *Epicoccum* DNA present in the leaf scars of augmented rootstocks at leaf fall
- More live *Epicoccum* isolated from augmented rootstocks
- Awaiting results from second exp. repeat and also long term monitoring across 2 seasons.

	Sprayed	Drenched	Sprayed + Drenched	Control
Leaf scar	0	1	3	0
Leaf	1	4	1	0

WP2 results so far

Q: Do biocontrol endophytes protect against *N. ditissima* in field conditions?

A: Not conclusive.

- Very low canker infection frequency
- No significant differences in canker frequency between treatments

Experiment has already been repeated and we expect more conclusive results in the summer 2020.

	No. of inoculated stems	No. of stems with canker
Control	141	3
Drench	126	6
Spray	144	5
Spray+drench	125	5

Bonus data : no neg. effect of *Epicoccum* on plant growth (rootstock girth) at harvest.

Harnessing endophytes as an aid to apple canker control

Matevz Papp-Rupar (NIAB EMR)

WP6: Overview

Q: Does duration of cold storage of trees before planting affects canker expression?

Approach:

- Trees uniformly inoculated with low *N. ditissima* spore conc. in the nursery (Frank P Matthews) at leaf fall
 - Golden Delicious, Grenadier, Gala, Braeburn, Jazz, Kanzi, and Rubens on M9 337.
- Planted on 3 sites at 2 times in
 - Dec 2018 (10 days after lifting)
 - April 2019 (4 months after lifting)

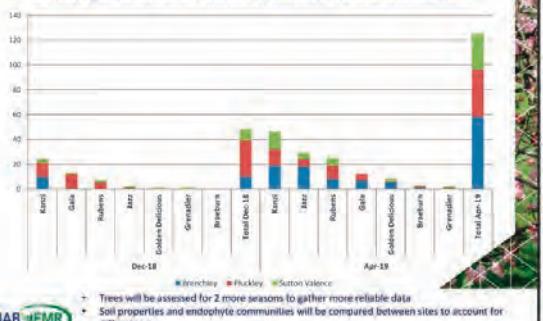
Trees stored at FPM between the 2 plantings

Canker expression assessed in Sept 2019



WP6: Results so far (canker counts in Sept 2019)

- April 2019 planting had 2.6 times higher total canker number than December 2018
- Kanzi had highest canker number; Braeburn, G. Delicious & Grenadier consistently lower



Conclusions so far

- WP1: Endophyte community in different apple cultivars is mostly affected by:
 - Site i.e., what is available in the environment
 - Scion cultivar does have some "filtering" effect
- WP2: Endophyte community can be augmented by spraying and/or drenching, but the effect on canker is so far unclear.
- WP6: Short cold storage of trees before planting does seem to reduce canker expression.



Harnessing endophytes as an aid to apple canker control
Matevz Papp-Rupar (NIAB EMR)



An investigation into new control methods for plum rust
Ruth D'Urban-Jackson (ADAS)

SCEPTREPLUS

SP 41: Control of rust on Plum

Ruth D'urban-Jackson, ADAS

AHDB Tree Fruit day – 27 February 2020

NORTHOFRUIT

Trial overview

SCEPTREPLUS

- Plum rust – *Tranzschelia discolor*
- Number of available actives in decline.
- Loss of Systhane (myclobutanil).
 - Authorised for top and soft fruit 18 July 2019, but not plum
- Identify suitable crop safe alternatives

Plum rust on plum

NORTHOFRUIT

ADAS

AHDB

Trial site and design

SCEPTREPLUS

- First year maiden, cv. Victoria stem grafted onto St. Julian A rootstock.
- Bareroot planted April 2019
- Plot size: 2 trees
 - 6 replicate blocks
 - 8 treatments
 - 4-spray programme
- Reliant on naturally occurring sources of infection from nearby mature plum orchard.

NORTHOFRUIT

ADAS

AHDB

An investigation into new control methods for plum rust
 Ruth D'Urban-Jackson (ADAS)



Treatments					SCEPTREPLUS
Treatment	Product / code	FRAC code	Conventional chemical or biopesticide	Authorised for	
1	Unreated	-	-		
2	Amistar	11	C		
3	AHDB 9851	11	C	Apple, pear	
4	AHDB 9911	7	C	Wheat, barley	
5	AHDB 9957	P 04	C	Wheat	
6	AHDB 9872	7	C	Apple, pear	
7	AHDB 9885	46	B		
8	AHDB 9852	BM 01	B		

• Water volume – 500 L / ha
 • Range of modes of action included in the trial

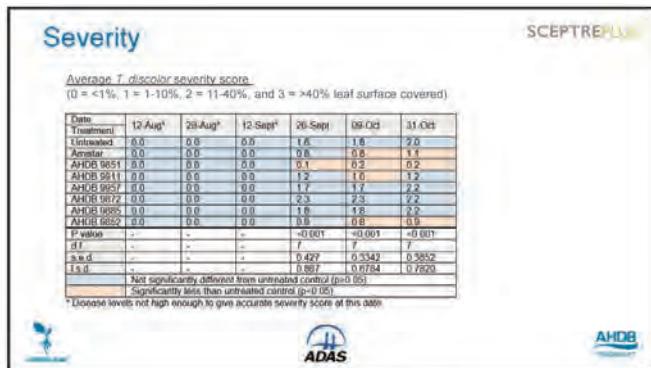
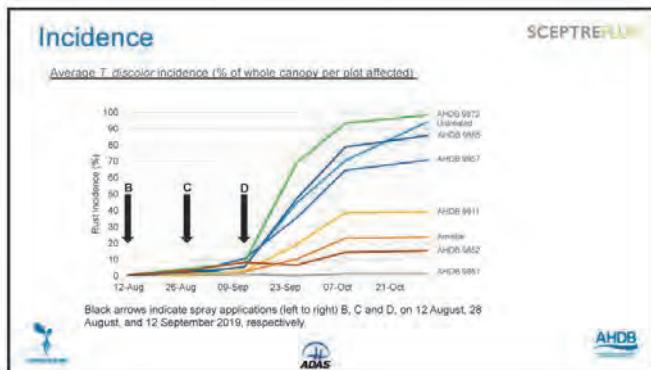
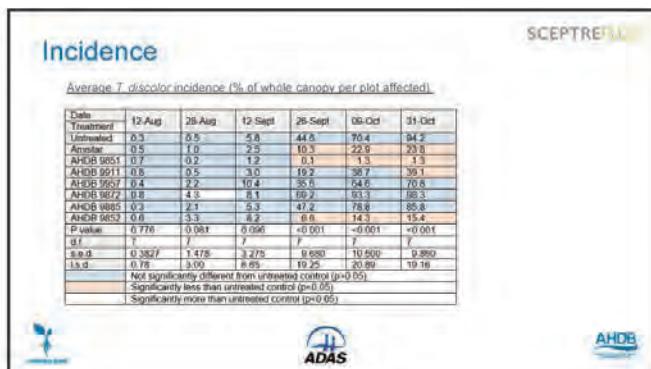
 

Assessments			SCEPTREPLUS
No.	Timing	Date	
1	Treatment application 1	30/07/2019	
2	Treatment application 2	12/08/2019*	
3	Treatment application 3	28/08/2019	
4	Treatment application 4	12/09/2019	
5	Treatment application 4 + 2 weeks	26/09/2019	
6	+ 4 weeks	09/10/2019	
7	+ 7 weeks	31/10/2019	

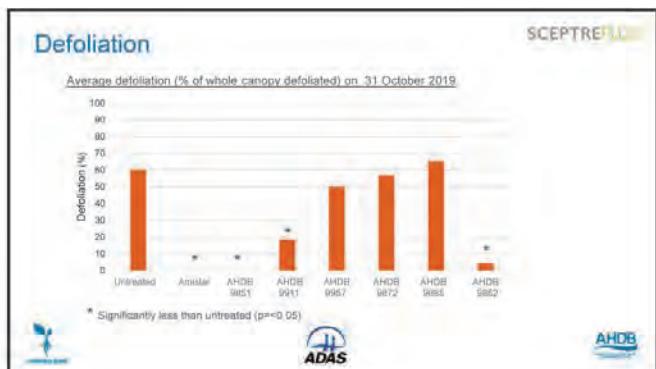
* Rust first observed in trial

An investigation into new control methods for plum rust
Ruth D'Urban-Jackson (ADAS)



An investigation into new control methods for plum rust
Ruth D'Urban-Jackson (ADAS)



An investigation into new control methods for plum rust
Ruth D'Urban-Jackson (ADAS)

Conclusions

- Some products in SP 41 reduced both the incidence and severity of rust (AHDB 9851, AHDB 9852 and Amistar).
- AHDB 9851 gave almost complete control of rust throughout the entire season, better than the industry standard Amistar.
- Compared to the UT control, AHDB 9851 and AHDB 9852 reduced incidence of rust at the final three assessment dates, when disease pressure was highest.
- AHDB 9852 appeared to hold back rust development for 4 weeks, so could be a valuable addition to an IPM programme.
- No phytotoxicity developed following any treatment at any assessment date.



Acknowledgements

AHDB Horticulture
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Dave Kaye (ADAS)
Tom Whiteside (ADAS)

New research into the control of bacterial canker of cherry
 Matevz Papp-Rupar (NIAB EMR)

New research into the control of bacterial canker of cherry

Matevz Papp-Rupar, Tom Passey, Sarah Cohen
 Jenifer Kingsnorth, Mojgan Rabiey, Shyamali Roy, Rob Jackson

AHDB SCEPTREPLUS
 TF223

Bacterial canker

Caused by strains of *Pseudomonas syringae* bacteria from 3 main pathovars:
Pss (*P.s. pv. syringae*) , *Psm1* (*P.s. pv. morsprunorum* race 1), *Psm2* (*P.s. pv. morsprunorum* race 2)

Control (copper): Reduction of bacterial populations in summer → less autumn infections → less canker

The aim of our work is to:

- Identify existing products or products very close to the market for direct replacement for copper in the short term (SCEPTRE PLUS)
 - Bactericidal chemicals, biocontrol organisms, systemic acquired resistance (SAR) and tree health boosters
- Develop new sustainable approaches to control bacterial canker in the future
 - TF223 project, developing bacteriophages

Sceptre Plus: list of treatments/products tested in 2019

Treat.	Product	Active ingredient	Product type	Company	Reason for inclusion
1	Untreated, NOT INOCULATED	n/a			Testimonies/best practice/potential interest
1	Untreated, INOCULATED	None			Testimonies/best practice/potential interest
1	Cuprolyte (not approved)	Copper oxychloride	Fungicide	Valent	Previous entries still in trial/in use/interest
4	AHDB9988	-	Insect control	-	Indicates a 'susceptible' strain - limited efficacy in trials in UK
1	AHDB9989	-	Fungicide/nematicide	-	AHDB (Approved)
1	Serenade ASO	<i>Bacillus subtilis</i> strain OGST 713	RCA	Biobest	Follow to field activity against bacterial diseases in UK and abroad
1	Amylo-X	<i>Bacillus amyloliquefaciens</i> nspsp-Plantago strain D747	RCA	Cella	Additional RCA product
1	AHDB99831	N-acetylcycteine	Bactericide	Non-patented	Impressively against <i>Xanthomonas</i> recorded by AHDB
1	AHDB99859	-	Editor	-	Evidence of efficacy from AHDB
1	AHDB99857	-	Editor	-	Evidence of efficacy from AHDB

New research into the control of bacterial canker of cherry
 Matevz Papp-Rupar (NIAB EMR)



Experimental protocol

Uniform inoculation of shoots:

- Bacterial mix of isolates from 3 pathovars
 - Better representation of natural system
 - PSS (9097) / PSM1(5244) / PSM2 (5255)
 - Quantification of inoculum on leaves after inoculation

Treatment / product applications:

- Whole trees were sprayed with **motorised knapsack sprayer** to better simulate commercial conditions
- Visual inspection for toxicity
- Leaf bacterial population quantification
 - Random sampling of the leaves from inoc. shoots
 - Plating on *Pseudomonas* semi selective media
 - Counting bacterial colonies

Experimental progress to date

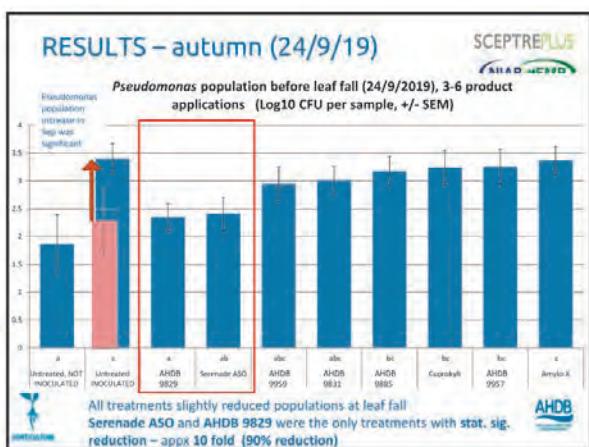
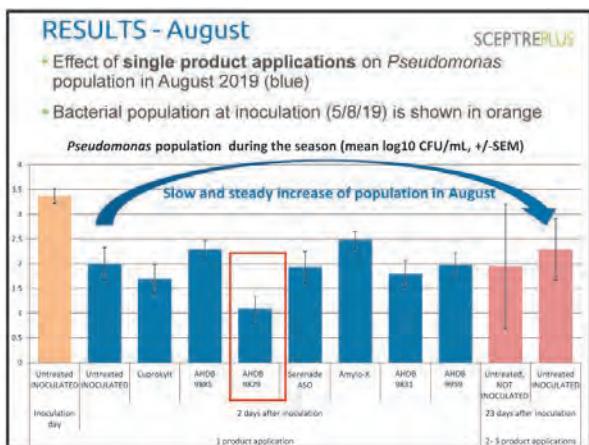
Treatment No.	Product	conc.*	no. of applications	SCHEDULE											
				interval (days)	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
T1	Z	/	/	/	-	-	-	-	-	-	-	-			
T2	Water	/	/	/	-	-	-	-	-	-	-	-			
T3	Cuproaktiv, not approved	3 g/L	4	20	-	-	-	-	-	-	-	-			
T4	AHDB9883	6 ml/l	7	30	-	-	-	-	-	-	-	-			
T5	AHDB9829	2.7 g/l	4	20	-	-	-	-	-	-	-	-			
T6	Serenate ASO	20 ml/l	7	30	-	-	-	-	-	-	-	-			
T7	Amylo-X	5 g/l	6	10	-	-	-	-	-	-	-	-			
T8	AHDB9831	2.4 g/l	4	30	-	-	-	-	-	-	-	-			
T9	AHDB9959	4.65 ml/l	7	10	-	-	-	-	-	-	-	-			
T10	AHDB9957	2 ml/l	6	10	-	-	-	-	-	-	-	-			

* based on SDHI/MA

product application: Z incipient inoculation: / sampling/removal: - visual assessment of the trees: 1

We started treatments more than 2 weeks later after than we planned due to delivery issues with some of the products
 As a consequence, sampling was done before last product application because of the fast progression of senescence and leaf fall.

New research into the control of bacterial canker of cherry
 Matevz Papp-Rupar (NIAB EMR)



New research into the control of bacterial canker of cherry Matevz Papp-Rupar (NIAB EMR)

What are bacteriophages? (Phages)

- Nature's way to control bacterial populations.
- Viruses that infect and kill bacteria only
 - Very narrow host range, e.g. one or few bacterial strains
- Very abundant and present everywhere
 - 10x more phages than all other organisms on Earth combined
- Phages need to infect bacteria in order to survive
 - Not able to reproduce outside the bacterial cell
 - Can be (very) stable in some environments outside bacterial cells



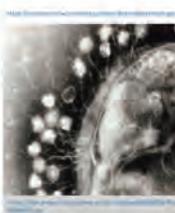
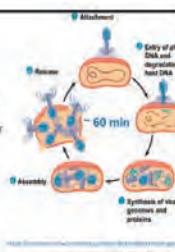
How phages work?

PROS:

- Strain specific bacterial infection → bacterial lysis
 - Reducing unintended killing of beneficial bacteria and other organisms
- Self replicating in the presence of the host
- Evolving and adapting to the host
- No animal or plant toxicity
- No toxic residues in food chain
- Phages occur naturally, we are exposed to them daily without harm

CONS:

- Narrow host range: new phages for new bacterial strains and species
- Phage resistance can emerge in bacteria
- Can facilitate gene transfer between bacteria



Phages in plant disease management

Commercial products:

- AgriPhage (Omnilytics, USA): Bacterial spot on tomato and pepper control compliant with organic standard (OMRI)
- Erwiphage (Enviroinvest, Hun): fire blight on apple -
- BioLysse (APS biocontrol, Scotland): soft rot in potato storage

Our aim is to prove the concept for using phages in cherry canker disease management and facilitate product development



New research into the control of bacterial canker of cherry

Matevz Papp-Rupar (NIAB EMR)

Phage host range tests

Collection of phages isolated from UK orchards in 2018

Are phages specific to pathogenic *Pseudomonas* strains?

- In vitro assay on plates
- 23 *Pseudomonas* strains tested
 - 15 pathogenic
 - 8 beneficial (related to pathogenic)
- Bacteria exposed to phages
 - Phage infection → clear zone or plaque



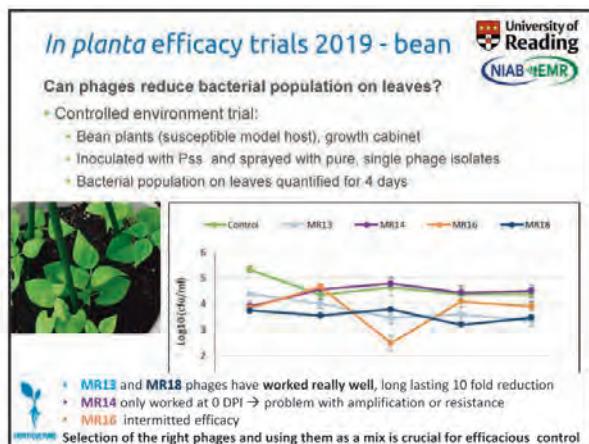
University of Reading
NIAB EMR

AHDB

Collection reference	Patho1.10	Patho1.11	Patho1.12
Isolated from:	Leaf	Leaf	Soil
Phage isolates			
<i>Pseudomonas</i> isolates:	MR13	MR14	MR16
<i>Pss</i> (9097)	YES	YES	YES
<i>Pss</i> 9630	YES	YES	YES
<i>Pss</i> 9654	YES	NO	NO
<i>Psm</i> (5245)	YES	YES	YES
<i>Pum</i> 1.3305	YES	NO	NO
<i>Pum</i> 1.9326	YES	NO	NO
<i>Pum</i> 1.9629	YES	NO	NO
<i>Pum</i> 1.9646	YES	YES	YES
<i>Pum</i> 1.9657	YES	NO	NO
<i>Pso</i> 17.12029	YES	YES	NO
<i>Pum</i> 1.9670	YES	YES	YES
Pathogenic strains			
<i>P. s. lachrymans</i> 789	YES	NO	NO
<i>P. putida</i> psw340	NO	NO	NO
<i>P. prote</i>	NO	NO	NO
<i>P. fluorescens</i> ATCC 17400	NO	NO	NO
<i>P. fluorescens</i> F113	NO	NO	NO
<i>P. fluorescens</i> PFR37	NO	NO	NO
<i>P. fluorescens</i> PT-5	NO	NO	NO
Beneficial strains			
<i>P. s. lachrymans</i> 789	YES	NO	YES
<i>P. putida</i> psw340	NO	NO	NO
<i>P. prote</i>	NO	NO	NO
<i>P. fluorescens</i> ATCC 17400	NO	NO	NO
<i>P. fluorescens</i> F113	NO	NO	NO
<i>P. fluorescens</i> PFR37	NO	NO	NO
<i>P. fluorescens</i> PT-5	NO	NO	NO

Yes, our phages are specific to pathogenic strains, no action against beneficial strains.
Different host range of different phage isolates → selection important for broad efficacy

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New research into the control of bacterial canker of cherry Matevz Papp-Rupar (NIAB EMR)

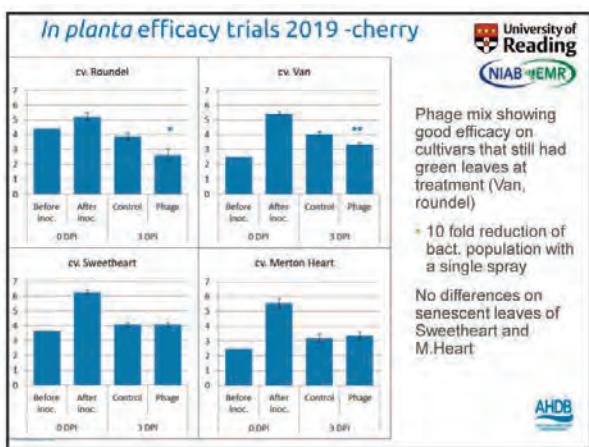
In planta efficacy trials 2019 -cherry

University of Reading
NIAB EMR

Can phages reduce bacterial population on leaves in field?

- FIELD trial:
 - Permit obtained from CRD/HSE, valid for testing UK phages until 2022
 - Cherry cvs:
 - Van, Roundel, Merton Heart, 20+ year old trees in field
 - Sweetheart, 3 year old potted trees in polytunnel
 - Shoots / leaves inoculated with *Pseudomonas* (Pss 9097) and sprayed with a mix of 4 phage isolates
 - At leaf fall, early-mid Oct 2019
 - Bacterial population on leaves quantified at 3 days after treatment

AHDB



Conclusions and future work

SCEPTRE PLUS
University of Reading
NIAB EMR

- Short term canker control:
 - Serenade ASO and AHDB 9936 were identified as effective products
 - 3 applications of AHDB 9936, 6 applications of Serenade ASO
 - AHDB 9936 showed effect already at single application
- Medium/long term canker control:
 - Phages were shown to specifically inactivate pathogenic *Pseudomonas* strains without detrimental effect to beneficial bacterial
 - Phage treatments were able to reduce bacterial population to similar extend as the current control products in both controlled environment and field trials.
 - Large scale orchard trial with high disease pressure over 2 seasons would be required to confirm the efficacy observed in small scale trials and gather further data required for commercialisation.
 - Collaboration with PPP producing companies is required to deliver product to the market as soon as possible

AHDB

New research into the control of bacterial canker of cherry
Matevz Papp-Rupar (NIAB EMR)

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Angela Berrie



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Robert Jackson



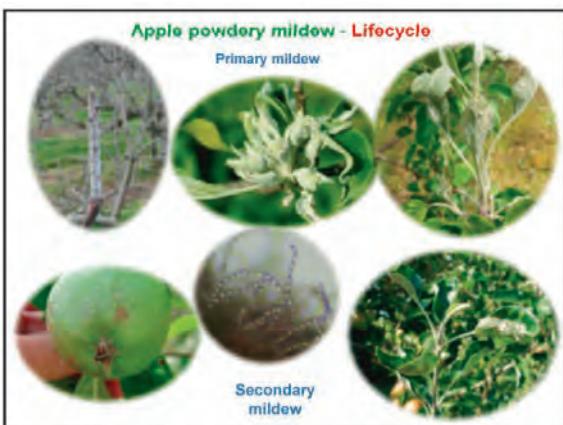
Thank you!



New approaches to apple powdery mildew control

Angela Berrie (NIAB EMR)





Background - Apple powdery mildew

• Apple powdery mildew – *Podosphaera leucotricha*

• Second most important disease of apple in UK

• All apple cultivars susceptible

• Cox and Braeburn very susceptible but can find high incidence mildew on most cultivars in many orchards

• Favoured by warm humid conditions >18°C

• Surface water on leaves not needed for spore germination

• Only youngest leaves susceptible to infection

NIAB EMR

AHDB

Plant Science into Practice

New approaches to apple powdery mildew control

Angela Berrie (NIAB EMR)

NIAB EMR Background - Apple powdery mildew Control

- Provided growing shoots, mildew inoculum and not raining every day is a mildew infection day
- In favourable conditions infection to sporing mildew lesions 4-5 days. So potential for rapid disease build-up in summer
- Mildew epidemics driven by incidence primary mildew at start of summer
- Need to protect new growth on developing shoots from blossom to the end of extension growth 10-15 sprays per season
- The availability of effective fungicides has improved but still with a limited number of sprays per product
- There is still pressure to reduce fungicide use

Plant Science into Practice AHDB

NIAB EMR AHDB project TF223 – Top fruit pest and disease management

- Task 3.2 - Alternative treatments to fungicides for mildew control
- Focus on evaluating biostimulants, plant strengtheners / elicitors
- These may be cheaper and if effective could form the basis of a programme with reduced fungicide use
- They may also be effective against other apple diseases and possibly have benefits for fruit yield and quality

Plant Science into Practice AHDB

NIAB EMR AHDB project TF223 – Alternative treatments for mildew control

2015 - 2017

- Emphasis on evaluating potential products
- All test products delayed onset of mildew epidemic
- Best of the products evaluated were SB Invigorator, Cultigrow, Trident, Wetcit, Mantrac
- Such products are not effective enough to be used alone
- But if included in a programme can contribute to control and reduce fungicide inputs

2018-2019

Evaluated programmes combining products with fungicides

Plant Science into Practice AHDB

New approaches to apple powdery mildew control

Angela Berrie (NIAB EMR)

NIAB EMR Project TF223 – Powdery mildew control 2019 - Method

- NIAB EMR Orchard MP196, planted in 2012
- Large orchard of alternate rows of Gala and Braeburn on M9 rootstock
- Opportunity to evaluate programmes on another cultivar
- Divided into large plots of 6 rows of 37 trees with 3 reps of 4 programmes. No untreated control
- Treatments applied using tractor trailed air-assisted sprayer at 200 L/ha
- 14 spray rounds applied at approx. 7-10 day intervals from early bloom (24 April) until 24 July

Plant Science into Practice AHDB

NIAB EMR Project TF223 – Powdery mildew control 2019 - Assessments

- All assessments done on trees in middle 2 rows of each plot on Gala and Braeburn
- Primary mildew assessed on blossoms on 1 May and primary vegetative mildew on shoots on 22 May
- Mildew assessed on top 5 leaves on 10 shoots per plot weekly from 29 May on 10 occasions
- Fruit set and fruit drop was recorded on 2 branches on each of 10 trees per cultivar per plot and any phytotoxic symptoms
- At harvest 200 fruit samples were taken and assessed for fruit quality – size, russet and colour

Plant Science into Practice AHDB

NIAB EMR AHDB project TF223 – Alternative treatments for mildew control

Project TF223
Alternative treatments for
mildew control
2019

Plot 1
Plot 2
Plot 3
Plot 4
Plot 5
Plot 6
Plot 7 (untreated)

Plot 8
Plot 9
Plot 10
Plot 11
Plot 12
Plot 13
Plot 14

MP196

Plant Science into Practice AHDB

New approaches to apple powdery mildew control
 Angela Berrie (NIAB EMR)

Products used in 2019				
Product	Active ingredient	Product type	Rate of product / ha	Number of sprays
Topas	penconazole	Fungicide	0.5 L	3
Cosine	cryflufenamid	Fungicide	0.5 L	2
Sercadis	fluxapyroxad	Fungicide	0.3 L	3
Talius	proquinazid	Fungicide	0.25 L	2
Flint	trifloxystrobin	Fungicide	150g	4
Cultigrow CBL	flavonoids	Elicitor/biostimulant	500 ml	Blossom then monthly.
Wetcit	Alcohol ethoxylate	Energiser adjuvant	0.2 %	7-10 days
SB invigorator	Various nutrients and natural products	Physical action Controls various pests and mildew	1ml/L	7-10 days Weekly sprays
Mantrac Pro	manganese	Nutrient	0.5 L	5-6 applications from green cluster / pink bud
Trident	Silicon 1%, Copper 2%, Zinc 4%	Nutrient / elicitor	2 L	7-10 days

Plant Science into Practice

TF223 Mildew – Programmes applied in 2019				
Date	Fungicide 7 days	1 CBL / Mantrac	2 Mantrac / Trident	3 CBL / Trident
24 April	Flint	Mantrac + Flint	Mantrac + Flint	Trident + Flint
1 May	Sercadis + Captan	CBL + Captan	Trident + Captan	CBL + Captan
6 May	Flint	Mantrac + Flint	Mantrac + Flint	Trident + Flint
15 May	Sercadis	SBI	SBI	SBI
21 May	Topas + Captan	Topas + Captan + Mantrac	Topas + Captan + Mantrac	Topas + Captan + Trident
29 May	Talius	CBL + Wetcit	Trident	CBL + Wetcit
5 June	Cosine + Captan	Cosine + Captan + Mantrac	Cosine + Captan + Mantrac	Cosine + Captan + Trident
12 June	Topas	SBI	SBI	SBI
19 June	Flint	Mantrac + Flint	Mantrac + Flint	Trident + Flint
26 June	Cosine	CBL + Wetcit	Trident	CBL + Wetcit
3 July	Sercadis	Sercadis + Mantrac	Sercadis + Mantrac	Sercadis + Trident
10 July	Topas	SBI	SBI	SBI
17 July	Flint	Mantrac + Flint	Mantrac + Flint	Trident + Flint
24 July	Talius	SBI	SBI	SBI

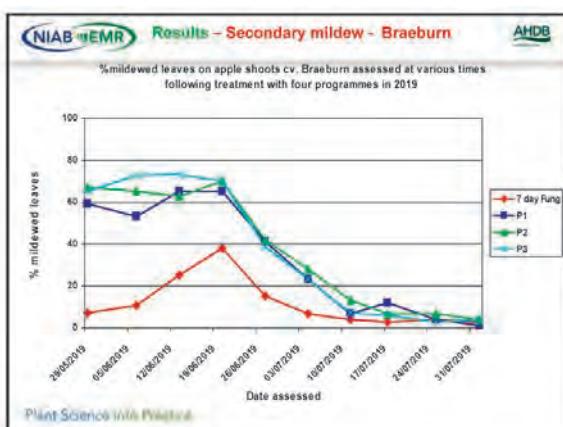
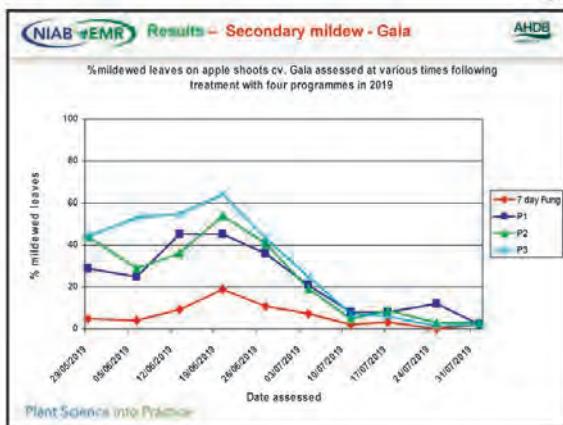
Plant Science into Practice

Item	Programmes			
	Fungicide 7 days	1 CBL / Mantrac	2 Mantrac / Trident	3 CBL / Trident
Mildew fungicides	14	7	7	7
Scab fungicides	3	3	3	3
CBL	0	3	0	3
Mantrac	0	7	7	0
Trident	0	0	3	7
Wetcit	0	2	0	2
SBI	0	4	4	4

Plant Science into Practice

New approaches to apple powdery mildew control

Angela Berrie (NIAB EMR)



NIAB EMR Results – Primary mildew & overall secondary mildew

Programme	% Primary blossom mildew		Mean number primary mildewed shoots per 10 trees		Overall % secondary mildew	
	Gala	Braeburn	Gala	Braeburn	Gala	Braeburn
Fungicide 7 days	1.0	1.3	4.0	11.7	6.2	11.7
1 CBL / Mantrac	0.7	2.3	8.3	41.3	23.1	33.2
2 Mantrac / Trident	0.3	2.7	12.0	28.7	24.1	36.5
3 CBL / Trident	0	1.0	12.7	27.0	30.1	36.3

Plant Science into Practice

New approaches to apple powdery mildew control
 Angela Berrie (NIAB EMR)



NIAB EMR Results - Fruit set Gala and Braeburn AHDB

Programme	Gala			Braeburn		
	% Initial fruit set	% Final fruit set	% Fruit drop	% Initial fruit set	% Final fruit set	% Fruit drop
Fungicide 7 days	71.3	58.3	18.3	40.8	35.8	12.6
1 CBL / Mantrac	67.0	45.9	31.3	32.7	27.8	15.0
2 Mantrac / Trident	69.4	59.9	13.7	34.6	29.0	16.3
3 CBL / Trident	66.2	54.9	16.8	32.6	29.5	9.7

Plant Science into Practice

NIAB EMR Results - Fruit quality Gala AHDB

Programme	Weight of 200 fruit kg	Mean russet score	Mean colour score	No fruit > 65 mm	Wt fruit >65 mm
Fungicide 7 days	31.1	157.7	763	168.7	28.2
1 CBL / Mantrac	29.4	156.0	752	151.0	24.5
2 Mantrac / Trident	29.4	151.7	750	160.3	25.6
3 CBL / Trident	28.4	167.0	767	150.7	23.9

Russet score - Higher score = more russet
 Colour score - Higher score = > fruit colour

Plant Science into Practice

New approaches to apple powdery mildew control

Angela Berrie (NIAB EMR)

NIAB EMR

Results – Fruit quality Braeburn

Programme	Weight of 200 fruit kg	Mean russet score	Mean colour score	No fruit > 65 mm	Wt fruit >65 mm
Fungicide 7 days	36.2	133.0	741.0	178.0	33.7
1 CBL / Mantrac	33.8	112.3	733.3	171.7	30.7
2 Mantrac / Trident	33.9	139.7	764.3	178.0	31.5
3 CBL / Trident	34.5	129.3	746.0	169.3	31.3

Russet score – Higher score = more russet
Colour score – Higher score = fruit colour

Plant Science into Practice

NIAB EMR

**Project TF223 –
Powdery mildew control 2019 - Conclusions**

- Secondary mildew in programmes 1-3 was much higher in May and June, but by July was low and similar to 7 day fungicide programme
- Primary vegetative mildew was much lower in Standard 7 day fungicide programme when assessed at end of flowering, most likely due to the intensive fungicide sprays applied
- This resulted in the lower secondary mildew recorded in the standard programme in June
- If the test programmes 1-3 had started with the same intensive fungicide sprays before switching to the 14 day fungicide programmes it is likely that secondary mildew recorded would have been similar to that in the standard 7 day programme throughout the trial

AHDB

NIAB EMR

**Project TF223 –
Powdery mildew control 2019 - Conclusions 2**

- The results demonstrate that by incorporating biostimulants / elicitors into a fungicide programme it is possible to reduce fungicide inputs by up to 50%
- However, it is important that primary mildew is assessed and if high dealt with at the start from pre-bloom to reduce inoculum
- Secondary mildew must be monitored so that if incidence increases above 10% mildewed leaves or 30% mildewed shoots, the programme can be adjusted

AHDB

New approaches to apple powdery mildew control
Angela Berrie (NIAB EMR)

NIAB EMR

ACKNOWLEDGEMENTS

Thanks to:

AHDB for funding Project TF223

Farm team at NIAB EMR for applying the sprays
Tom Passey, Jennifer Kingsnorth and Sarah Cohen
for assistance with the trials

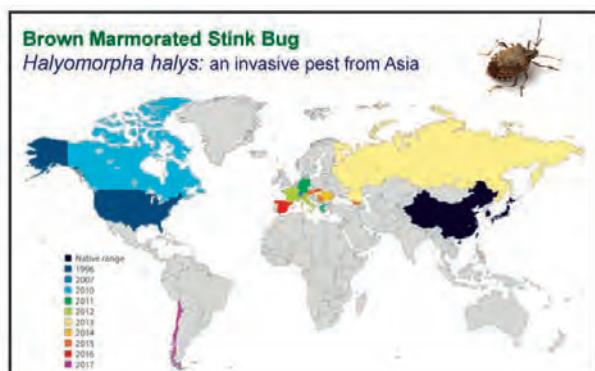


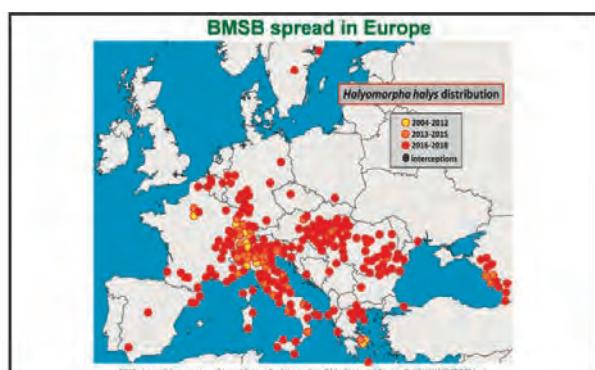
AHDB
AGRICULTURE

Plant Science into Practice

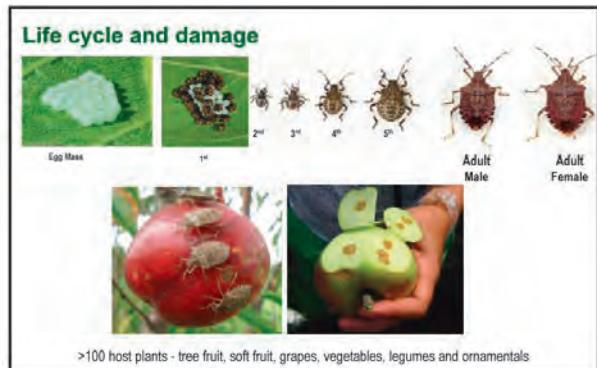
Up-date on two shield bug pests – a native and an invader
Glen Powell (NIAB EMR)

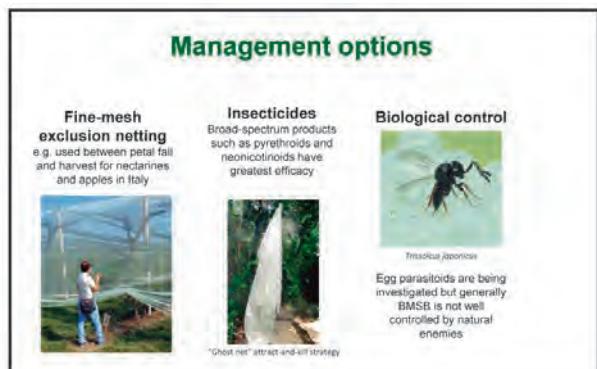






Up-date on two shield bug pests – a native and an invader
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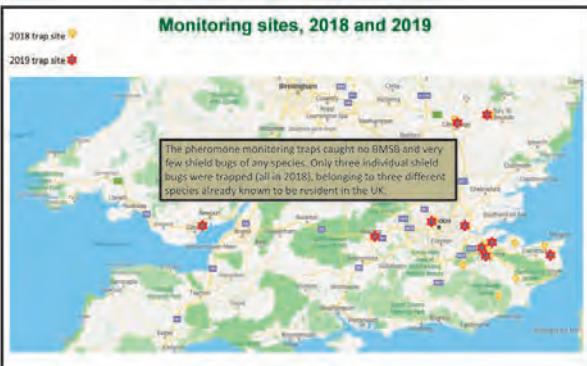


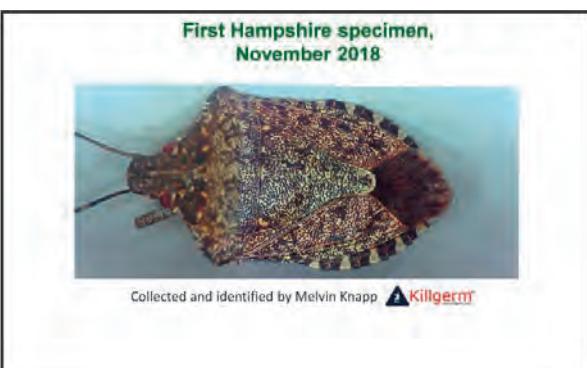


Up-date on two shield bug pests – a native and an invader
Glen Powell (NIAB EMR)

Traps are checked weekly for 12 weeks and then brought into the laboratory for closer inspection







Up-date on two shield bug pests – a native and an invader
Glen Powell (NIAB EMR)

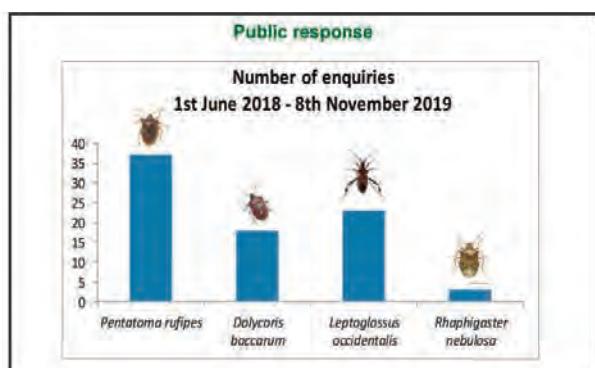


Awareness campaign in 2018 and 2019

Alerts to growers and the general public

- NIAB EMR issued press releases to publicise the pheromone monitoring programme and appeal for reports of sightings
- Requests to send specimens or images for identification

BMSB Mottled shield bug Forest bug



Up-date on two shield bug pests – a native and an invader Glen Powell (NIAB EMR)



A previous test has been developed and published, but this is not high-throughput and cannot deal with mixed-species samples (e.g. from insect traps)



Dr. Tara Gariepy,
Agriculture and
Agri-Food Canada

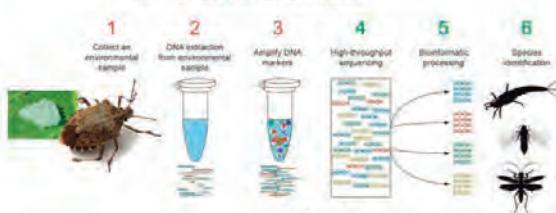
Microscale Biology (2014) 2: 393–394
DOI 10.1111/mec.12251

SPECIAL ISSUE: MOLECULAR DETECTION OF TROPHIC INTERACTIONS
A molecular diagnostic tool for the preliminary assessment of host-parasitoid associations in biological control programmes for a new invasive pest

T. G. GARIEPY • R. WAYET and J. ZHANG
‘Southern Crop Protection and Food Research Centre, Agriculture and Agri-Food Canada, London, Ontario, Canada N6T 4T3,
ICAR-Rouleau Division, CH-3600 Dufour, Senneterre, (MN), Canada J1M 2A8 and Lab for Biotax, 27 Vlaamsdreef, West-Rood
Beek, 3510 Heverlee, Belgium

NEW PROJECT: DNA METABARCODING

This approach allows high-throughput processing of mixed / degraded samples



Adapted from: <http://www.sixthresearcher.com>

AHDB HORTICULTURE BBSRC

Up-date on two shield bug pests – a native and an invader

Glen Powell (NIAB EMR)

PROJECT OBJECTIVES

- Create a large reference collection for BMSB ✓
- Add in references from commonly confused species ✓
- Design species-specific primers ✓
- Test PCR sensitivity with eggs, nymphs, adults ✓
- Test PCR sensitivity to DNA dilution ✓
- Use sequencing to confirm specificity

-Provide growers with a diagnostic tool for BMSB identification



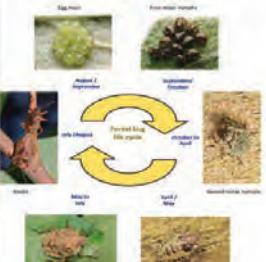
Forest bug

- Another shield bug (*Pentatomida rufipes*) emerging as an orchard pest
- Feeding activity on developing fruits is being linked with pitting and distortion damage (pear and apple), corky tissue
- Limited information on the ecology or control of this pest





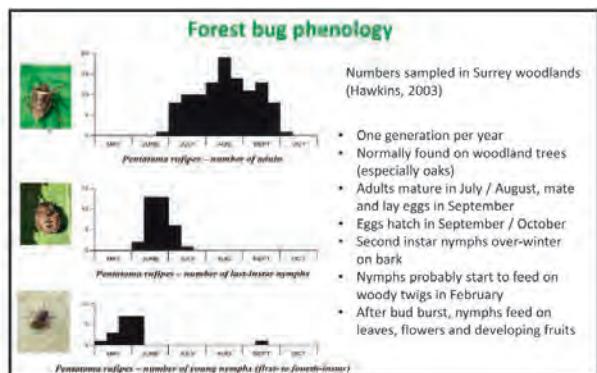
Forest bug life cycle



From AHDB review

Up-date on two shield bug pests – a native and an invader

Glen Powell (NIAB EMR)



Key findings of recent review

- Increasing UK damage reported (South-East and West Midlands)
- Very limited research into the ecology and control of this species
- No information linking UK local population levels and activity with damage
- Nymphs feed early in the season on developing buds, flowers and fruits (shortly after flowering)
- Highest risk is before or shortly after flowering
- Risk increases with tree age (rougher bark)
- Low densities are sufficient for fruit damage
- Economic thresholds of 2-3 nymphs per 100 sampled branches have been suggested
- Very few insecticide efficacy studies have been carried out

Recommendations for future research

- Establish economic thresholds for UK orchards
- Trials to test the efficacy of insecticides
- Identify the sex pheromone and make this available for monitoring
- Investigate vibration-based communication signals and potential for mating disruption



Up-date on two shield bug pests – a native and an invader
Glen Powell (NIAB EMR)

Conclusions	
BMSB (invasive)	Forest bug (native)
<ul style="list-style-type: none">Globally-important pest, causing extensive crop lossesAlready here (at least as adults)Possibly breeding in UK?Likely to establish and spread within the next few yearsOften confused with other shield bug speciesDNA-based test in development	<ul style="list-style-type: none">Widespread UK speciesNymphs over-winter in orchards and damage developing fruitIncreasing UK damage to pear / appleNo UK research or threshold availableNo pheromone(s) identifiedLimited information available on control measures

Acknowledgements

AHDB

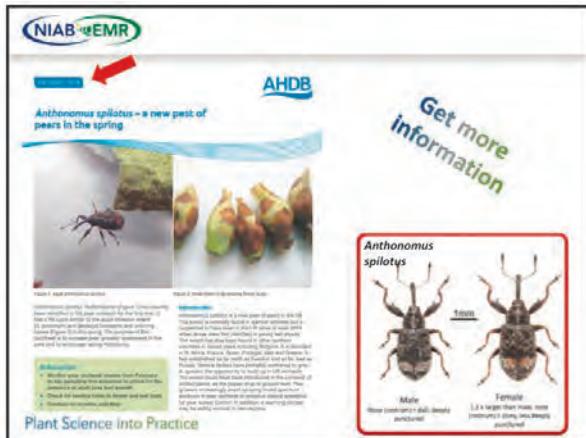
- Michelle Fountain for guidance and advice
- AHDB for funding the pheromone-based monitoring (part of Tree Fruit Project TF 223) and the forest bug review
- BBSRC for funding the BMSB DNA project
- Lara Maistrello, Tim Haye, Melvin Knapp, Jonathan Michaelson, Tristan Bantock, David Skittrall, Andy Bull for sharing samples, information and images
- The many helpers who have set up and monitored pheromone traps

NIAB EMR

BBSRC



Anthonomus spilotus – a climate change pest Michelle Fountain (NIAB EMR)



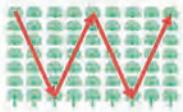
Anthonomus spilotus – a climate change pest

Michelle Fountain (NIAB EMR)

NIAB EMR

Monitoring

- Once a week
- Tap-sample for adult weevils – one branch per tree
- Forty trees per orchard (W shape)



- Collection of 40 random flower and leaf buds per week
- Examined under a microscope for feeding damage, eggs, larvae and cocoons



Plant Science into Practice

NIAB EMR

Holes - Adults

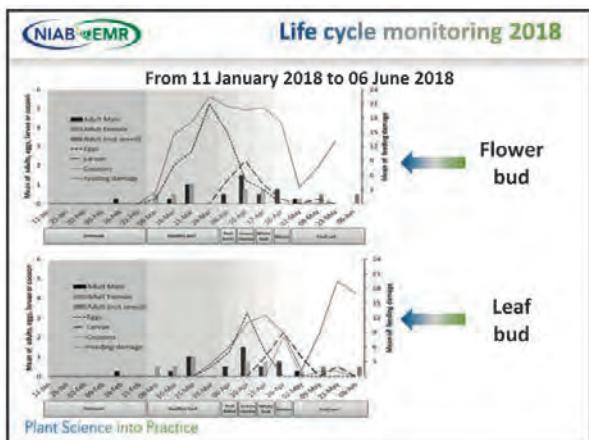


Feeding damage on leaf bud Feeding damage on flower buds

Necrosis and feeding damage



Plant Science into Practice



Anthonomus spilotus – a climate change pest

Michelle Fountain (NIAB EMR)

NIAB EMR

Damage

- Damaged flower buds labelled – mid-Mar to early Apr
- Damaged leaf buds labelled – Early to mid-Apr
- Undamaged 10 flower buds and 10 leaf buds were meshed and used as control
- Checked for damage - open blossoms and leaf emergence

Damage from feeding within flower buds

Damage from feeding on parenchyma of leaf

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NIAB EMR

Numbers of flowers or leaves damaged

- Larvae development damaged in average 1 flower per truss (≈ 6 flowers/truss) - may be more of a thinning effect
- Larvae development damaged in average 4 leaves per shoot (≈ 6 leaves/shoot)

Leaves/shoot 12.5% of shoots
Leaves/truss 1.9% of shoots
Flowers/truss 22.6% of trusses
 3% of shoots

■ Adult feeding
■ Development damage
Control

No of flower/leaf damaged per truss/shoot.

Plant Science into Practice

NIAB EMR

Chemical control

- Optimum spray timing
- Most sprays will be targeted to control adults
- Pollinators present and spray persistence may effect natural enemies = pear sucker



Plant Science into Practice

Anthonomus spilotus – a climate change pest

Michelle Fountain (NIAB EMR)

NIAB EMR

Chemical control 2017

- Lab studies
 - Directly sprayed adults with each insecticide – Field rate
 - Calypso (80%) and Spruzit (70%)
 - Steward and Coragen ineffective

Treatment	% mortality
Calypso	~80
Spruzit	~70
Hallmark	~20
Gavelle	~10
Enviro 10SE	~10
Coragen	~5
Steward	~2
Untreated control	~1

Growers should be guided by experienced pear agronomists who are BASIS qualified before making a final choice

Plant Science into Practice

NIAB EMR

Chemical control 2018

- Lab studies
 - Adults fed with each insecticide – Field rate
 - Calypso (100%) and Steward (70%)
 - Tracer ineffective

Treatment	% cumulative mortality
Calypso	~100
Steward	~70
Tracer	~35
control	~35

Plant Science into Practice

NIAB EMR

Field trial 2019

Pre assessment, Post green-cluster spray, Green-cluster Petal fall, and 3 week after

Each branch select, one cluster of buds; number of buds in section with holes – expressed in damage/bud and tap sample

30 branches 4 orchards

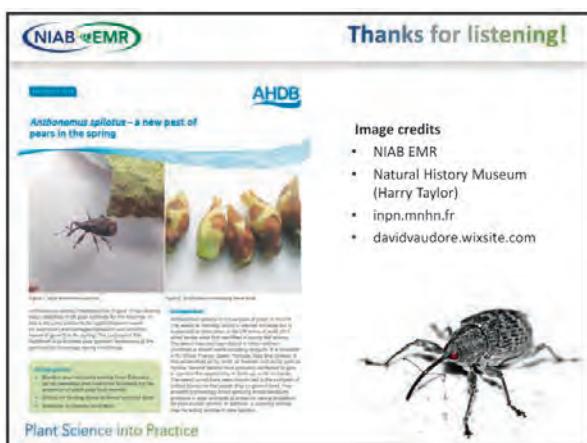
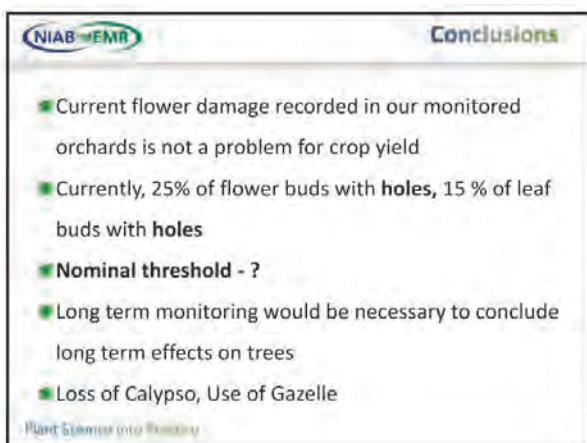
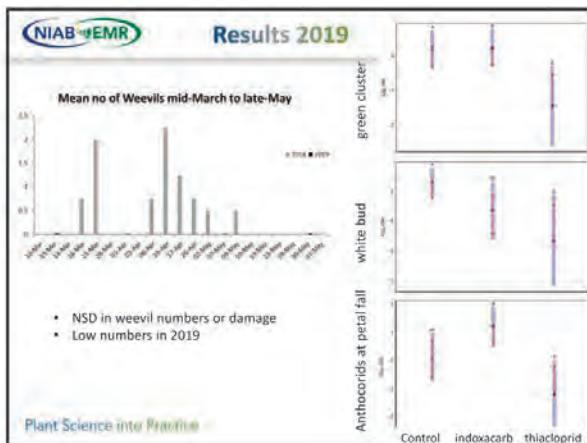
Table 9.1. Product details and field rate to be applied in this trial. * Label rate for pre-blossom application on pear. See appendix 2 and 3.

Col. code	Product	q.l.	Field dosage/ha*	Max. No. of Applications	Hi t	Timing
Red	Calypso	thiacloprid	375 ml	3	14 d	Green cluster – white bud
Black	Steward	indoxacarb	250 g	3	7 d	Green cluster – white bud
Blue	Calypso	thiacloprid	375 ml	2	14 d	Petal fall
Yellow	Steward	indoxacarb	250 g	3	7 d	Petal fall
Green	Untreated			–	–	

Plant Science into Practice

Anthonomus spilotus – a climate change pest

Michelle Fountain (NIAB EMR)



Enhancing the ecology of newly planted orchards

Celine Silva (NIAB EMR)

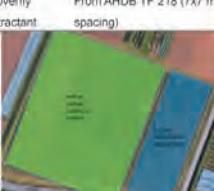


Why this study?

- Establishing new crops requires substantial investment (~£35k/ha for apple)
- Newly planted orchards have an un-established ecosystem
- Minimal, simplified or absent vegetation cover with a low diversity of plant species resulting in low pollen and nectar provision and low structure, hence refugia
- Tree bark and canopy are simple compared to older established trees affording little availability for predatory arthropods to gain refuge
- Natural predators and pollinators have not built up and established in new orchards leaving the crop exposed to attacks from a number of pest species

Plant Science into Practice

Interventions				
Treatment	Detail	Target beneficial	Improve	Date implement
Alleyway sowings	Yarrow, Knapweed, Ox-eye daisy, Bird's foot trefoil, Self-heal, Red campion, Red clover	Pollinators, parasitoids, anthocorids, spiders	Pest control inc aphids, tortrix networks	Spring 2017
Earwig refugia	Innovate UK Bioactive predator refuge	Earwigs, spiders, ladybirds	Aphids, caterpillar, codling moth	Autumn 2017
Hoverfly attractant	From AHDB TF 218 (7x7 m. Hoverfly adults and larvae spacing)	and larvae	Aphid control and pollination	From 2018



- six replicate orchards
- 0.25 ha was treated with ecological enhancement interventions
- orchards were separated by >1 km

Enhancing the ecology of newly planted orchards

Celine Silva (NIAB EMR)

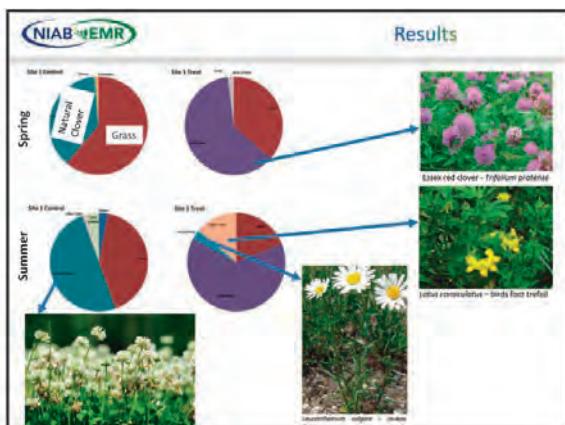
NIAB EMR Assessed – invertebrates in the apple trees

	Spring	Summer	Autumn
Ground coverage	✓ 2018	✓	-
Solitary Bee Nesting	✓	-	-
Aphids	✓	✓	-
Earwigs Refuges	✓	-	-
Natural Predators	✓	✓	✓
Apple leaf curling midge damage	-	✓ 2018	-
Phytophagous and predatory mites	-	✓	-
Codling/tortrix/capsid/weevil fruit damage	-	✓	✓
Earwigs activity at night	-	✓	-
Hoverflies abundance	-	✓ 2018	✓ 2018
Plant Science into Practice			

NIAB EMR Results

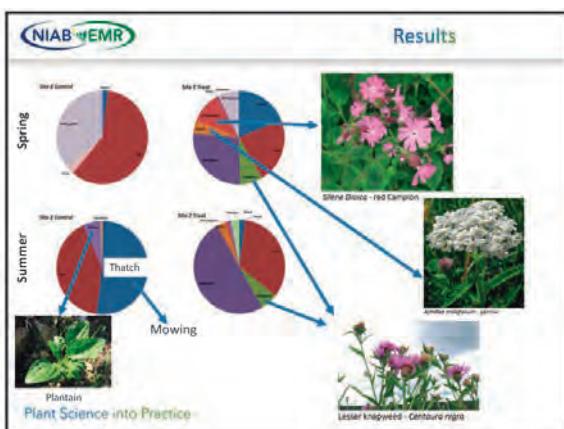
Percentage cover of each species in the seed mix successfully sown, per treated site, in spring and summer 2018 and summer 2019

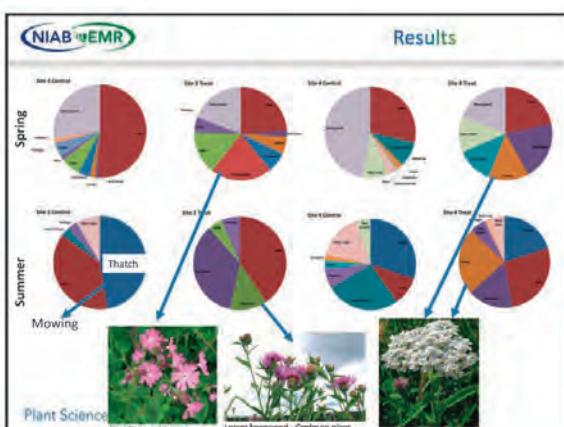
Site	Season	Coverage of seed mix	
		2018 (%)	2019 (%)
1	spring	61.5	-
	summer	81	64.5
2	spring	50	-
	summer	60	81.6
3	spring	29.5	-
	summer	48	83.6
4	spring	47	-
	summer	42	53.9
5	spring	-	-
	summer	-	-
6	spring	15.5	-
	summer	22	43.1
Plant Science into Practice			

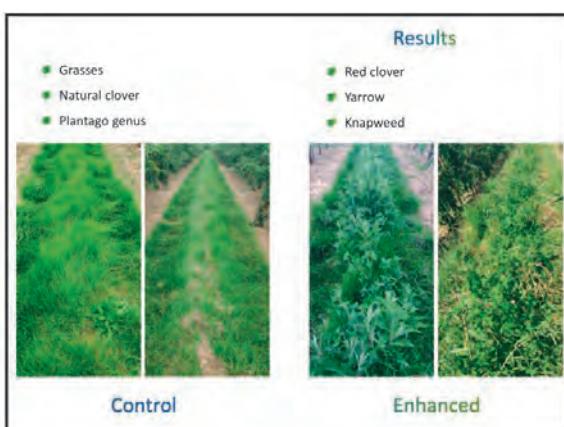


Enhancing the ecology of newly planted orchards

Celine Silva (NIAB EMR)







Enhancing the ecology of newly planted orchards

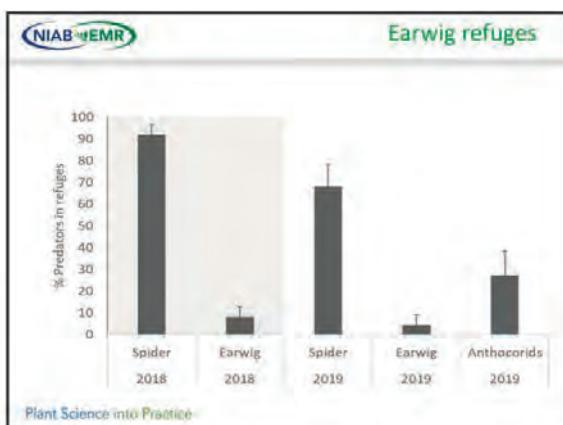
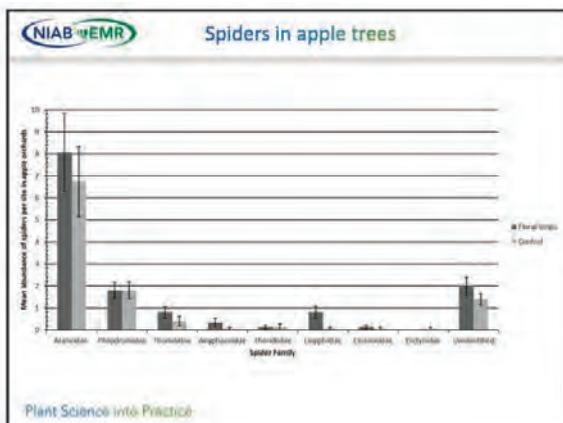
Celine Silva (NIAB EMR)

NIAB EMR

Results – warning – very low numbers

Table 2. Summary of data collected from 'Enhancing ecology' in 5 newly plant orchards 1 and 2 years after intervention establishment. Green = positive effect, red = negative effect, and black = no effect or insufficient data (x)

Arthropod	Timing	2018	2019
'Wigwests'	Summer	91.75% spiders 8.25% earwigs	68.1% spiders, 4.5% earwigs 27.4% anthocorids
Hoverflies (sticky traps)	Summer	p<0.001 (August)	0.7918 (July)
Coddling moth	Summer	Decrease, p<0.001	x
	Autumn	x	Significant, p<0.001
	Autumn dropped apples	Significant, p<0.001	Few dropped fruit
Aphids on shoots	Spring	p<0.001	NSD
	Summer	NSD	Few aphids
Tree tapping	Spring	x	Significant, p<0.001
	Summer	Decreasing (p=0.047)	x
	Autumn	x	x
	Night assessment	NSD	x
Mites on leaves	Predatory mites	Rust mites (p<0.001), Predatory mites (p=0.004), fruit tree and spider mites (p=0.001, only significant 1 year)	Few mites
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Enhancing the ecology of newly planted orchards

Celine Silva (NIAB EMR)

NIAB EMR				Cost /ha
	Per unit	Per ha	Time (Hours)	
Seed Mix for 1 ha- every other row (e.g. Cotswold seeds, Emorsgate EM1)		~£152-310		
Sowing/Drilling an Rolling over large area (no ground prep because new orchard)	Large areas	New orchard £28	8 hours – 10 ha	
Earwig Refuge in every tree (1500-2000/ha) Hoverfly attractant (7x7 m spacing)	?	?	-	
	£2.70/device = 196/ha	£529.20 [£265 – half rate]		
Cost of Labour (2019) inc NA + PEN	£8.77/hr.	-	1	
Deploying refuge and hoverfly attractant	-	£35.08	4	
Reduced cost due to less mowing through labour and fuel		Faster mowing sprayer		
Cost of insecticide applications		[Calypso ~ £40/ha] 25WD in cherries x 5		
Total		£480-902		

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Conclusions

- Seed mix establishment very successful in 4/6 orchards
- Not all species in the seed mix established at all sites:
 - Self-heal
- Red clover and yarrow were most abundant
- General trend for increased natural enemies and decreased pests in apple trees in enhanced treated plots
- Statistic values - interpret with caution since data obtained on low numbers of arthropods – dry summer
- LONG TERM GAINS – beyond 2 years?

Plant Science into Practice



NIAB EMR

Proposed Future Work

- Continue with pest, beneficial and vegetation surveys in all three seasons depending on phenology of organism
- Identify hoverflies and spiders to family and species where possible to discriminate between different functional groups

Plant Science into Practice



Enhancing the ecology of newly planted orchards
Celine Silva (NIAB EMR)

NIAB EMR

Acknowledgements



Plant Science into Practice

Any Questions?

SWD – The search for new repellents
Christina Conroy (NIAB EMR and Greenwich NRI)

NIAB EMR

UNIVERSITY OF GREENWICH
NRI | National Research Institute

SWD – The Search for New Repellents

Christina Conroy

C.E.Faulder@gre.ac.uk

The slide features a white background with a decorative green and yellow floral border at the bottom. The NIAB EMR and University of Greenwich logos are at the top. The title and author information are centered in the middle.

Project Funding

- Funding:
 - AHDB
 - BBSRC
 - CTP
 - Berry Gardens
 - BBSRC
 - CTP
 - AHDB
- Internship

AHDB BBSRC CTP Berry Gardens

UNIVERSITY OF GREENWICH
NRI | National Research Institute

NIAB EMR

The slide lists project funding sources and includes logos for AHDB, BBSRC, CTP, and Berry Gardens. The NIAB EMR and University of Greenwich logos are also present. The design is similar to the first slide, with a white background and a floral border.

Talk Structure

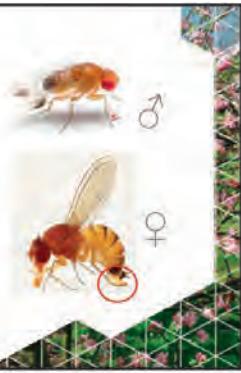
- Problem of SWD
- Aims of work
- Current Research
- Future Research

The slide shows a large illustration of a bee in flight in the center. The text is on the left, and the NIAB EMR and University of Greenwich logos are at the top right.

SWD – The search for new repellents
Christina Conroy (NIAB EMR and Greenwich NRI)

SWD – The Problem

- The major European horticulture pest
- Serrated ovipositor
 - Fruit degradation

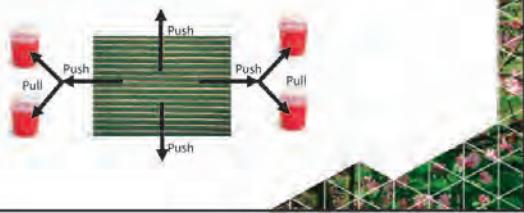


Summer and Winter morph



Overall Project Aim

To develop an integrated push-pull control strategy for the year-round management of *D. suzukii* which is less reliant on pesticides



SWD – The search for new repellents
Christina Conroy (NIAB EMR and Greenwich NRI)

EAG, Bioassays and Field Work

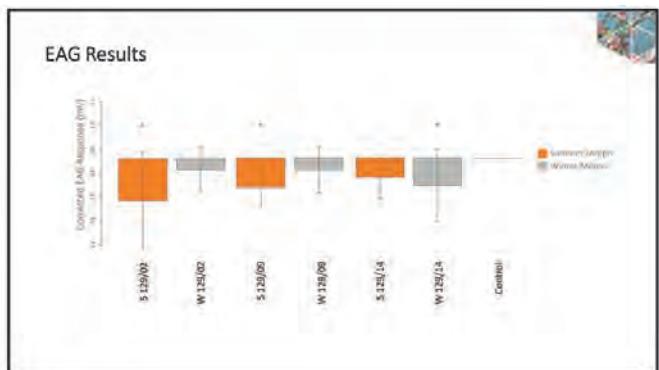
Aim: To identify chemicals which act as repellents for *D. suzukii*, summer and winter morphs.

The diagram shows three chemical structures side-by-side. From left to right: 1. N-(2-methylphenyl)propan-1-amine, represented by a benzene ring with a -CH₂-NH-CH₂-CO- group attached. 2. Ethyl 2-methylpropionate, represented by a propionate chain (-CH₂-CH₂-COO-) with a methyl group (-CH₃) attached to the second carbon. 3. 4-phenyl-2-pentanone, represented by a phenyl ring attached to a five-carbon chain that ends in a carbonyl group (-C=O).

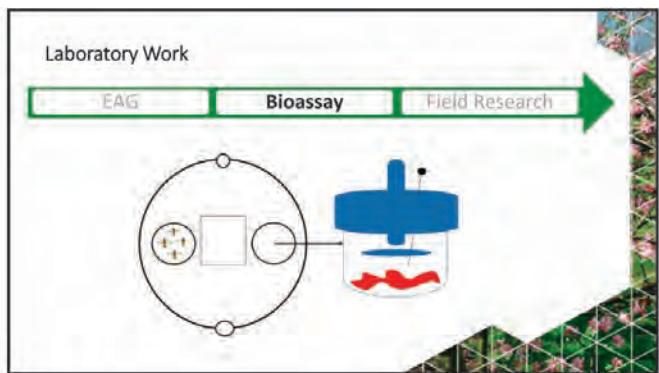
Laboratory Work

EAG **Bioassay** **Field Research** →

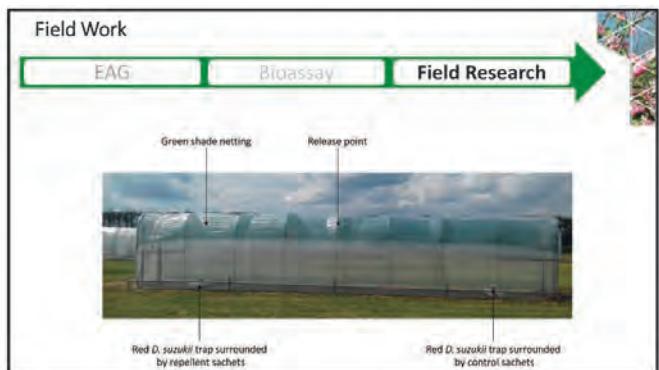
The diagram shows a laboratory setup for an Electro-Antennogram (EAG). A fly is placed in a small glass tube, with one end of the tube connected to a detector. The detector is a small device with a red light and a digital display showing a signal. Above the tube, there are three colored boxes labeled "EAG", "Bioassay", and "Field Research". A green arrow points from "Field Research" towards the right side of the slide, where there is a stylized illustration of a garden or field.



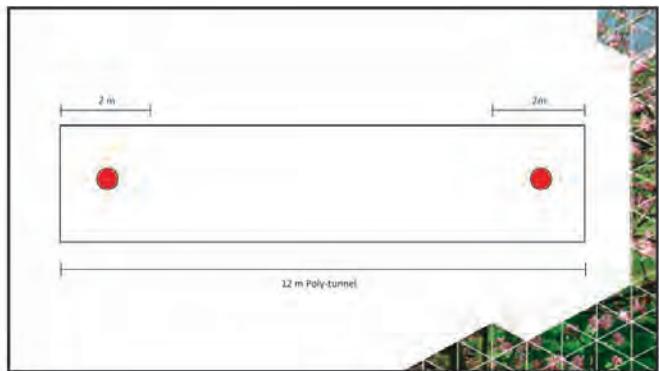
SWD – The search for new repellents
Christina Conroy (NIAB EMR and Greenwich NRI)

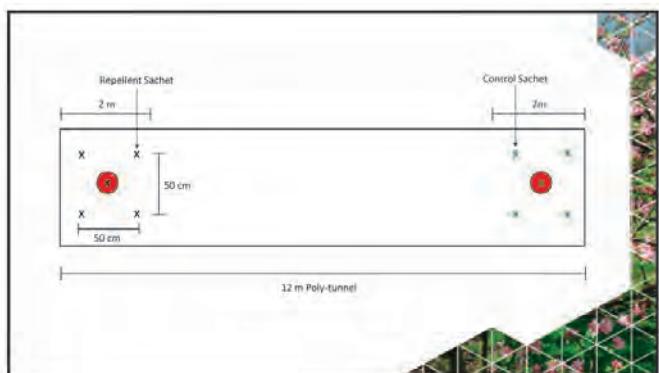


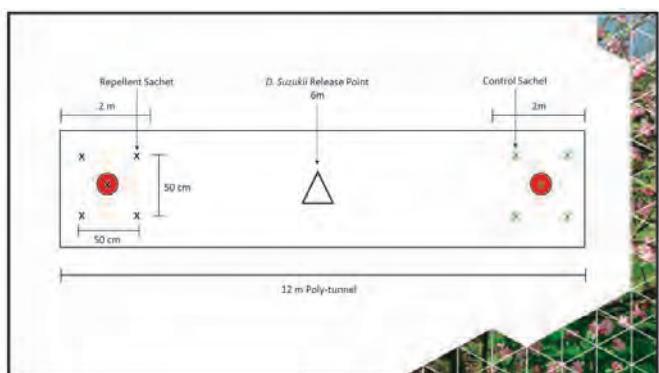
	Chemical	SM (v/v%)			WM (v/v%)		
		0.1	0.01	0.001	0.1	0.01	0.001
Ester	129/04	*	*		**	*	
	129/08	***	**	*	***	**	*
Aldehyde	129/13	*	*	*	**	**	*
Amide	129/14	*		*	**	*	



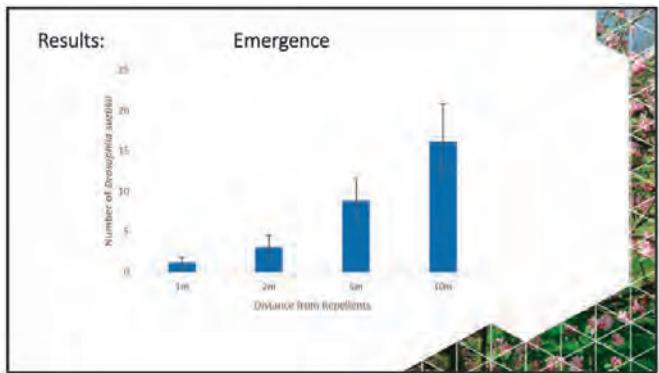
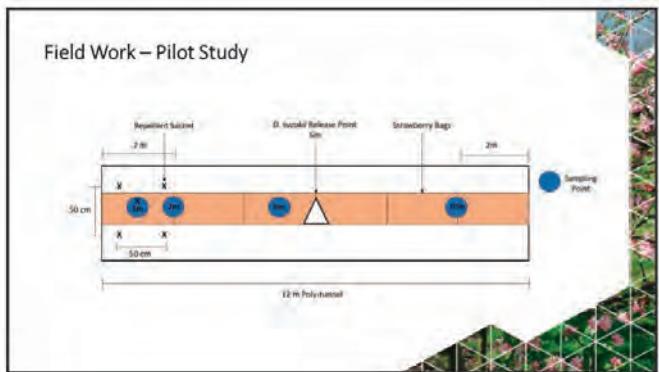
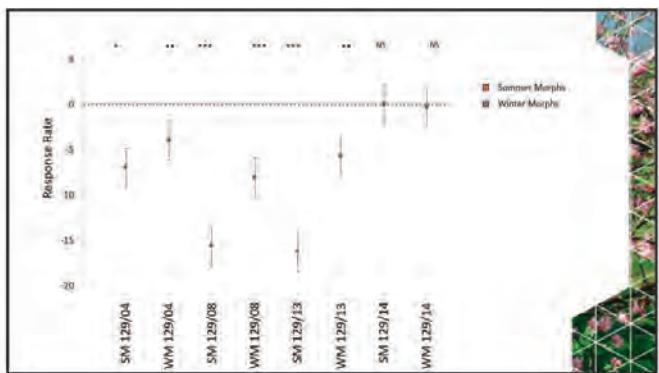
SWD – The search for new repellents
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SWD – The search for new repellents
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SWD – The search for new repellents

Christina Conroy (NIAB EMR and Greenwich NRI)

Future Work

- Distance repellents are behaviourally active
- Push-pull strategy within the field

A) Push-pull
B) Push
C) Pull
D) Control

Attractant odour
Repellent odour

Acknowledgments

- NRI
 - Dr Daniel Bray
 - Professor David Hall
- NIAB EMR
- UNIVERSITY of GREENWICH
- NIAB | National Resources Institute

Contact: C.E.Faulder@gre.ac.uk

Special Thanks

- Scott Raffle
- Harriet Duncalf
- Nicola Harrison

SWD – Developing the use of bait sprays

Ralph Noble (Microbiotech)

SWD - Developing the use of bait sprays

NIAB EMR: Michelle Fountain, Adrian Harris, Francesco Maria Rogal,
Jacob Lowe, Adam Walker, Celine Silva
Microbiotech: [Ralph Noble](#), Andreja Dobrovin-Pennington



Bait Sprays - Objectives

- Improve efficacy of existing SWD insecticides, e.g. Tracer, Benevia
- Make other insecticides effective, broadening range of products
- Spray on to foliage and attract SWD away from fruit
- Reduce risk of pesticide residues and resistance
- Minimise pesticide effects on beneficial and non-target organisms

Baits



SWD – Developing the use of bait sprays
Ralph Noble (Microbiotech)

Semi-field scale strawberry treatments

- 1 Untreated control
 - 2 Two foliar sprays of Benevia (750ml in 500L/ha) weeks 1 and 2
 - 3 Four band sprays of Benevia (30ml in 40L/ha) with Combi-protect weeks 1, 2, 3 and 4
 - 4 Four band sprays of Benevia (30ml in 40L/ha) with *H. uvarum* weeks 1, 2, 3 and 4
-  10 female and male SWD introduced 1 day after spraying in weeks 1, 2 and 3



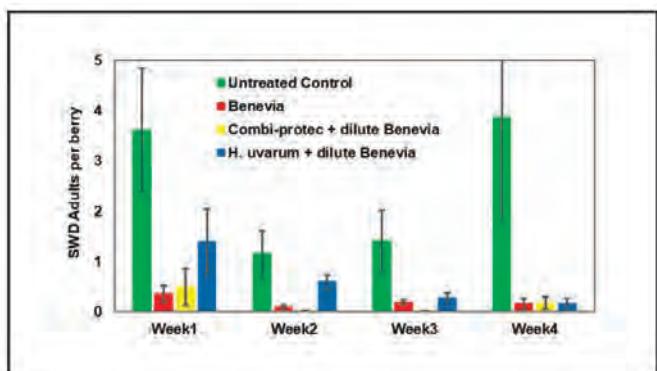
Band spraying

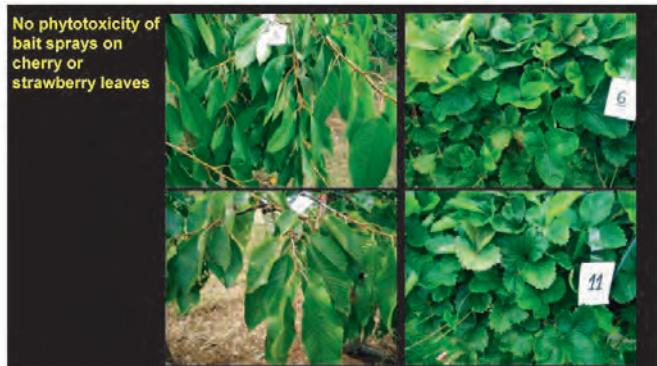
- Lechler nozzle type IDK 120-015 (compared with Orange Albus hollow cone)
- 200 mm band across upper middle canopy of strawberry plants
- Low volume (40 L/ha) (compared with 500 L/ha)
- Coarse 340 micron droplets (compared with 154-225 micron)



SWD – Developing the use of bait sprays
Ralph Noble (Microbiotech)







SWD – Developing the use of bait sprays Ralph Noble (Microbiotech)

Application of bait and insecticide droplets to different leaves



Bait Sprays - Conclusions

- All treatments achieved control of SWD
- Band bait sprays as effective as full foliar spray but with 91% less Benevia
- Combi-protect easier to prepare than *H. uvarum*
- Foliar Benevia applications remained effective two weeks after application
- Foliar applications took x4 as much time as band spraying
- No phytotoxicity of bait sprays

Bait Sprays - Further development

- Test efficacy of bait sprays on raspberries and cherries
- Use of baits with alternate sprays of Benevia/Exirel, Tracer and/or other insecticides
- Investigate longevity of control efficacy of Benevia/Exirel and Tracer applications

SWD – Developing the use of bait sprays
Ralph Noble (Microbiotech)

SWD - Developing the use of bait sprays

NIAB EMR: Michelle Fountain, Adrian Harris, Francesco Maria Rogal,
Jacob Lowe, Adam Walker, Celine Silva
Microbiotech: [Ralph Noble](#), Andreja Dobrovin-Pennington



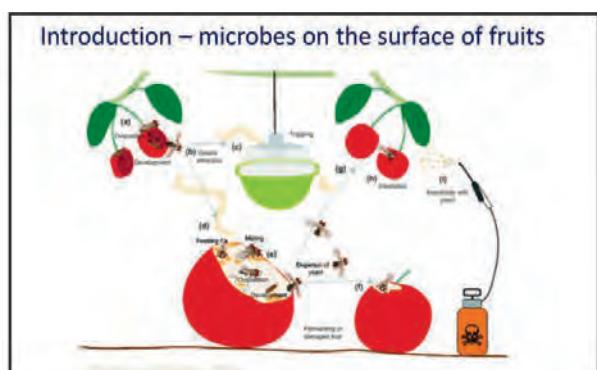
SWD – Developing yeast attractants
Rory Jones (NIAB EMR and University of Lincoln)



Introduction – Aims

Aims

1. Testing attractiveness/repulsiveness of yeast species
2. Characterising yeast communities on ripening fruit
3. Using yeast in control



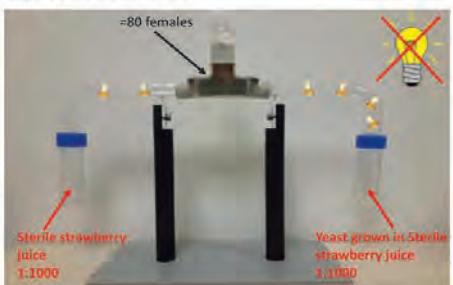
SWD – Developing yeast attractants Rory Jones (NIAB EMR and University of Lincoln)

Opportunities

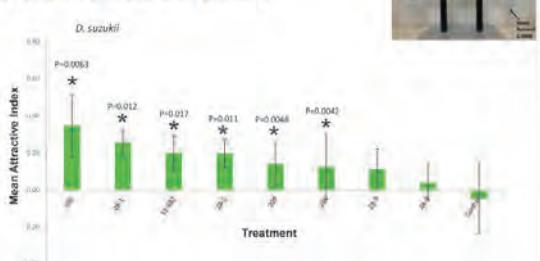
- *H. uvarum* attractive-does attraction vary with strain?
- SWD also attracted to ripening fruits - selective attractant?
- Microbial communities on fruit complex-more attractive?
- Species specific combinations exploited to improved attract and kill strategies?
- Reduce dose of plant protection products needed to kill SWD?



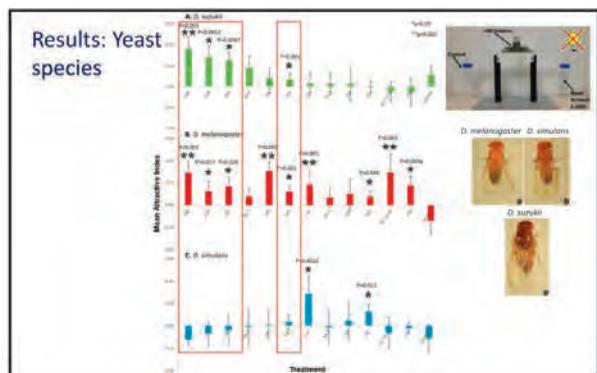
Choice test methods:

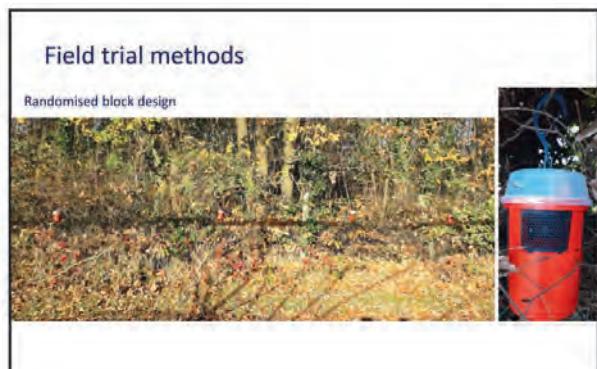


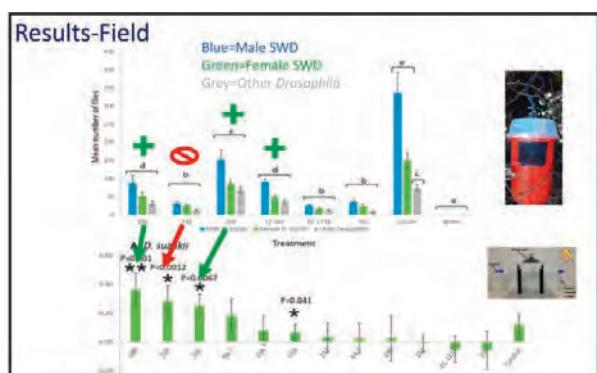
Results: *H. uvarum* strains



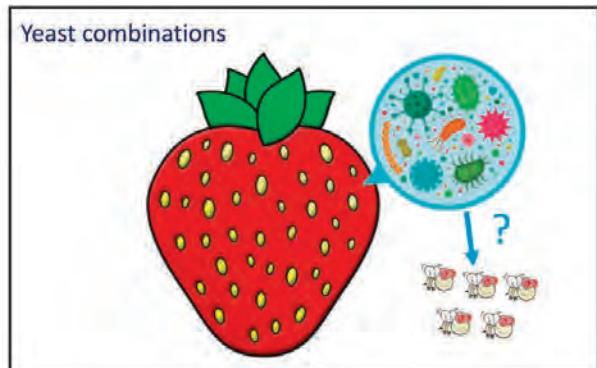
SWD – Developing yeast attractants Rory Jones (NIAB EMR and University of Lincoln)

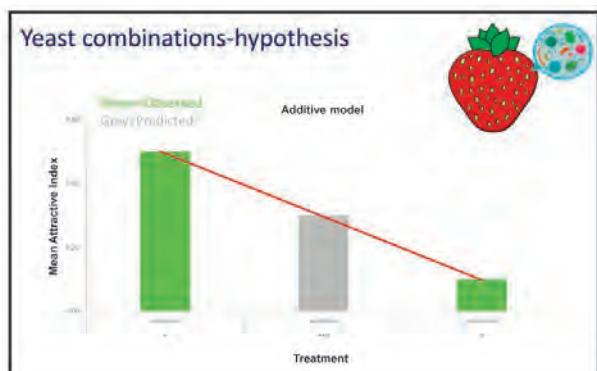


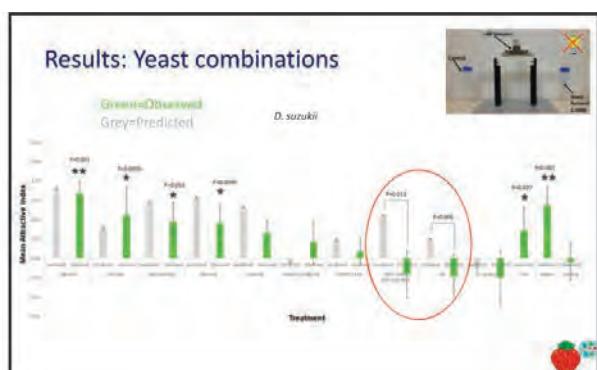




SWD – Developing yeast attractants
Rory Jones (NIAB EMR and University of Lincoln)

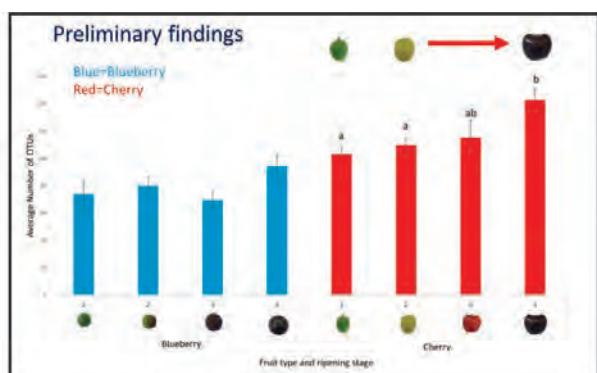
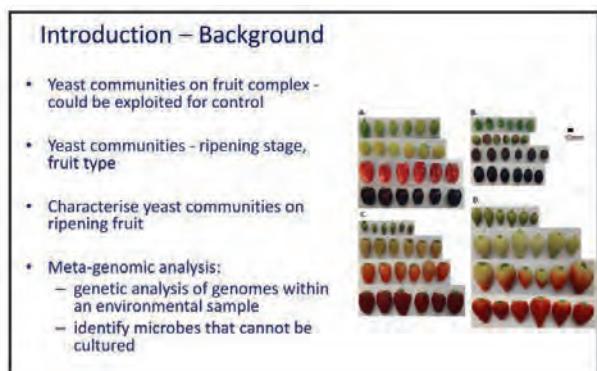
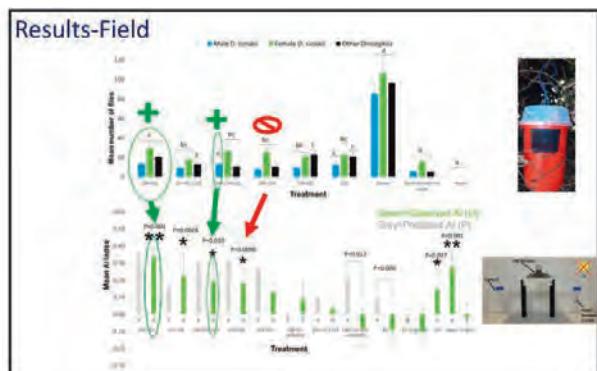






SWD – Developing yeast attractants

Rory Jones (NIAB EMR and University of Lincoln)



SWD – Developing yeast attractants

Rory Jones (NIAB EMR and University of Lincoln)

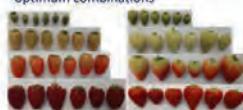
Conclusions

- 6 out of 8 *H. uvarum* strains attractive in the lab also 201 more attractive - field assay
- 4 yeast species attractive, 2 also attractive in the field
- 4 combination attractive, with 2 also attractive in the field
- 2 combinations showed interaction effect
- Microbes vary on fruit - number of species



Future work

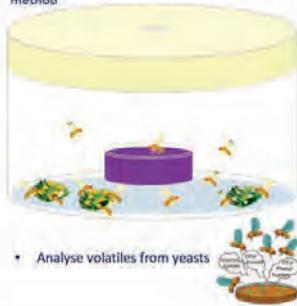
- Characterise yeast communities on ripening fruit to further investigate optimum combinations



- Activity monitor-further test attraction of yeast spores and combinations



- Combine most attractive combinations with PPPs and test efficacy as a lure-and-kill control method





Acknowledgments

- AHDB
- Supervisors
- Growers



SWD – Protecting natural enemies
Michelle Fountain (NIAB EMR)



• Identify parasitoids that emerge from *Drosophila suzukii* pupae in the UK

• Confirm parasitism ability by re-infecting laboratory cultures



• Sentinel traps deployed fortnightly

• Sentinel fruits assessed weekly for 6 weeks

• Emerging parasitoids recorded and identified



• Laboratory test to validate parasitism

SWD – Protecting natural enemies

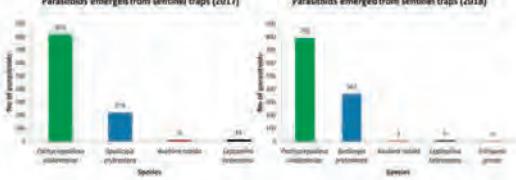
Michelle Fountain (NIAB EMR)

Surveying parasitoid wasps in England 2017 data

Found in wild areas not in crops- very sensitive to protection products

Family, Species	Habitats	Individuals	Traps
Pteromalidae			
	Woodland, Brambles, Elderberry edge, Farmyard, Hedgerow, Raspberry and Strawberry edges, Wild cherry orchard and Vineyard	1100	31
	Woodland, Hedgerow, Raspberry and strawberry edges, Wild cherry orchard	219	14
Figidae			
	Woodland	15	2
Braconidae			
	Woodland	9	2

Parasitoids emerged from sentinel traps (2017)



Species	No of parasitoids
Pachycrypoideus vindemmiae	82
Spalangia erythromera	29
Leptopilina heterotoma	3
Asobara tabida	1

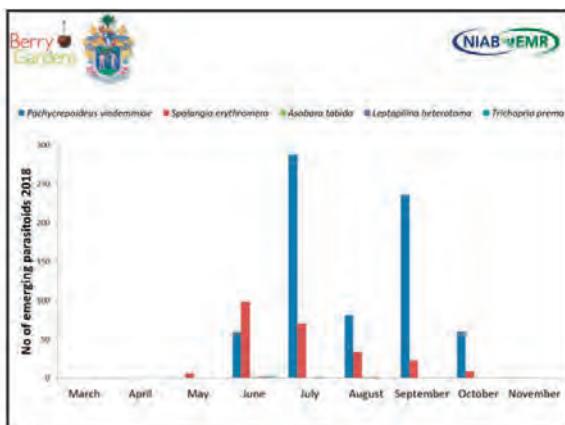
Survey 2017:

- Monitoring June – September
- 28 sites

2018:

- Monitoring March – November
- 10 sites - high presence of parasitoids
- 5 species: *Pachycrypoideus vindemmiae*, *Spalangia erythromera*, *Leptopilina heterotoma*, *Asobara tabida*, and *Trichopria prema*





SWD – Protecting natural enemies

Michelle Fountain (NIAB EMR)

Validating parasitism

Total numbers of parasitoid offspring that emerged from *D. suzukii* laboratory cultures in 2017

Culture I.D.	Species	No. of adult parasitoids applied	No. of emerged offspring after 6 weeks incubation	No. offspring per adult
T16	<i>P. vindemiae</i>	25	80	3.2
T22	<i>P. vindemiae</i>	10	45	4.5
T20	<i>P. vindemiae</i>	14	41	2.9
T15	<i>P. vindemiae</i>	8	11	1.4
T41	<i>P. vindemiae</i>	9	67	7.4
T38	<i>P. vindemiae</i>	16	47	2.9
T72	<i>S. erythromera</i>	11	3	0.3
T8	<i>S. erythromera</i>	10	5	0.5
T30	<i>S. erythromera</i>	12	2	0.2
T29	<i>S. erythromera</i>	13	1	0.1
T14	<i>L. heterotoma</i>	10	1	0.1
F9	<i>A. tabida</i>	3 (♀)	0	0.0

Biological Control of Spotted-Wing Drosophila (Diptera: Drosophilidae) – Current and Pending Tactics

Jenia G. Lee,^{1,2} Xiangyang Wang,¹ Kent M. Daane,³ Kim A. Holman,² Rufus Isaacs,² Shubing A. Shi,^{1,2} and Vaughn M. Walton⁴

- Predator gut content DNA analyses (Wolf et al. 2018);
 - 43% of collected **earwigs**,
 - 16% of **damsel bugs**,
 - 21% of **web-building spiders**,
 - 8% of **hunting spiders**
- Video recordings **ants** digging up and carrying away pupae in strawberry and blueberry fields (Woltz and Lee 2017)
- Spiders and ants feed on spotted wing drosophila larvae and pupae (Woltz et al. 2015)
- Orius** feed on larvae in field raspberries (Walsh et al. 2011)
- Carabid beetles**, **crickets**, **green lacewing larva**, earwigs, and Orius fed on spotted-wing drosophila in the lab (Arno et al. 2012, Gabarra et al. 2015, Englert and Herz 2016, Ballman et al. 2017)
- Birds or mammals** potentially predate SWD – more SWD open field than caged fruit (Ballman et al. 2017).

The diagram illustrates the life cycle of SWD and its natural enemies. It shows a plant with green leaves and red berries. Larvae are depicted at different stages: egg, first instar, second instar, third instar, and pupa. Various predators are shown interacting with these stages: a bee, a fly, a wasp, a ladybird, a lacewing, a cricket, a carabid beetle, and an ant. Labels indicate 'Adult female oviposition' and 'Males pupate in soil'.

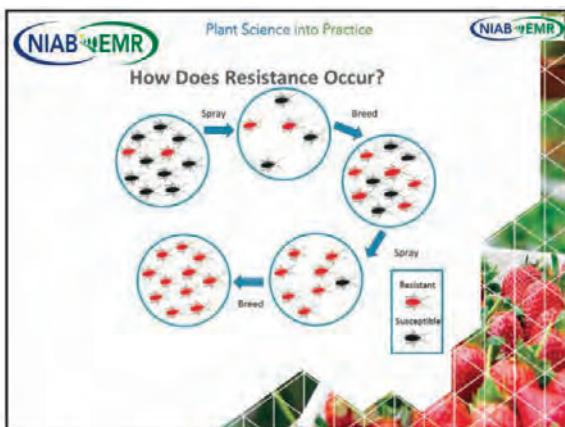
Generations / year

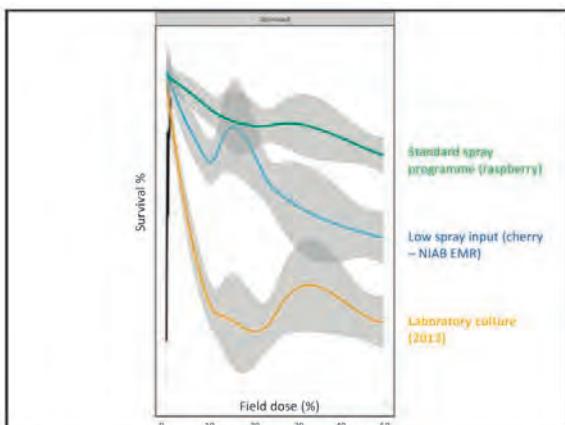
Invertebrate **Generations**

Invertebrate	Generations
Earwig	1
Anthocorids	Up to 4
Spiders	1-2 (mostly)
Orius	Up to 4
Ground beetles	1-2
7-spot ladybird	1
Harlequin ladybird	2
Hoverflies	? overlapping
Lacewing	? overlapping
*nb: temperature and species dependant	
<i>Drosophila suzukii</i>	(3-13) typically = 6-9

The illustrations show a variety of insects: an earwig, several small brown bugs (anthocorids), several spider species (including a large orb-weaver and smaller hunting spiders), the assassin bug (Orius), several ground beetles, two types of ladybirds (7-spot and Harlequin), and a lacewing larva.

SWD – Protecting natural enemies
Michelle Fountain (NIAB EMR)







SWD – Protecting natural enemies

Michelle Fountain (NIAB EMR)

Plant Science into Practice

NIAB EMR

Conclusions

- *Trichopria drosophilae* has not yet been identified in UK
- Parasitoids mostly in unsprayed areas
- Other natural enemies migrate into crop from surrounding landscape
- Broad range of generalist NE that feed on SWD
 - Protect them
- Insecticide resistance
 - Keep spraying to a minimum by employing other control techniques
 - mesh,
 - hygiene,
 - monitoring infield and pack-house fruit
 - tight picking,
 - fruit disposal,
 - precision monitoring around crop



NIAB EMR

Many thanks for listening

Berry Gardens



AHDB
HORTICULTURE

Plant Science into Practice

UK fruit growers

