Prospects for Disease Control – Highlights from recent BCPC Disease Reviews – Dr David Ellerton, H L Hutchinson (BCPC Advisory Board))

BCPC Diseases Expert Working Group - Current Membership

- Rothamsted
- NIAB
- SRUC
- ADAS
- Corteva
- Bayer
- Syngenta
- BASF
- Certis
- AIC
- AICC
- RHS
- FRAG
- BCPC
- NFU
- CRD, BSPP, BSPB, PGRO, AHDB

BCPC Diseases Expert Working Group - Purpose

- To provide a forum for discussion on plant health issues, relevant new legislation, new developments and research.
- It also acts as a lobby to influence potential funding for crop protection and to provide expert opinion to inform policy makers.
- The group organises an annual review for an invited audience, the first review was held in December 2014.

Key Issues Affecting Future Disease Control

- Revocation of some key fungicides including multi – sites and difficulties in registering new fungicides.
- New fungicides which are registered generally have single site modes of action prone to disease resistance which is increasing
- There is an increasing need for new Modes of Action and alternatives to conventional crop protection products such as biological control products
- There will be an increasing requirement for agronomists to justify/optimise the use of crop protection products
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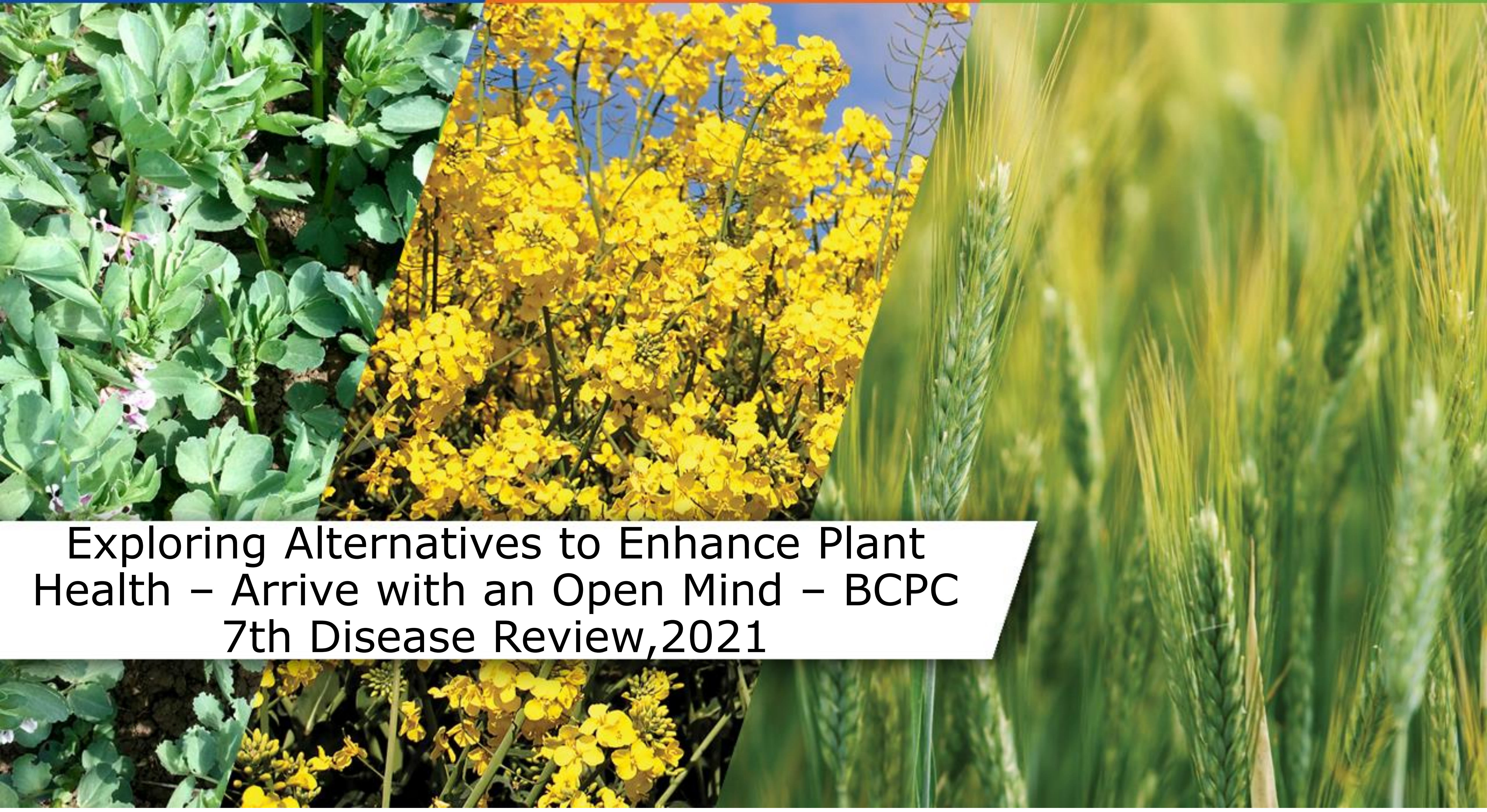
BCPC Diseases Expert Working Group - Previous Review Presentations



Exploring Alternatives to Enhance Plant Health – Arrive with an Open Mind – BCPC 7th Disease Review,2021

The BCPC 7th Disease Review 2021

BCPC
British Crop Production Council

Exploring alternatives to enhance plant health – arrive with an open mind

10.00 Chair Introduction – *Kate Storer*, ADAS
10.20 The ins and outs of endophytes – *Matevs Papp-Rupar,* East Malling Research
10.55 Modern plant breeding mycorrhizal interactions – *Tim Mauchline*, Rothamsted Research
11.30 Elicitor use for disease control – *Neil Havis*, SRUC
12.05 PhD Presentations

12.25 Lunch and posters

13.15 How can we help growers get the most out of bio fungicides? The AHDB AMBER Project – *David Chandler,* Warwick University
13.50 Can regulation keep pace with biofungicide technology? – *Roma Gwynn,* VP International Biocontrol Manufacturers Association

14.25 Discussion & Chair Summary
15.00 End

BCPC Congress 2-3 Nov 2021, Harrogate – visit: bcpccongress.org

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The Ins and Outs of Endophytes – Matevs Papp-Rupar, NIAB/East Malling Research

What is an Endophyte?

- Endophytes are organisms, often fungi and bacteria, that live between living plant cells.
- The relationship that they establish with the plant varies from symbiotic to bordering on pathogenic.
- The opportunity to find new and interesting endophytes among the myriad of plants is great.
- Sometimes extremely unusual and valuable organic substances are produced by these endophytes that are sources of novel chemistry and biology to assist in helping solve not only human health, but plant and animal health problems also such as
- ***Cryptocin:*** antifungal agent
- ***Cryptocandin:*** a molecule with potent anti-fungal properties.
- ***Jesterone:*** antifungal agent
- ***Oocydin:*** antifungal agent
- ***The pseudomycins:*** antifungal agents for use in humans.
- ***Ambuic acid:*** antifungal agent

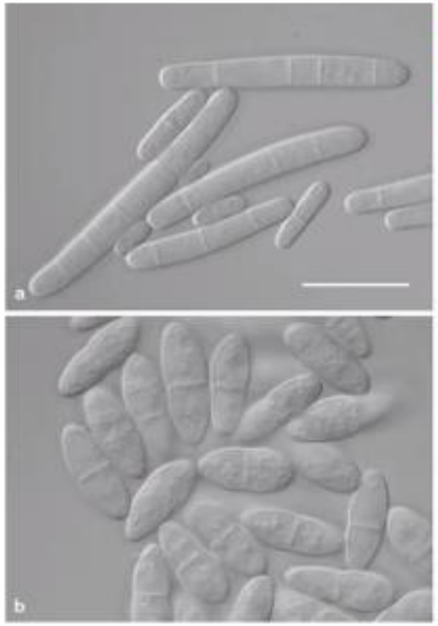
Endophyte applications

- Bio-resource for drug discovery in pharmaceutical industries
- Plant growth-promoting regulators (PGPRs)
- Abiotic stress mitigation
- Environmental remediation
- **Bio-control agents (BCAs) for disease and pest management**
  - easily applied/disseminated to crops
  - one or more effective mechanisms
  - easily identified and commercialized
  - not under any circumstance (environmental or otherwise) cause symptoms

Card et al., 2016, FEMS microbiology

European apple canker disease

- Caused by fungal pathogen *Neonectria ditissima:*
- Pathogen infecting **wounds** with **conidia and ascospores**:
  - **Killing trees** - up to 30% of newly planted orchards
  - **Reducing yield and quality**
  - Causing **postharvest fruit rot**
- **Commercial apple cultivars are highly susceptible.**
- Difficult chemical control:
  - Lack of chemical products at the end of season
  - Timing / delivery issues (**leaf scars, picking wounds)**
  - Difficult conditions (wind, rain)
- Can endophytes help control apple canker?



Weber, R. Commercial *fruit growing* **56,** 95-107 (2014).

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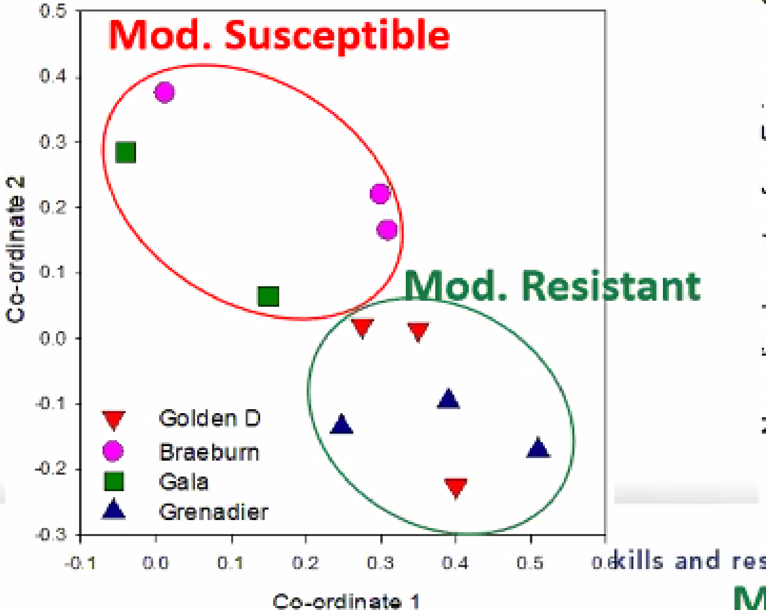
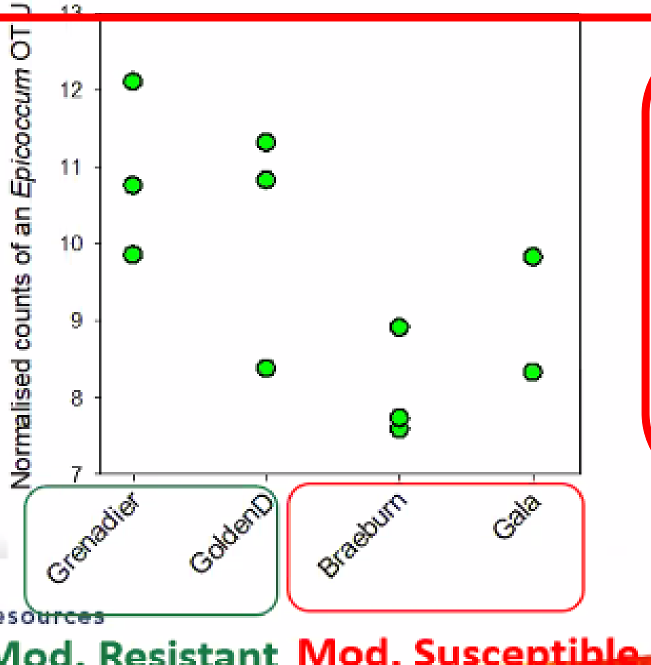
Endophyte BCA case study: *Epicoccum purpurascens*

BCPC

A clue from community profiling of NIAB EMR trees

- Comparing fungal endophytes in apple shoots (ITS2 metabarcoding)
  - Canker "resistant" cultivars (Golden D., Grenadier)
  - Canker susceptible (Gala, Braeburn)
- "<u>Resistant</u>" cultivars had appx. <u>10 fold higher abundance</u> of ***Epicoccum purpurascens***





Biocontrol properties of *E. purpurascens* against:

- ***Fusarium spp.***
  - (Ogórek and Plaskowska, 2011),
- ***Pythium*** damping-off
  - (Hashem and Ali, 2004)
- ***Monilinia spp***. brown rot in peaches
  - (De Cal et al., 2009; Larena et al., 2004).

kills and resources

E. purpurascens case study conclusions:

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- Higher relative freq. in resistant cultivars.
- Present and **isolated from apple trees** on site.
- Inoculum production not trivial.
- Canker control *in-vitro*? **Yes.**
- Colonisation of apple trees? **Yes, but…**
  - Spray amendment in summer had variable success
  - Short term leaf scar colonisation in autumn successful
    - Little spread above and below the leaf scar
    - Does not persist across seasons
- Control of canker in the field? **Yes.**
  - Summer amendments inconclusive
  - **Autumn co-inoculation very successful (50% reduction)**
- Detrimental effects on the host? **No.**

Class 3 endophyte

Elicitor Use for Disease Control – Neil Havis, SRUC

What are elicitors derived from natural products ?

SRUC

- Products derived from plant or other natural material. (Carbohydrate polymers, lipid, glycopeptides, glycoproteins)
- Antifungal proteins have been characterised from many plant species
- Many plant products also initiate the defence mechanism in crop plants

Chitosan

Polysaccharides & oligosaccharides

Ascophylum nodosum

Elicitor effect

- Following perception – signal transduction pathways
- Active oxygen species produced (linked to hypersensitive response)
- Phytoalexin biosynthesis initiated
- Cell wall reinforcement (phenyl propanoid compounds)
- Callose deposition
- Synthesis of defence enzymes
- Accumulation of PR (pathogenesis related proteins) – antimicrobial activity

Salicylic Acid (SA), a stress reducer is increased which switches on the salicylic acid pathway producing a Systemic Acquired Resistance (SAR) response

SAR & ISR main plant defence mechanisms

Jasmonic Acid (JA) and Ethylene (ET) increase which produce defence proteins & switch on the Induced Systemic Resistance (ISR) response

Elicitors prime and uprate both the SAR and ISR responses in the host plant resulting in a quicker response to disease attack

Conclusions

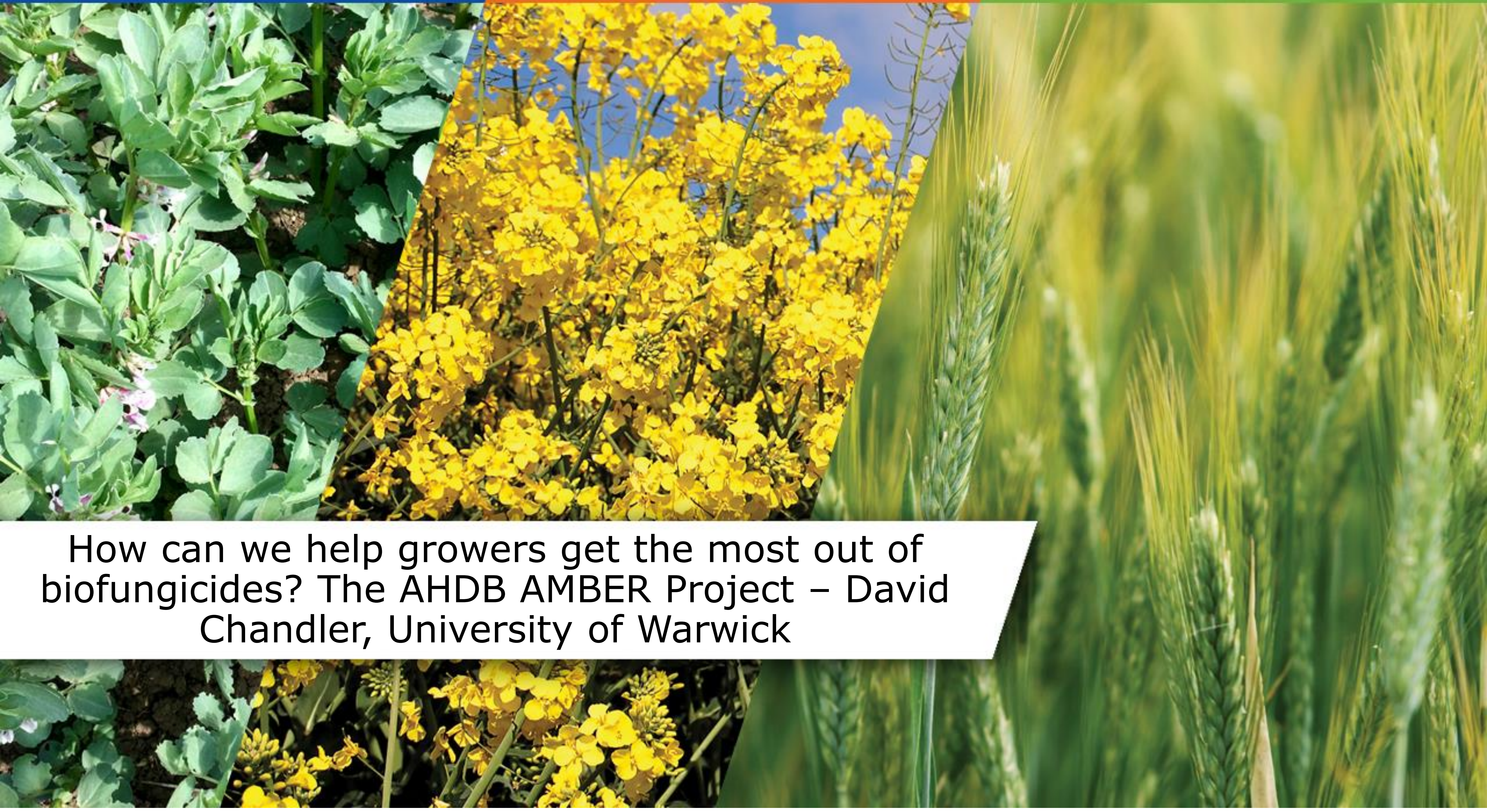
- The integration of elicitors into programmes for cereal crops will require careful management
- Control will be more variable than that achieved by conventional programmes
- Seasonal disease pressure needs to be factored in to programmes
- The effects of crop stress may affect elicitor performance
- The influence of variety needs to be tested more extensively

- In trials on Winter and Spring Barley elicitors were often found to reduce Rhynchosporium, Mildew and Net Blotch and give significant yield increases
- Best disease control was often achieved using elicitor + fungicide combinations

PHD Presentations

PhD Presentations

- Chemical Warfare – The Chemical Quest to Conquer Oilseed Rape – **James Fortune**, University of Hertfordshire
- Trichoderma as a Biological Control Agent of Armillaria – **Morgan Millen,** University of Bristol
- Fostering Populations of Arbuscular Mycorrhizal Fungi Through Cover Crop Choices and Soil Management – **George Crane**, University of Cambridge/ NIAB
- Examining Biofumigant Crops for the Management of Pea Foot Rot Complex Pathogens – **Lisa King**, University of Warwick



How can we help growers get the most out of biofungicides? The AHDB AMBER Project – David Chandler, University of Warwick

Advice for growers & agronomists

- Use biofungicides in a programme to reduce total number of conventional fungicide applications.
- Measurable, incremental improvements in management practice rather than a ‘giant leap’.
- Combine with other IDM tools (cultural control, environment management). Smart decision support.
- Biofungicides work differently to conventional fungicides. They are less forgiving and require much more attention to detail.
- Take into account the modes of action. Consider compatibility with other products.
- Good spray application is critical. Efficacy is dose dependent; deliver highest dose of product per unit area of foliage. Lower water volume is best. Label reform needed.

- Performance varied, from zero control, to better than conventional pesticides.

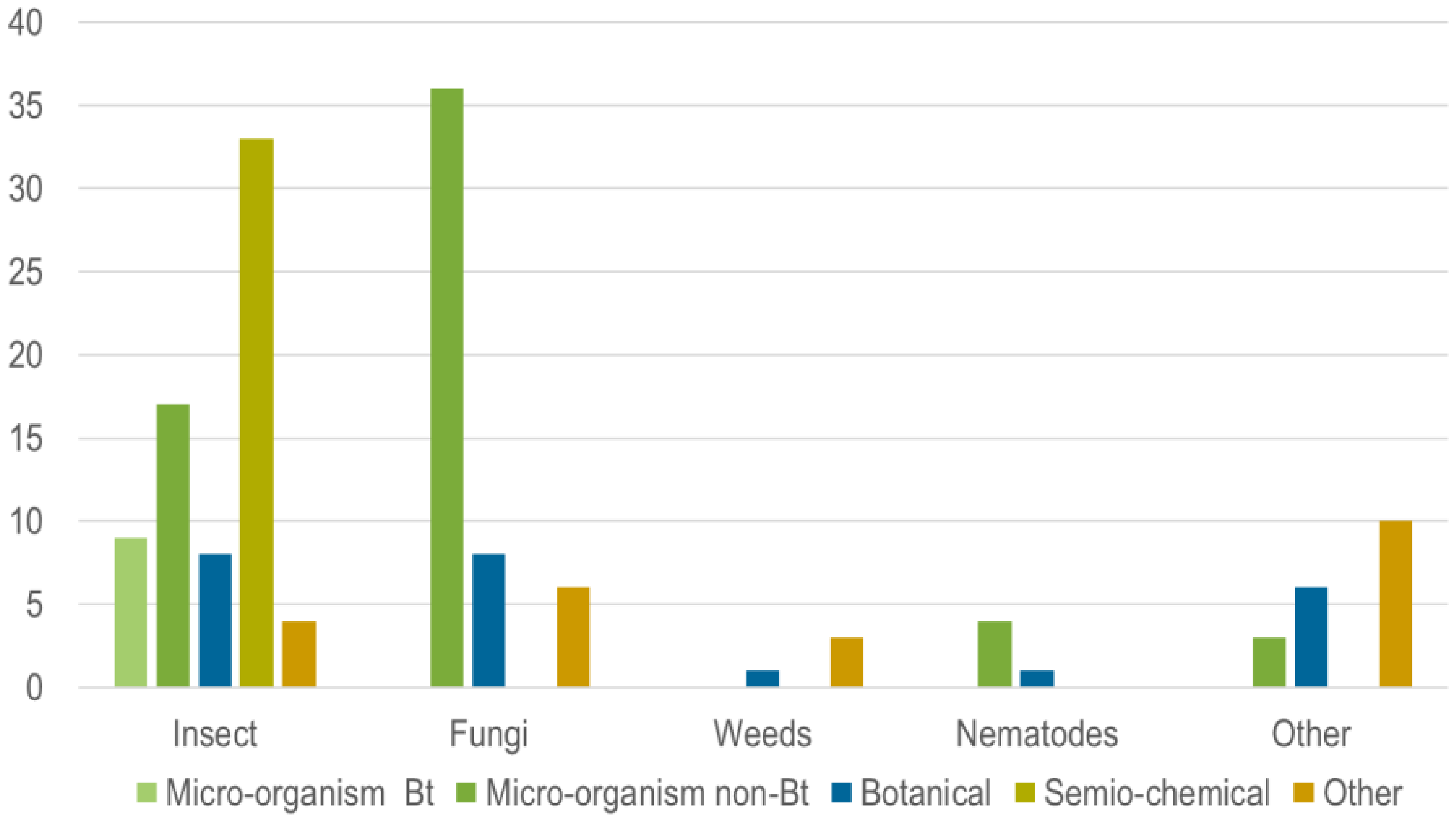
Can Regulation Keep Pace with Biofungicide Technology? – Roma Gwynn, Rationale

Bioprotectants – biological technologies – biocontrol solutions

Macroorganisms	Microorganisms	Botanicals/Natural substances	Semio-chemicals
			
Biocontrol, Natural enemies, Beneficials	Biopesticides – biorationals - biologics		

Bioprotectants have multiple modes of action on target pests and multi-interactions with plants

EU bioprotectant* PPP - active substances



Approved PPP

> 40% approved PPP
= biological technologies

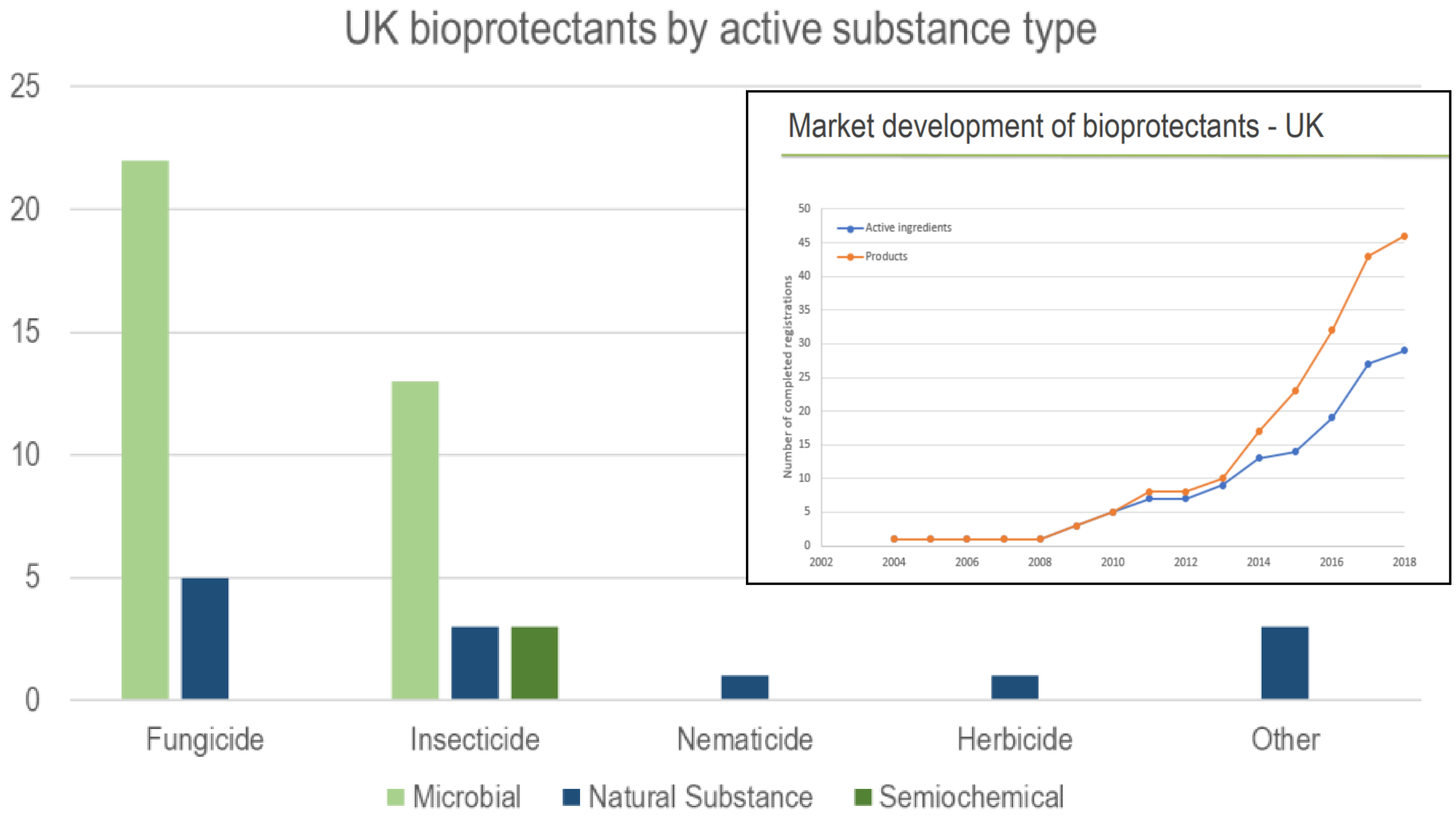
Total all PPP = 493

EU active substances (updated February 2021)*

* Definition of bioprotectant PPP not fixed so approximate numbers only

RATIONALE
BIOPESTICIDE STRATEGISTS

Number of bioprotectants – UK 7th February 2021



Bioprotectant totals

Active substances = 51 (out of 259) ~20%

Products = 103 (out of 3137) ~3%

Few Low Risk products yet

32 active substances for use in open field

70 products for use in open field

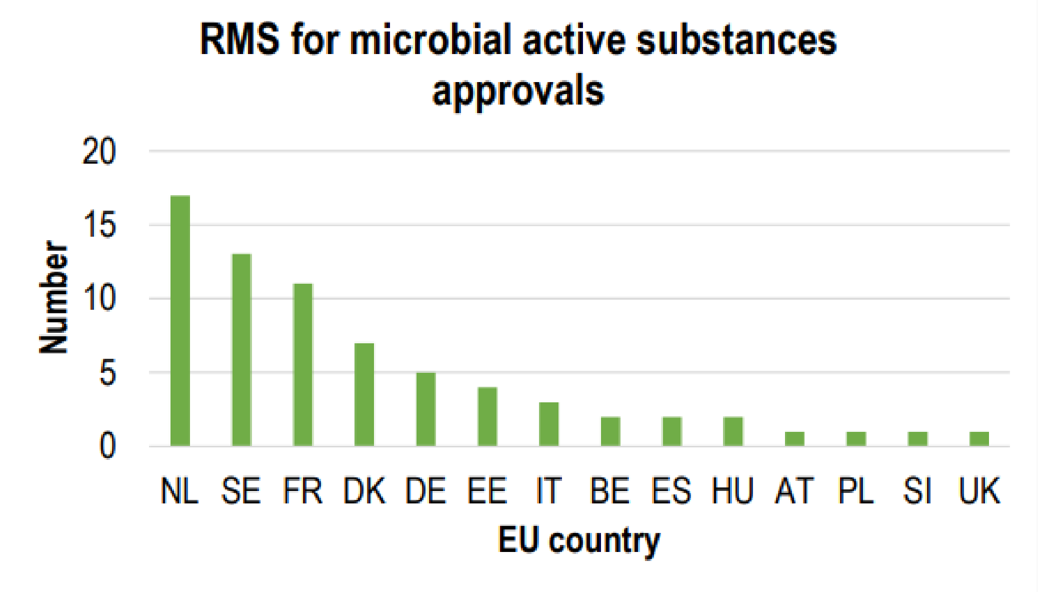
RATIONALE
BIOPESTICIDE STRATEGISTS

Biological technology specific regulation

Improving regulatory approval processes for biopesticides and other new biological technologies in agriculture

Wyn Grant, University of Warwick, UK; and Roma Gwynn, Biorationale, UK

RMS = Rapporteur Member States



http://dx.doi.org/10.19103/AS.2020.0073.04

Chapter taken from: Birch, N. and Glare, T. (ed.), *Biopesticides for sustainable agriculture*, Burleigh Dodds Science Publishing, Cambridge, UK, 2019, (ISBN: 978 1 78676 356 3; www.bdspublishing.com)

Good regulatory practice:

1. Dedicated biological technology regulators
2. Clear pre-submission and submission process
3. Provide a high-level framework for the principle that data are excluded 'except when …'
4. Trusted partnerships
5. Harmonisation of evaluations
6. Reciprocity of evaluations between regulatory agencies
7. Reciprocity/extrapolation for efficacy data

RATIONALE

Changing Challenges and Changing Tools for Integrated Crop Management, BCPC Disease Review,2022

Key Issues Affecting Future Disease Control

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Changing challenges & changing tools for Integrated Crop Management

PROGRAMME

- Welcome: Jenna Watts, Head of Crop Health and IPM, AHDB
- IPM Strategies to control mycotoxins: *Prof. Simon Edwards, Harper Adams*
- The impact of mycotoxins on processors: *Derek Croucher, Morning Foods*
- Varietal resistance breakdown – parallels with fungicide resistance: *Mike Grimmer, ADAS*
- PhD Poster Sessions
- Lunch – Rolling Posters
- Molecular detection of pathogens: *Natarajan Subramani, University College Dublin*
- A perspective on the practical use of PCR testing to aid farm management, *Nick Anderson, Velcourt*
- Discussion and closing remarks

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DISEASES

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IPM Strategies to Control Mycotoxins – Simon Edwards, Harper Adams University College

Key Fusarium mycotoxins

Harper Adams University

Mycotoxin	Main producers
Deoxynivalenol (DON) Wheat	*F. graminearum* and *F. culmorum*
Zearalenone (ZON) Wheat	*F. graminearum* and *F. culmorum*
HT2 and T2 Oats	*F. langsethiae* and *F. sporotrichioides*
Fumonisins Maize Storage	*F. verticillioides and F. proliferatum*

IPM to minimise Fusarium mycotoxins in milling wheat

Harper Adams University

Fusarium resistant varieties

Good rotation - avoid maize as previous crop

Cultivation – Intense cultivation following a high risk crop (particularly maize)

Use a robust rate of a Fusarium active fungicide at T2 (GS39) and at T3 (GS 59)

Eg: Prothioconazole
Tebuconazole
Adepidyn

Timely harvest

IPM to minimise Fusarium mycotoxins in milling oats

Harper Adams University

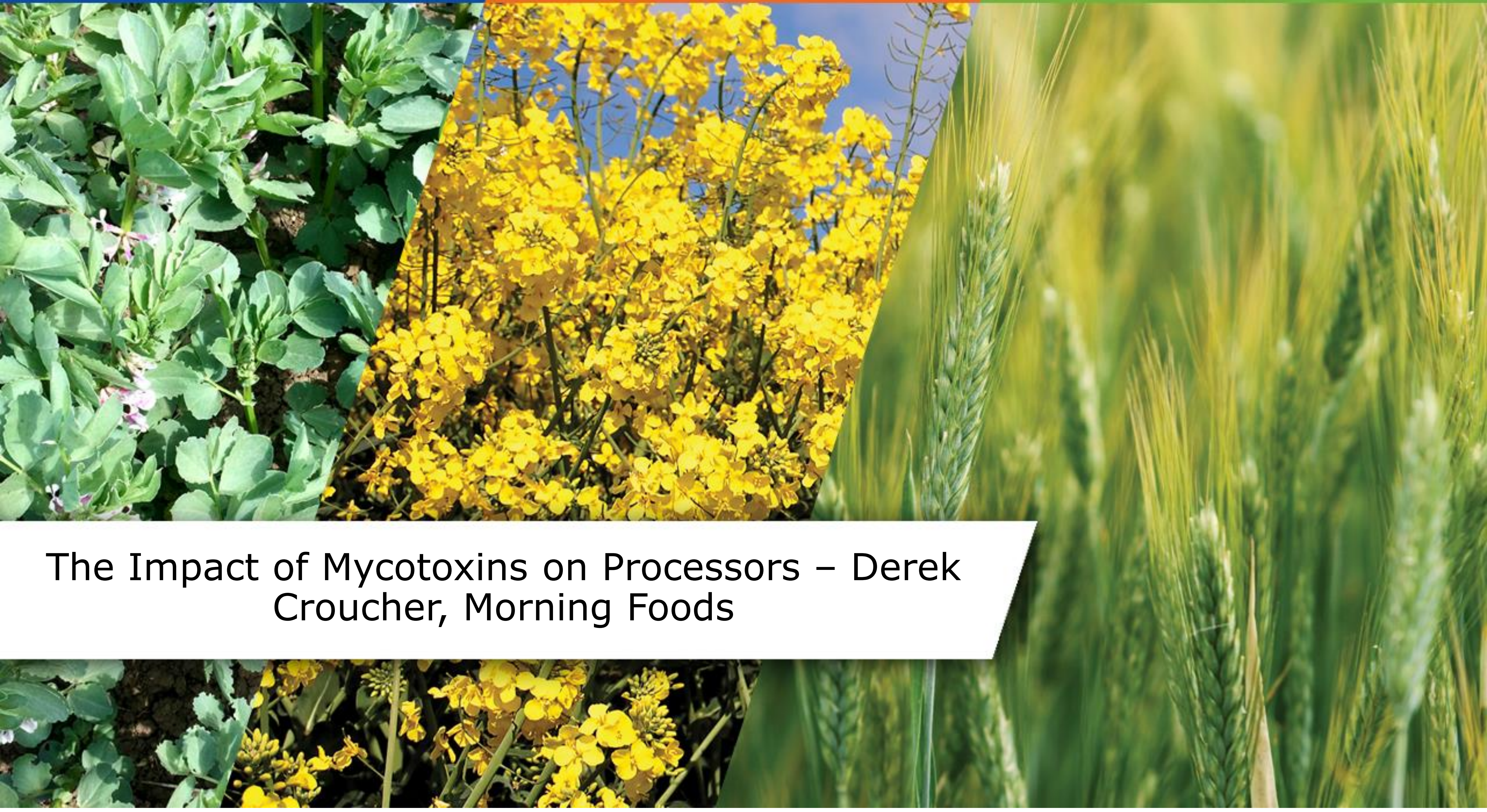
Switch to spring varieties

Broad/long rotation (reduce cereal intensity)

Select Fusarium resistant tall varieties

Cultivation – dependant on rotation, better to plough after cereals and grass

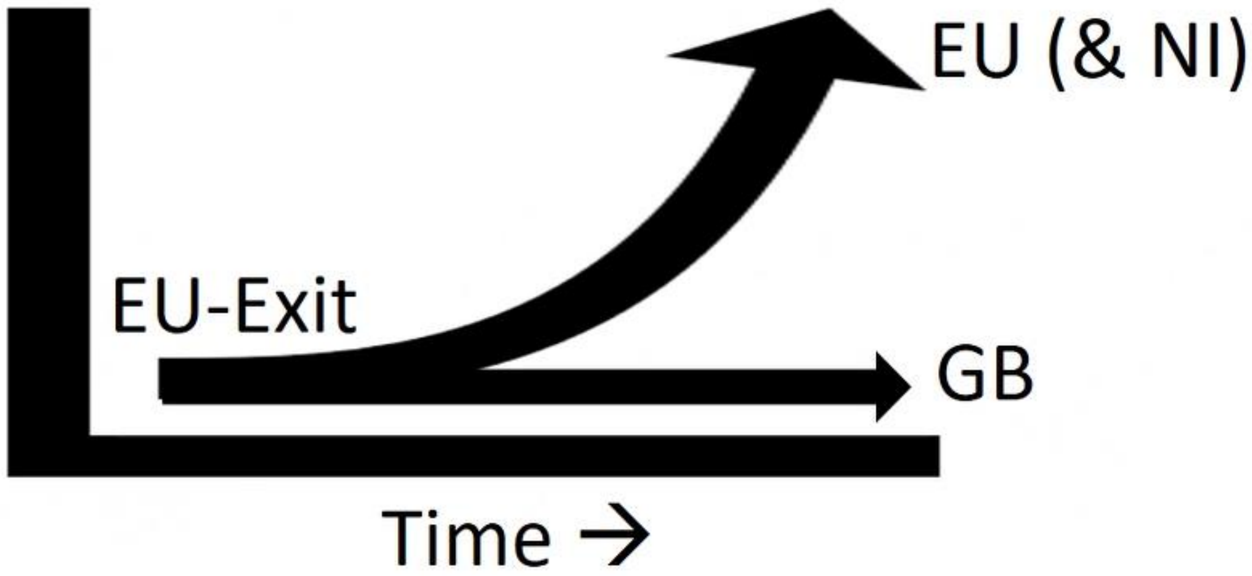
(first two are not economically viable compared to alternative crops)



The Impact of Mycotoxins on Processors – Derek Croucher, Morning Foods

Legislative Compliance

- Clear parallels with legislation on plant protection products
- GB Regulation as of 11pm 31/12/2020 ≡ EU (Reg 1881/2006)



EU (& NI) Regulation

- Commission Regulation (EU) 2021/1399 of 24 August 2021 **Ergot Sclerotia & Ergot Alkaloids** (Effective 01/01/2022)
- *Commission Regulation (EU) 2021/1408 of 27 August 2021 Tropane Alkaloids (Effective 01/09/2022)*
- Commission Regulation (EU) 2022/1370 of 5 August 2022 **Ochratoxin A** (Effective 01/01/2023)
- Advanced discussions on **T-2/HT-2** & **Deoxynivalenol**……

Morning FOODS

GB Regulation

- No changes since EU-Exit
- GB Risk Analysis Process
  - FSA/FSS Priority list of Contaminants (Jan 2022)
  - Process now started on T-2/HT-2
  - Potential Divergence within GB .....
    - Specific stakeholder group in Scotland
- Risk of GB adoption of EU Regulations by Retailers to facilitate trade

PDF
FSA Priority List

PDF
UK Stakeholder Position

Morning FOODS

An Example – T-2/HT-2 Toxins in Oats

ANNEX TO DRAFT REGULATION

In the Annex to Regulation (EC) No 1881/2006, section 2, entry 2.7 is replaced by the following:

'Foodstuffs		Maximum level (μg/kg)
2.7	**T-2 and HT-2 Toxin**	Sum of T-2 and HT-2 Toxin
2.7.1	Unprocessed cereals	
	- Barley, maize and durum wheat with the exception of unprocessed maize intended to be processed by wet milling	100
	- Oats	1250
	- Other cereals	50
2.7.2	Cereals placed on the market for the final consumer	
	- oats, barley, maize and durum wheat	50
	- other cereals	20
2.7.3	Cereal milling products	
	- cereal bran, oat milling products (including oat flakes) and maize milling products	50
	- other cereal milling products	20
2.7.4	Breakfast cereals composed of at least 75 % of cereal bran, oat milling products, maize milling products and/or whole grains of oats, barley, maize and durum wheat	50
2.7.5	Bakery wares, pasta (dry), cereal snacks and breakfast cereals other than those referred to in 2.7.4	20
2.7.6	Processed cereal-based foods for infants and young children and baby foods	10
2.7.7	Dietary foods for special medical purposes intended for infants and young children	10'

96% reduction

T-2 / HT-2 Toxins in Oats

Morning FOODS

- Primary cause *Fusarium langsethiae*
- Symptomless disease in oats
- Relatively high in UK oats, especially in Scotland [.....Europe.....?]
- Levels show unpredictable year-to-year variation, with some "high" years (e.g., 2014 & 2015 harvests) and some "low" years (e.g., 2022)
- No commercially viable field mitigation
- Levels in field show significant variation
- Reduction through milling varies from c. 60-97% (cleaning & husk removal) – EC Proposal assumes 96% reduction (1250 → 50ppb)
- Reduction through milling is not batch-to-batch predictable

T-2 / HT-2 Toxins in Oats

- No reliable rapid test on oats – so testing is through LC-MS/MS at c. £120/sample and typical 5 working day lead time (Fera c. 30 days!)

- In a “high” year **10-30%** of UK unprocessed oats would be non-compliant
- In a “high” year c. **20%** of oat milling products would be non-compliant
- In a “high” years c. **20%** of composite products (breakfast cereals, biscuits etc) would be non-compliant

But identification of compliant vs non-compliant products is hugely challenging and carries a massive reputational / recall risk.

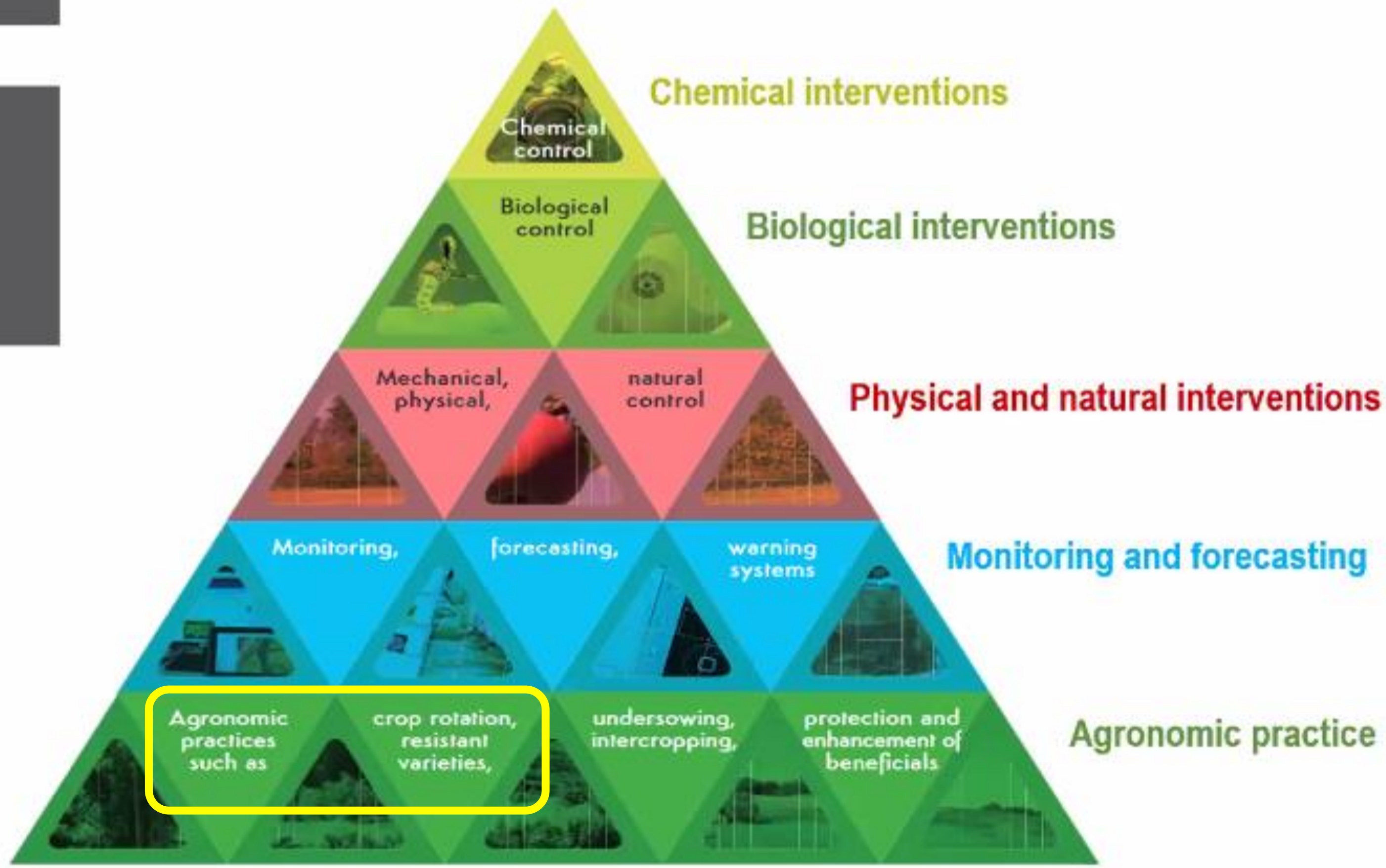
Morning FOODS

Varietal Resistance Breakdown – Drawing Parallels with Fungicide Resistance – Mike Grimmer, ADAS

Integrated Pest Management

IPM promoted for decades

EU Sustainable Use Directive 2009/128/EC : IPM compulsory since 2014



Erosion of varietal resistance in UK wheat

Key wheat varieties see slump in yellow rust rating

Farmers Weekly, 2019

Resistance breakdown: Septoria's resurgence in 2021

11th November 2021

Dr Cathy Hooper, RAGT Seeds technical sales manager, reviews the late Septoria tritici epidemic that hit many wheat crops this season.

Farmers Guide, 2021

W.Wheat – Varietal Yellow Rust Susceptibility, 2020/21 (2021/22) – Major changes

Variety	5-6	Variety	7	Variety	8	Variety	9	Variety	9
Zulu	5	**KWS Zyatt**	**7 (5)**	KWS Basset	8	RGT Illustrious	9 (8)	Elation	9 (8)
Skyfall	**5 (3)**	KWS Lili	7	LG Skyscraper	8	KWS Extase	9 (8)	LG Sundance	9
Bennington	5	**SY Insitor**	**7 (5)**	**LG Spotlight**	**8 (6)**	KWS Siskin	9	LG Motown	9
Leeds	6	**Gleam**	**7 (5)**	RGT Gravity	8 (7)	LG Detroit	9 (8)	Revelation	9
Viscount	6	**KWS Kerrin**	**7 (4)**	Graham	8	**KWS Firefly**	**9 (7)**	KWS Crispin	9
KWS Kinetic	**6 (4)**	**Shabras**	**7 (5)**			**KWS Barrel**	**9 (7)**	Theodore	9
		Dunston	7			RGT Saki	9 (8)	Crusoe	9
						KWS Jackal	9	Elicit	9 (8)
						Costello	9		

Large number of reductions on yellow rust ratings

W.Wheat – Varietal Septoria tritici Susceptibility,21/22 (changes 22/23)

Variety	4.0-4.9	Variety	5.0-5.9	Variety	6.0-6.9	Variety	7.0 +
Elation	4.1 (4.0)	Elicit	5.1 (4.9)	RGT Illustrious	6.0 (5.7)	**LG Illuminate**	**7.0 (6.1)(5.4)**
KWS Barrel	4.2 (4.3)	LG Skyscraper	5.1 (4.9)	KWS Cranium	6.0 (5.9)	**LG Prince**	**7.1 (6.4)(5.8)**
KWS Jackal	4.8 (4.6)	LG Spotlight	5.2 (5.1)	Costello	6.0 (5.8)	**LG Astronomer**	**7.4 (6.8)(6.2)**
KWS Kerrin	4.8 (4.6)	KWS Kinetic	5.3 (4.9)	Gleam	6.1 (5.8)	LG Sundance	7.9 (7.2)
RGT Gravity	4.9 (4.7)	RGT Wolverine	5.3 (5.7)	Shabras	6.1 (6.1)	KWS Extase	8.0 (7.8)
		LG Detroit	5.4 (5.4)	Crusoe	6.3 (6.2)	Theodore	8.3 (8.5)
		Swallow	**5.7 (5.5) (4.9)**	KWS Zyatt	6.4 (6.1)		
		Skyfall	5.8 (5.3)	KWS Siskin	6.5 (6.5)		
				RGT Saki	**6.5 (5.9)(5.1)**		
				LG Quasar	**6.6 (6.2)(5.7)**		
				Merit	**6.6 (5.8)(5.2)**		
				KWS Firefly	**6.8 (5.7)(4.9)**		
				SY Insitor	6.8 (6.5)		
				Graham	6.8 (6.7)		

Major change from 2021/22 ratings especially those with Cougar in parentage
New 3 year (2019-21) and 1 year (2021) ratings

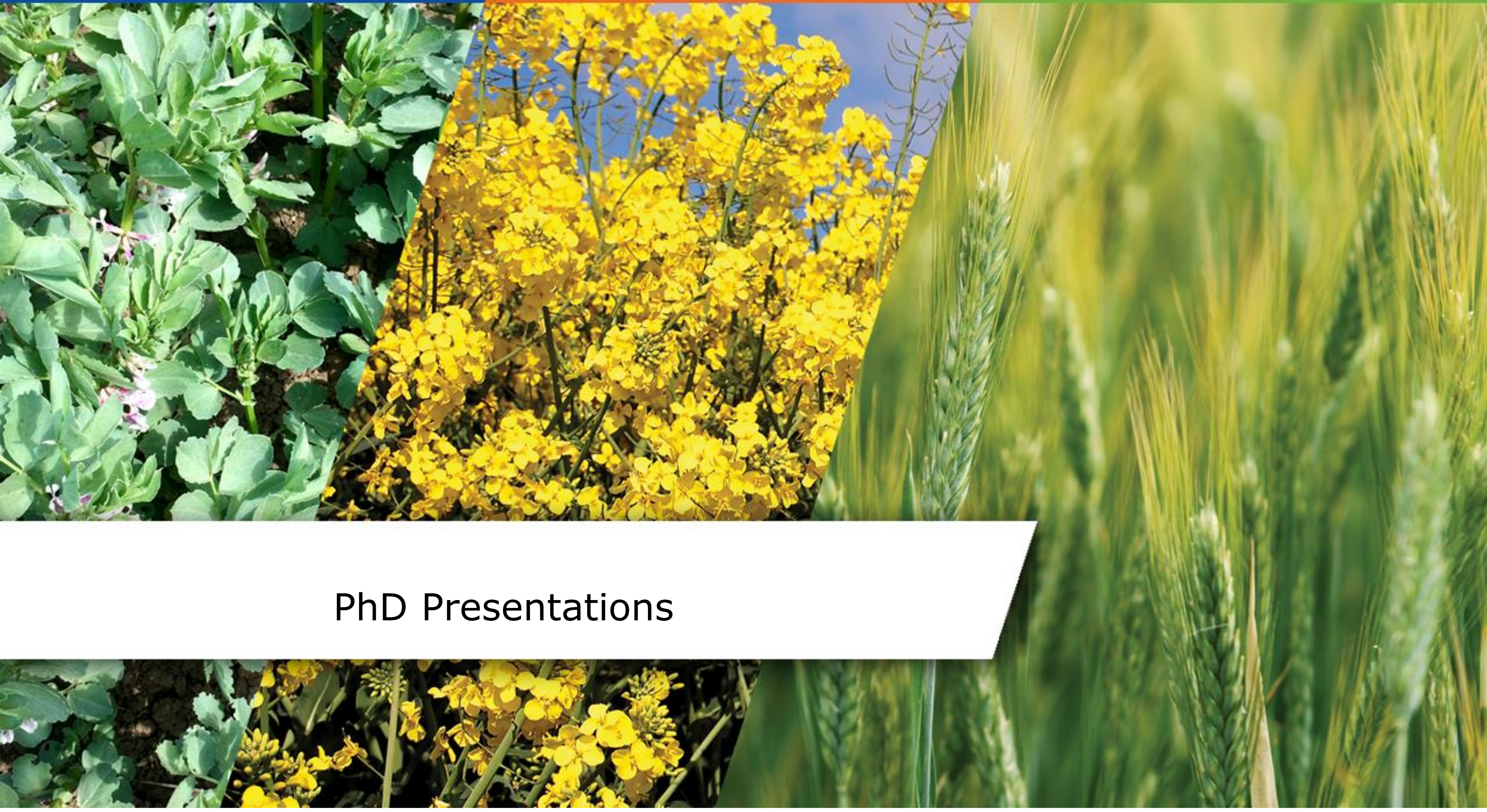
Cougar Parentage (3 year/1 year 2021 rating)

Generic:

Any independent disease control method that reduces the epidemic growth rate will reduce selection

Specific:

- Resistant cultivars reduce selection for fungicide insensitive pathogen strains.
- Fungicides reduce selection for virulent pathogen strains.
- More sustainable to integrate and balance chemical and genetic crop protection, than to be heavily dependent on either genetics or chemistry



PhD Presentations

PhD Presentations

- Incidence, Pathogenicity and Management of UK Raspberry Phytophthora – **Eithne Browne**, NIAB East Malling
- Understanding the Genetic Basis of Ramularia Disease Resistance in Barley – **Laura Roehrig**, SRUC
- Early Detection and Spread of Tomato Powdery Mildew in Commercial Glasshouses – **Anastasia Sokolidi**, Rothamsted Research
- The Epidemiology and Management of Cladosporium on Raspberry – **Lauren Farwell**, Cranfield University, NIAB

PCR Diagnostics of Trichothecene Producing Fusarium Fungi– Natarajan Subramani, University College, Dublin

Problems in the accurate identification of *Fusarium* species

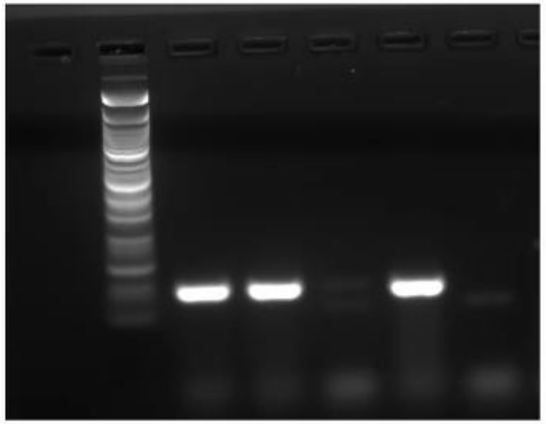
- Cultural and morphological characters are highly variable depending on the media and cultural conditions
- Degeneration of the cultures and production of mutants
- Conventional identification based on morphological characters is not enough to identify at the species level
- Time consuming
- Requires expertise in taxonomy

Species	Mycotoxins
F. graminearum ***F.aveneceum*** ***F.culmorum*** ***F.langsethiae***	**Type A Trichothecenes** • T-2 toxin • HT-2 toxin
F.poae ***F.equiseti*** ***F.crookwellense*** ***F.acuminatum*** ***F.sporotrichioides*** ***F.sambucinum***	**Type B Trichothecenes** • Nivalenol • Deoxynivalenol • Fusarenon-X

PCR methods used for the *Fusarium* diagnostics

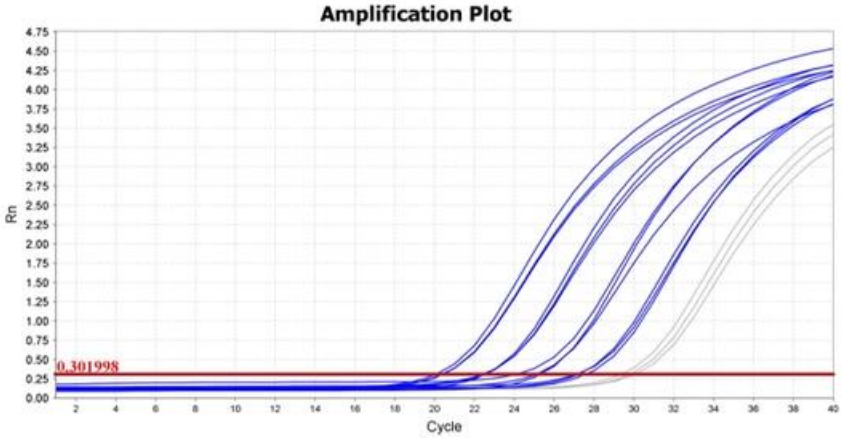
Polymerase Chain Reaction (PCR)

Conventional PCR



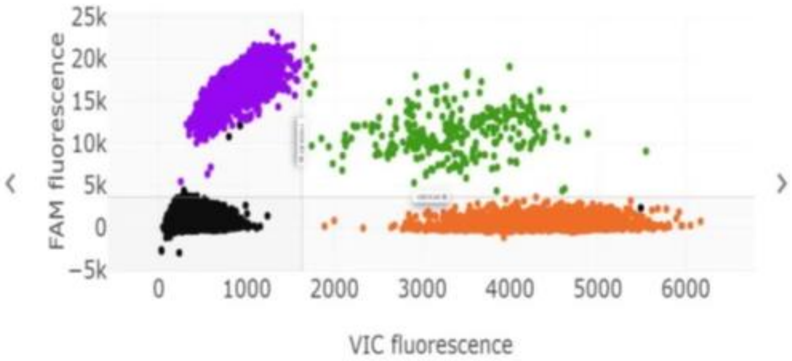
- End point
- Semi-quantitative

Quantitative PCR (qPCR)



- Real time analysis
- Relative and Absolute quantification

Digital Droplet PCR



- End point
- Absolute quantification

Supporting Findings- 01

- Species-specific qPCR analysis was utilized to quantify the DNA of *Fusarium culmorum* and *F. poae*

Plant Pathology (1999) 48, 209–217

Fusarium ear blight of wheat: the use of quantitative PCR and visual disease assessment in studies of disease control

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[a]John Innes Centre, Norwich Research Park, Colney Lane, Norwich NR4 7UH; and [b]Horticultural Research International, East Malling, West Malling, Kent ME19 6BJ; UK

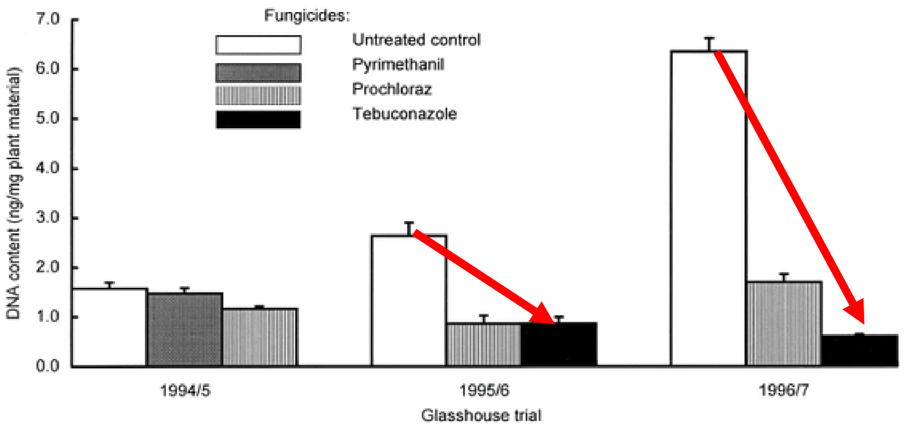


Figure 1 Analysis of the efficacy of fungicides against *Fusarium culmorum* ear blight of wheat (cv. Avalon) in the 1994–5, 1995–6 and 1996–7 glasshouse trials. Disease based on (a) visual disease assessment at GS 80 and (b) quantitative PCR analysis. Bars indicate standard error of the means.

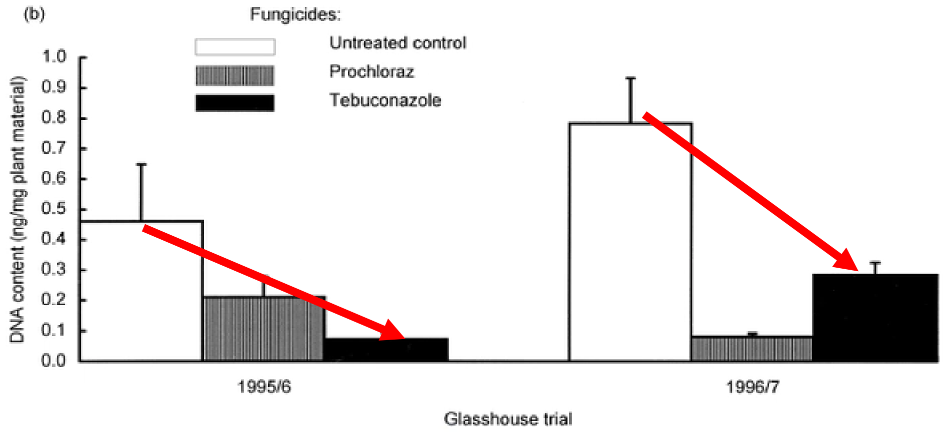
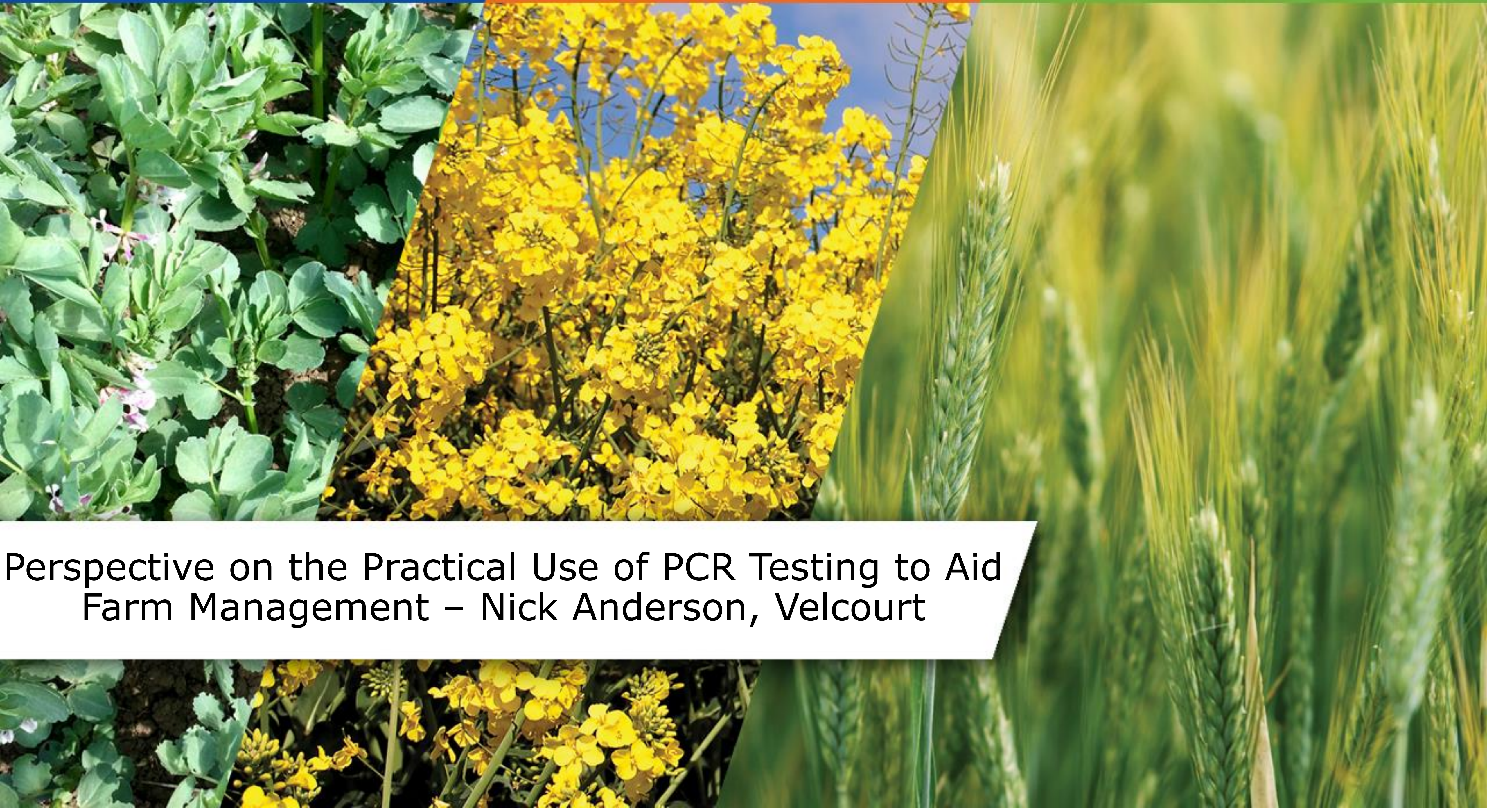


Figure 2 Analysis of the efficacy of fungicides against *Fusarium poae* ear blight of wheat (cv. Avalon) in the 1995–6 and 1996–7 glasshouse trials. Disease assessment based on (a) visual disease assessment at GS 80 and (b) quantitative PCR analysis. Bars indicate standard error of the means.

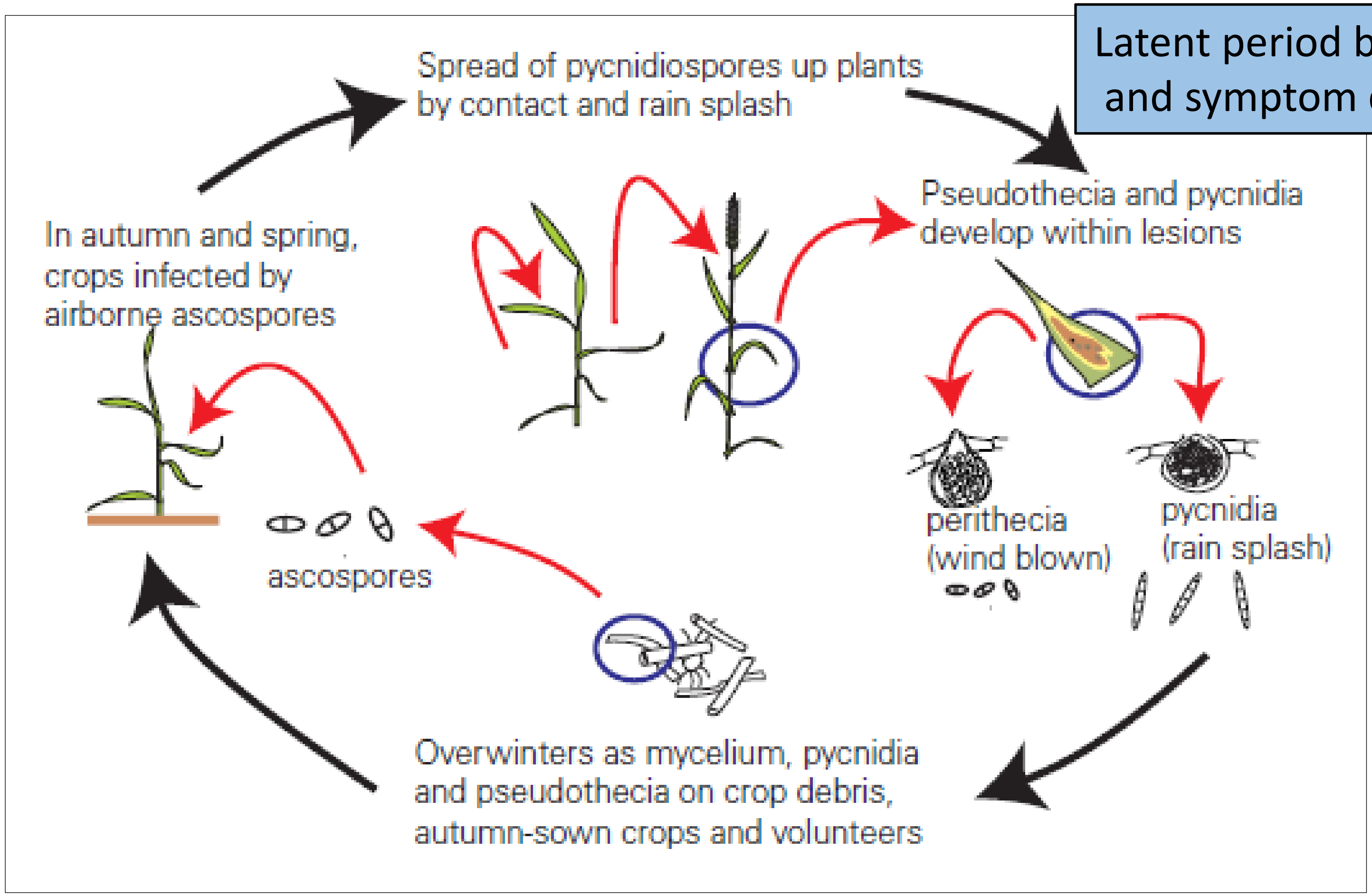
qPCR can identify reductions in Fusarium DNA with appropriate fungicides eg: tebuconazole



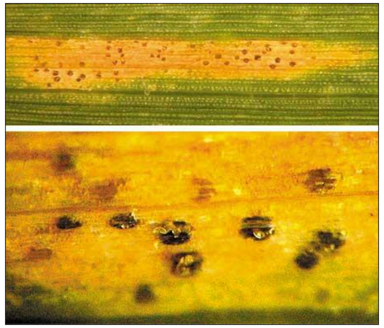
Perspective on the Practical Use of PCR Testing to Aid Farm Management – Nick Anderson, Velcourt

Septoria Leaf Blotch
Zymoseptoria tritici (Septoria tritici)

Life Cycle



Latent period between spores landing and symptom development



Opportunities with PCR testing

VELCOURT

'Can we measure the level of latent Septoria in wheat and use this to optimise fungicide inputs?'

Two Different Tests Available

Microgenetics Swift Detect test 10 leaves

Log genome scale

Results categorised as undetected, low, medium or high

Bayer Crop Check 30 leaves

1-100 scale

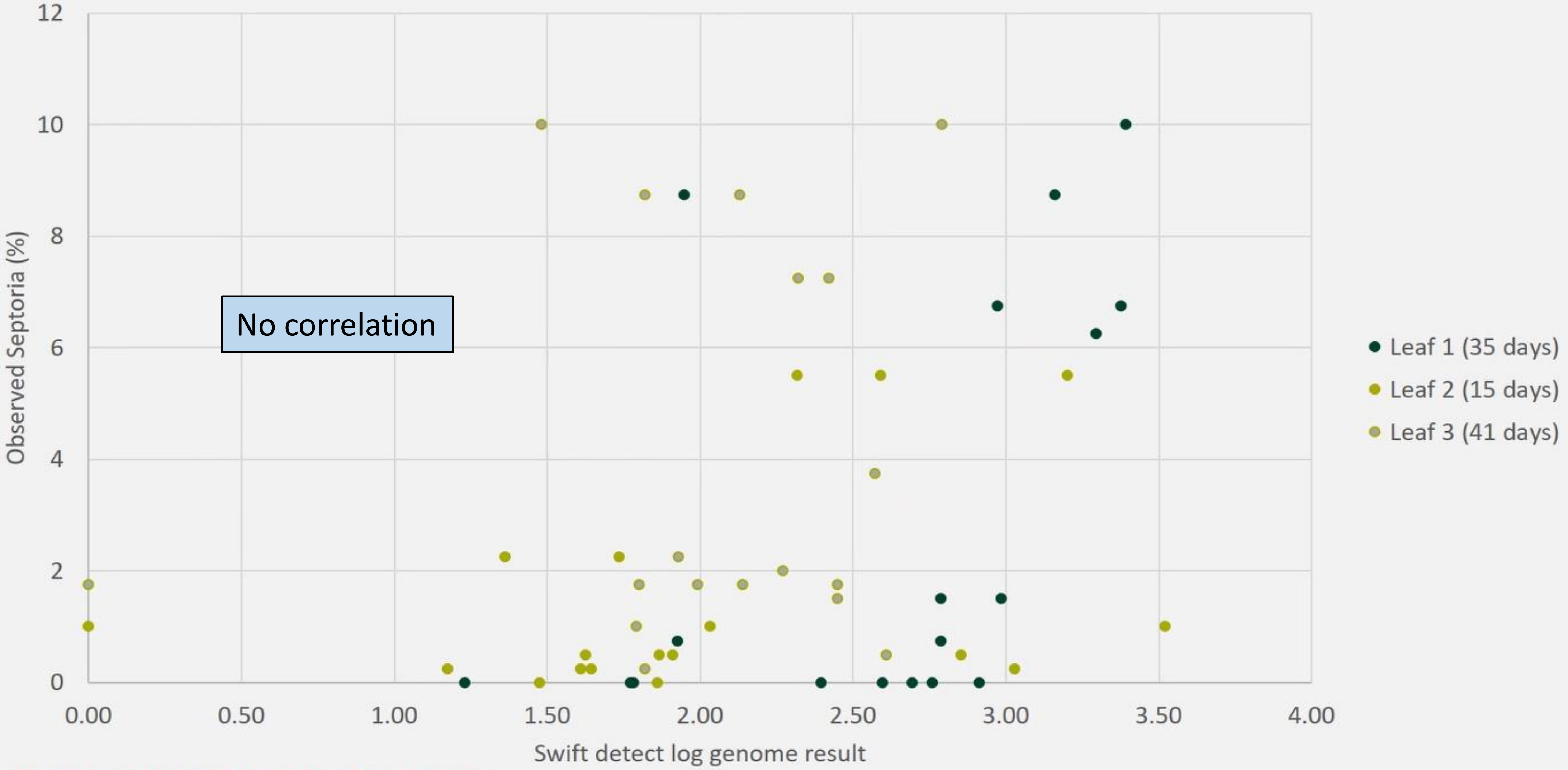
1 represents the threshold for reliable detection

Results categorised as 'protectant', 'early stage infection' and 'curative scenario'

Key Questions

1. Does qPCR testing appear to accurately reflect what is expected, and then relate to observed Septoria?
2. How does spatial variation in Septoria pressure impact upon testing?
3. Do different tests give the same results?

Swift detect log genome score compared with observed Septoria 15-41 days later



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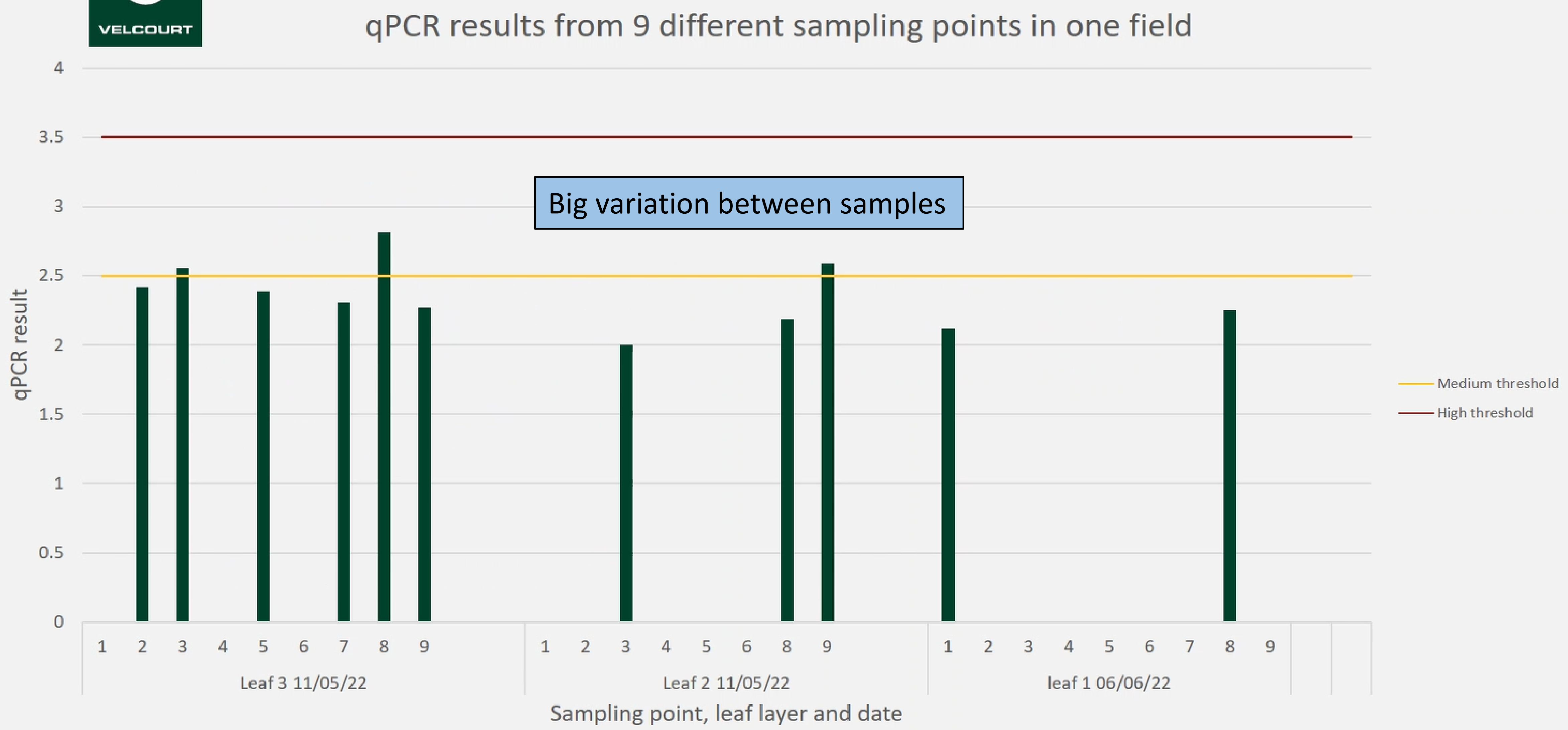
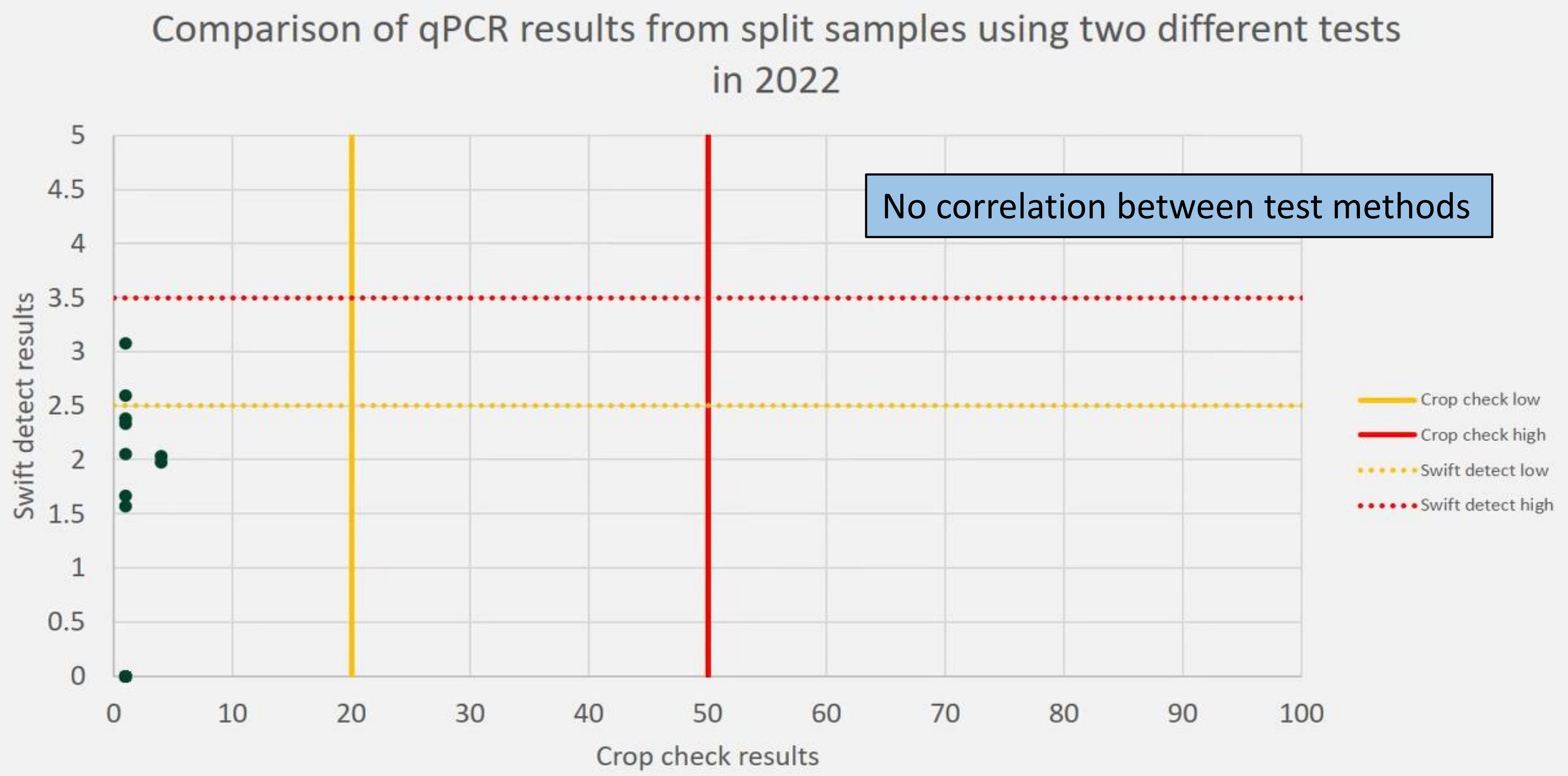


RESPONSIBLE FARMING FOR THE FUTURE



RESPONSIBLE FARMING FOR THE FUTURE

VELCOURT

What is required?

- Clarity around how to best use the tests and how to interpret them.
- Common scale?
- Ring testing?

- Confidence- the false negative risk is significant.
- Independent appraisal and guidance?

- An exciting technology, but much work yet to be done.

Key Issues Affecting Future Disease Control

- Revocation of some key fungicides including multi – sites and difficulties in registering new fungicides.
- New fungicides which are registered generally have single site modes of action prone to disease resistance which is increasing
- There is an increasing need for new Modes of Action and alternatives to conventional crop protection products such as biological control products
- There will be an increasing requirement for agronomists to justify/optimise the use of crop protection products
- Integrated disease management techniques, inc. new tools, will become increasingly important to relieve pressure on crop protection products
- As with fungicides key diseases are becoming increasingly able to overcome varietal resistance which is one of our major ICM tools

Prospects for Disease Control – Highlights from recent BCPC Reviews – Dr David Ellerton, H L Hutchinson (BCPC Advisory Board))