

STEWARDSHIP

Protecting the future.

Stewardship for New & Existing Chemistry: Fundamental in fungicide resistance management

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KEEP GROWING.

Fungicide Stewardship Overview

- What is stewardship, and why does it matter?
- Challenges presented for new and existing fungicides
- Pathogen Challenge: evolution in complexity through selection requires stewardship for chemistry
- In Practice stewardship: understand, manage and moderate resistance development to maintain field performance and yield.

Strobilurins Complete Failure vs Septoria Leaf Blotch

(UK/IRL 80-100%)

Why?

- Single site of action (QoI site in Cytochrome b-c1 complex in mitochondria, Resistant isolates carried recessive mutation G143A)
- Over-use, 2 successive applications per season
- Often @ high dose
- Often applied alone (esp. pre 2002)
- **HISTORY REPEATS ITSELF:** Metalaxyl (1970's)

1996: Launch of Strobilurins

2004: G143A mutation



Strob gains despite wide resistance

25 February 2005

More in

Arable

Disease management

Recommended



How OSR growers will benefit from genome-wide breeding

SEPTORIA RESISTANCE to strobilurin fungicides is now too widespread for resistance management strategies to be effective, according to the findings of a DEFRA-funded LINK project.

But the wider disease control benefits from strobilurins mean that, in the 100 samples tested, there is still a place for strops in the UK. The findings were published in the "Strobilurin Resistance" research paper by John Lucas.

"Septoria resistance in the UK developed far more quickly than anyone predicted and we started too late to do much about it," he says.

"We know the problem started back in 2001, but the detection techniques were not good enough then. By the time we started to do something about it in 2002, many septoria populations were already starting to develop resistance."

Needed Better Stewardship!

Source: Farmers Weekly 2005

We were lucky then.....

Strobs continued to be developed in mixtures and effective on rusts and range of other diseases globally

Muli-sites (CTL)
morpholines, triazoles
(epoxiconazole)

Prothioconazole
2005
Boscalid
2005

Peak development of new actives and chemistry, especially SDHI's,

But strobs never recovered from the G143A mutation for Septoria

.....Will we be so lucky next time?

STEWARDSHIP

“the conducting,
supervising, or managing
of something”

*especially: the careful and
responsible management
of something entrusted
to one's care*



Merriam Webster

Stewardship: We are ALL in it together!



Why Does Stewardship Matter For Disease Management?

We are ALL in it together!

- **Stakeholder Stewardship:** from R&D organisations to growers ALL have a collective responsibility to safeguard chemistry
- **Resistance Stewardship:** Critical to understand, manage, moderate and communicate best advice. Research and monitoring critical.
- **Regulatory stewardship:** Retain effective fungicides with different MOA's, enable new solutions & technology, labels. Government direction to regulators!
- **Grower and agronomist stewardship:** follow label/advice, using appropriate choice of products in programme and dose, IPM , varieties, cultivations, application timing!
- **Sustainable stewardship:** The most sustainable solution for disease control is continued access to a diverse set of tools that can be combined with IPM and other solutions including gene edited precision plant breeding

Stewardship challenges for new and existing fungicides

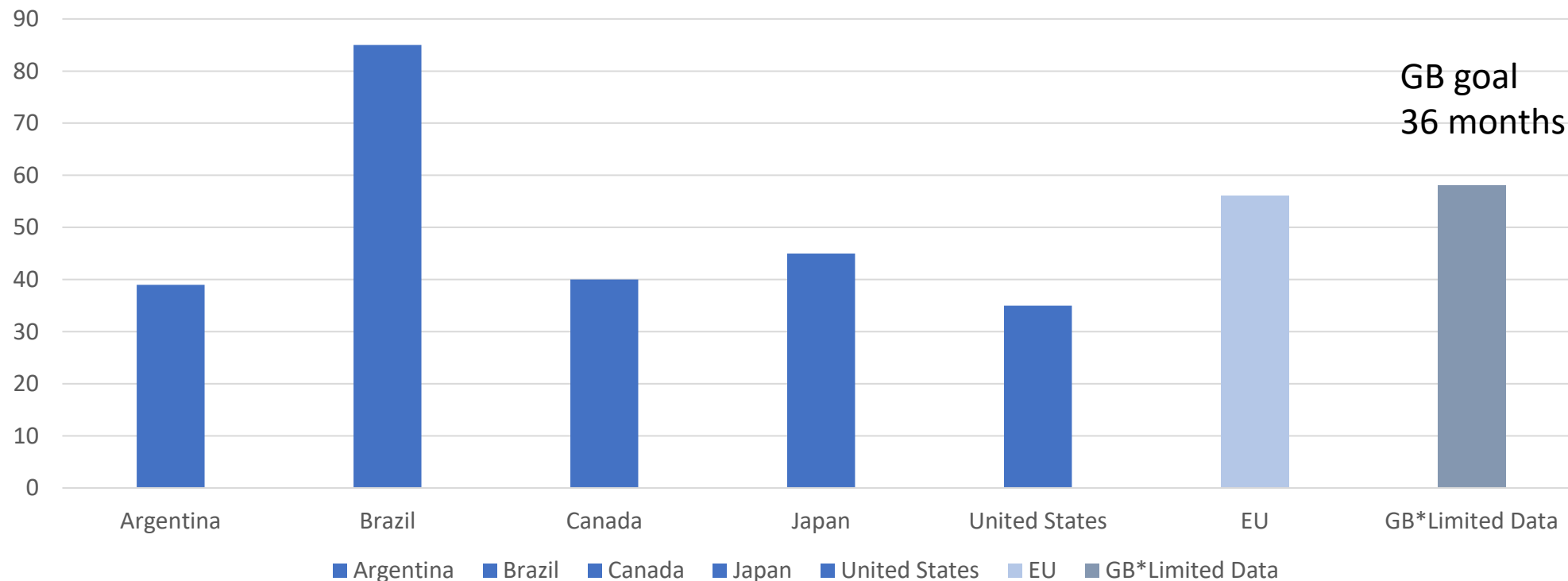
- Discovery for new mode of action (MoA) is increasingly challenging and complex
 - Required to meet multiple desirable criteria and stage gates to meet future grower needs in 10+ yrs
 - Resistance status is a key criteria
- In 25 years:
 - Development costs doubled – from \$152MM (1995) to > \$300+ MM BY 2019
 - Timeline increased by $\frac{1}{3}^{\text{rd}}$ – now 12.3 years
- Regulation hurdles more stringent for new AIs in Europe (454 actives registered)
 - Last new active substances approval in 2019 (Rinskor™), 2018 (Inatreq™), 2016 (Cyantraniliprole)
 - New Fungicide approval in Isoflucypram and Pydiflumetofen **registered GB 2024 (not yet EU)**
- Consequences of renewal requirements for current AIs and political will:
 - Endocrine Disruption, new end points, aquatic tox, PBT, carcinogen classification, PFAS etc.
 - Increasingly expensive to defend molecules/products through renewal
 - Economics drive decisions: Tools will continue be lost

Global Registration Time of New Actives

GB: Benefits

- Parallel processing of active substance, representative product, MRL and hazard classification and labelling
- Additional products review started before end of active substance approval
- Renewals delayed for 3-5 years

New A.I. avg Time to Authorization (in Months) 2014-2024



GB comments based on current transition period

Data based on mean actual global registration times

Remaining Cereal Actives in GB (Excl specific mildewicides)

Lost Cereal Als post 2017

THIOPHANATE M

FENPROPIMORPH

QUINOXYFEN

PROCHLORAZ

TRIADIMENOL

EPOXICONAZOLE

PROPICONAZOLE

CYPROCONAZOLE

FLUTRIAFOL

CHLOROTHALONIL

MANCOZEB

ISOPYRAZAM

PICOXYSTROBIN

Grouped by mode of action (MoA)

Triazoles

Metconazole, Difenconazole (EU renewed)
Tebuconazole, Prothioconazole
Mefentrifluconazole (2020)

Multi-sites

Folpet (EU renewed), **Mancozeb (last use 2025)**

Qol / Strobilurins

Azoxystrobin, pyraclostobin , trifloxystrobin, fluoxastrobin
No Septoria activity, good rust activity

New generation Carboxamides (SDHI)

Bixafen, Fluopyram, Benzovindiflupyr, Fluxapyroxad
Isoflucypram, Pydiflumetofen (2024 GB), fluindapyr (under development)

Qil (picolinamides)

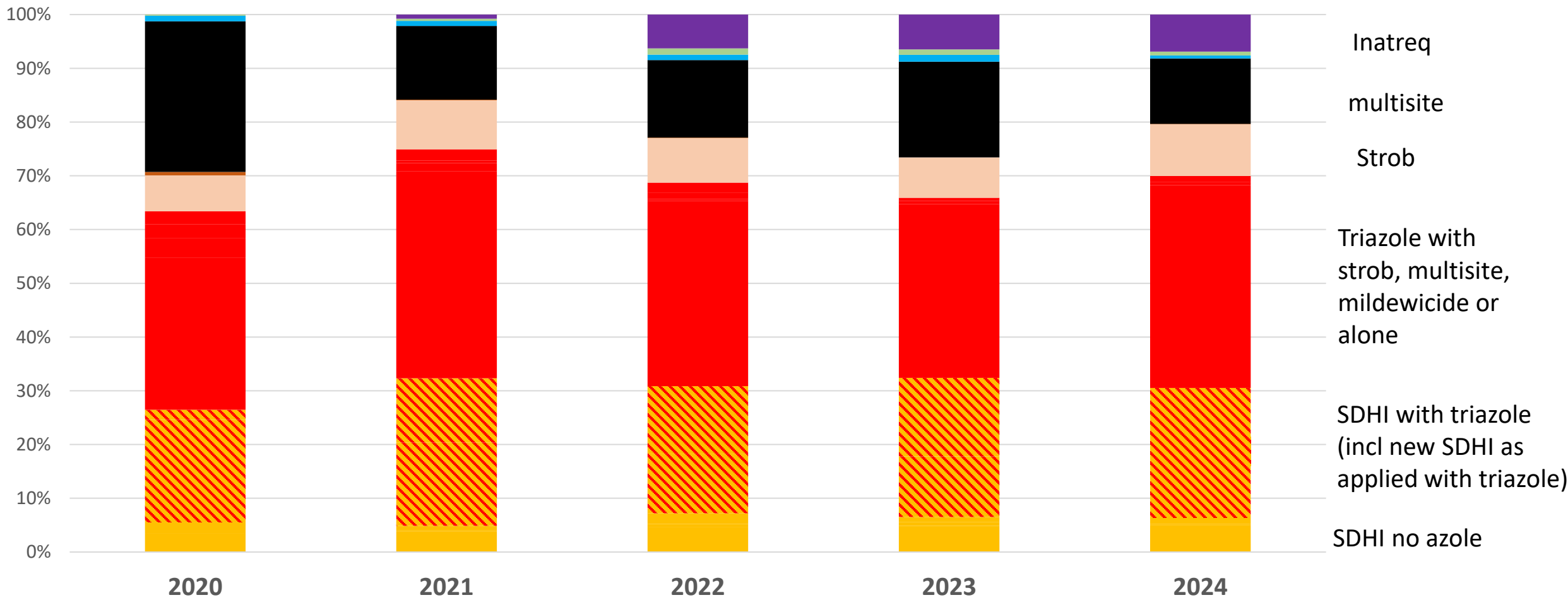
Fenpicoxamid 2021

QoIs

Metyltetraprole (**Pavecto®**) – Under development

When CRD release Active Substance renewal program: What impact labels/data generation/costs?

WW Fungicide use by product category SDHa UK 2024



Based on industry panel; data 2024

Pathogen Evolution

- Complex genetic diversity for Septoria isolates: Cyp51 variations, double mutant SDHI
- Gradual performance decline triazoles & older SDHI for Septoria (ADHB DR curves): still retain field efficacy in program
- Resistance mechanisms: MDR, Target site, efflux pumps, alternative oxidase
- Varietal resistance degraded: Cougar gene in wheat in 2021 c.v. Firefly
- Faster cycling, higher temperatures: Late blight isolates adaptation (EU36_A2)
- Monitoring and research are key elements of stewardship!

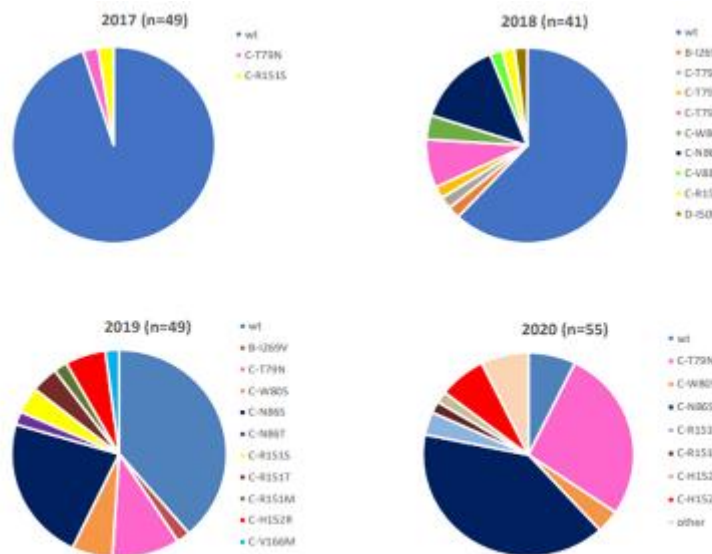
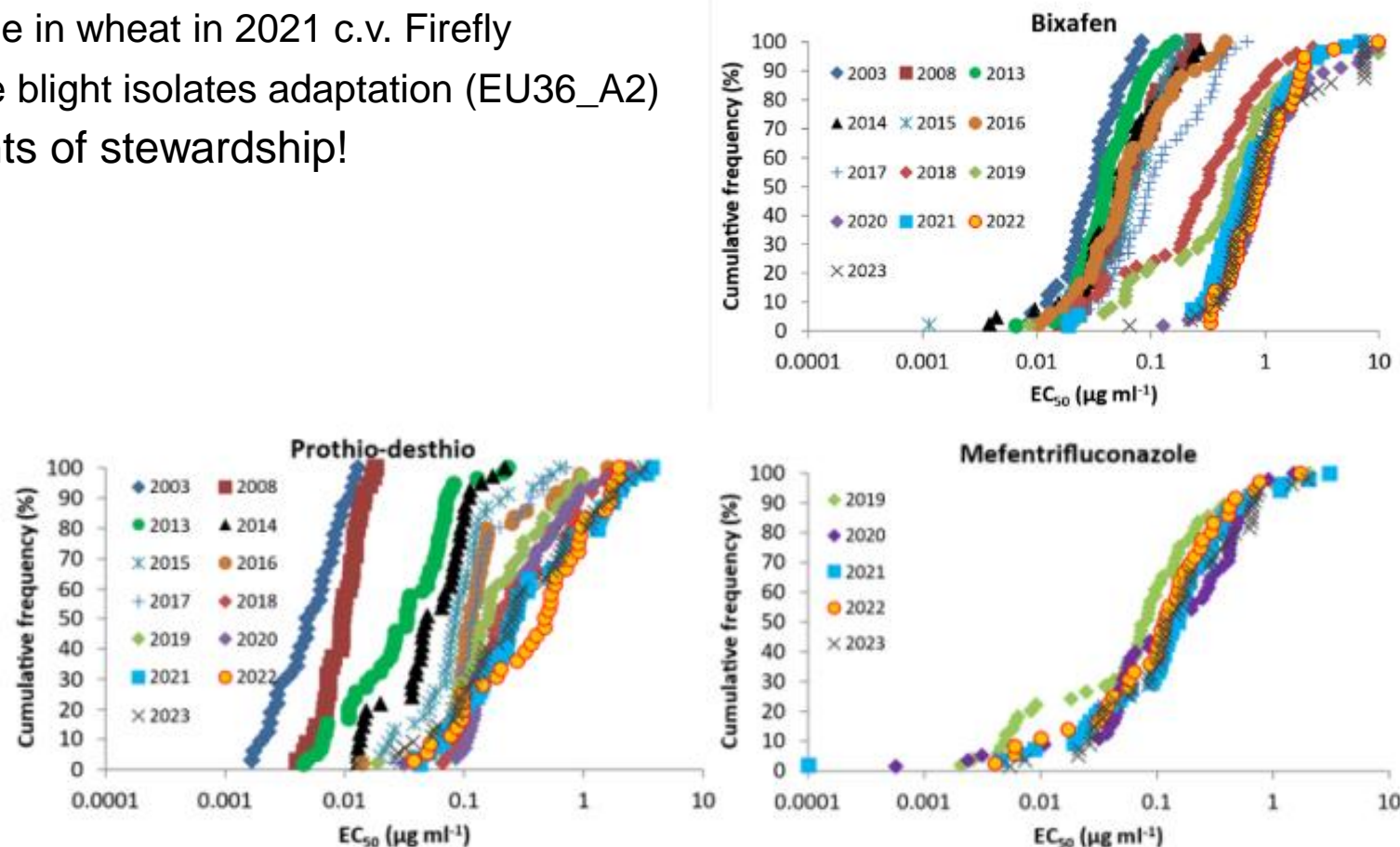


Figure 3. Distribution of Sdh variants within *Zymoseptoria tritici* populations sampled over time at Rothamsted from untreated fields at the start of the season.



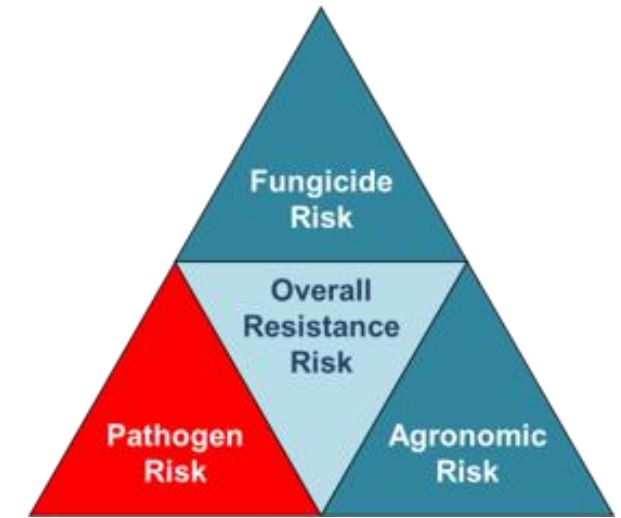
Climate Change: Pathogens Evolving? New Ones?

Wetter winters and hotter summers, frequent heavy rain events in summer



Assessing Pathogen Resistance Risk to MoA

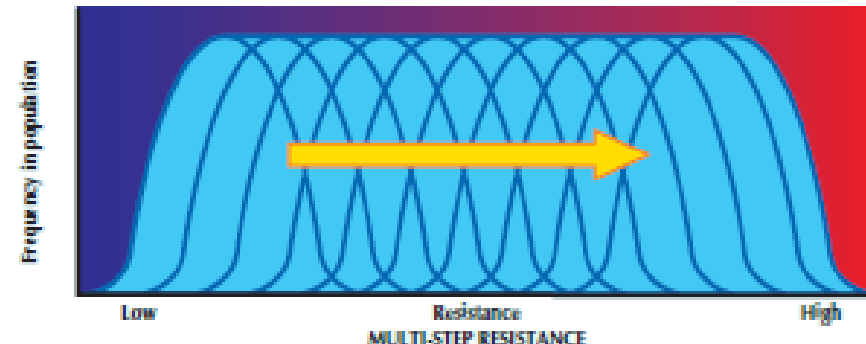
- Mechanisms for potential resistance
- Lab mutations aid understanding
- Monitoring and modelling
 - targeted locations
 - field performance
 - Determine genetics of isolates and mapping
- Pathogen risk driven by
 - Pathogen biology
 - Genetic diversity
- Stewardship factors to mitigate risk
 - Limiting the total dose of a MoA applied in a season is a key driver of resistance selection.



Discrete (qualitative) resistance



Multi-step (quantitative) resistance



Mechanisms of resistance

Stewardship: Mitigate Risk

Tools & parameters for managing resistance	Elements to consider	Challenges
Mixing different fungicides	<ul style="list-style-type: none"> N° of MoA available N° of applications of that MoA Multisite 	Resistance to many MoA in key pathogens - regulatory changes - persistence of mixing partners
Application strategy	<ul style="list-style-type: none"> N° applications per season/ crop (wheat 2.5, potatoes 15-20) Application timing / interval Block vs alternation Regional specificities 	Determine application strategy in light of chemical attributes and grower practice/economics
Dose rate	<ul style="list-style-type: none"> Balance efficacy vs selection potency and persistence of mix partners Regional specificities 	Generate data sets to make right recommendations



RACs



FIGHT AGAINST BLIGHT

➤ **Compliance with manufacturer recommendations and label** (trainings & communication)

Inatreq™ : Resistance Management

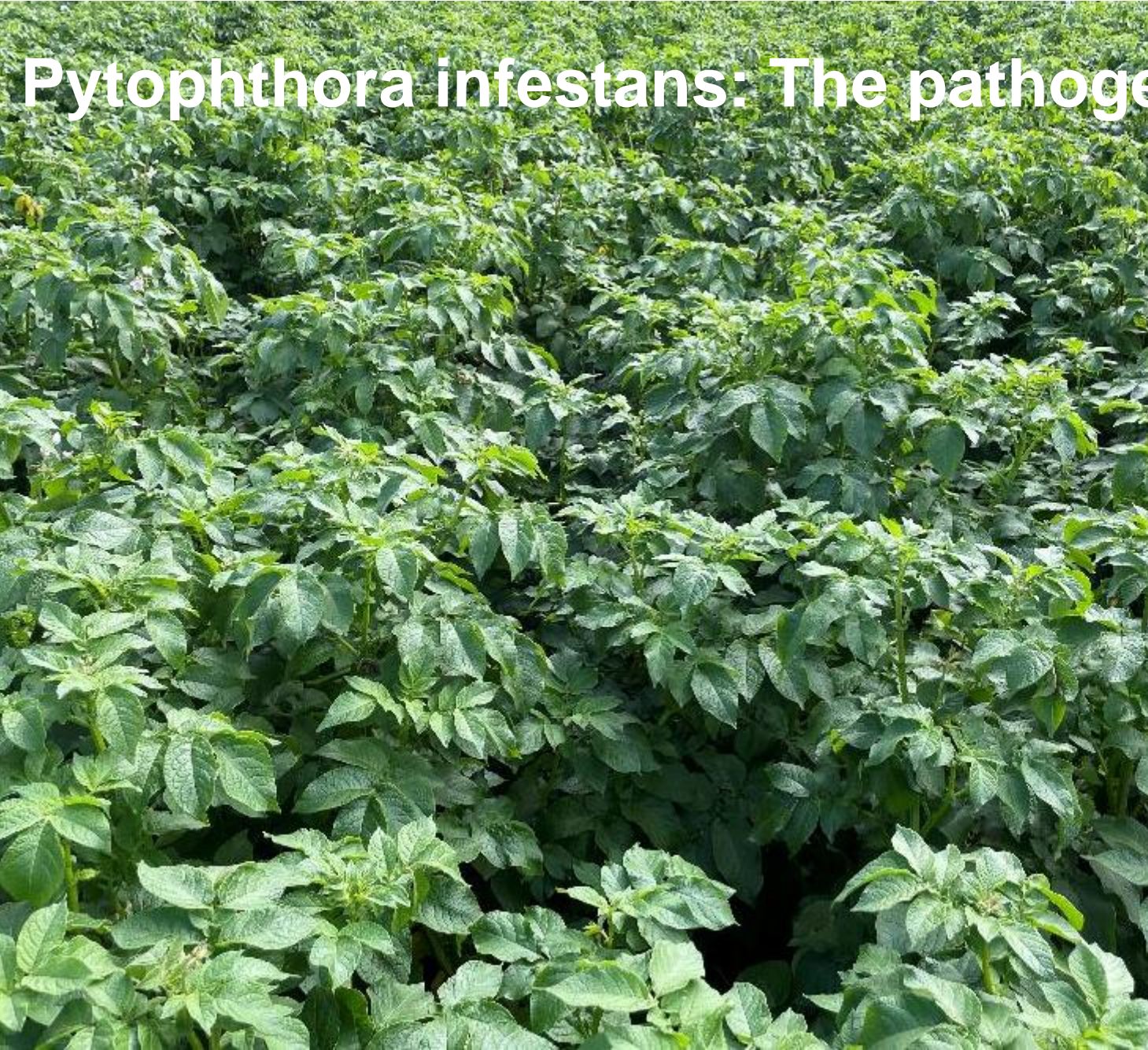
Inatreq™ active

- **Stewardship defined from launch- Single target site active but novel target site of action**
 - Apply only **ONE** Qil containing product to a cereal crop in a season.
 - Abide by the label and additional advice from manufacturer
- **ALWAYS apply Inatreq in mixture with effective partner product(s)**
 - Must have different MoA
 - Balance doses appropriate for conditions
- **Apply integrated strategies:**
 - More tollerant varieties/Field history/geography/program balance/DSS/Rotate chemistries/Mixture strategies
 - **TIMING!**
- Follow FRAC Qil guidance published April 2019, *“Resistance risk unknown- assumed to be medium to high”*
- *Resistance monitoring Inatreq and partners, Field Performance trials, lab mutants created, genetics modelling*

Stewardship: Once Resistance Isolates Identified

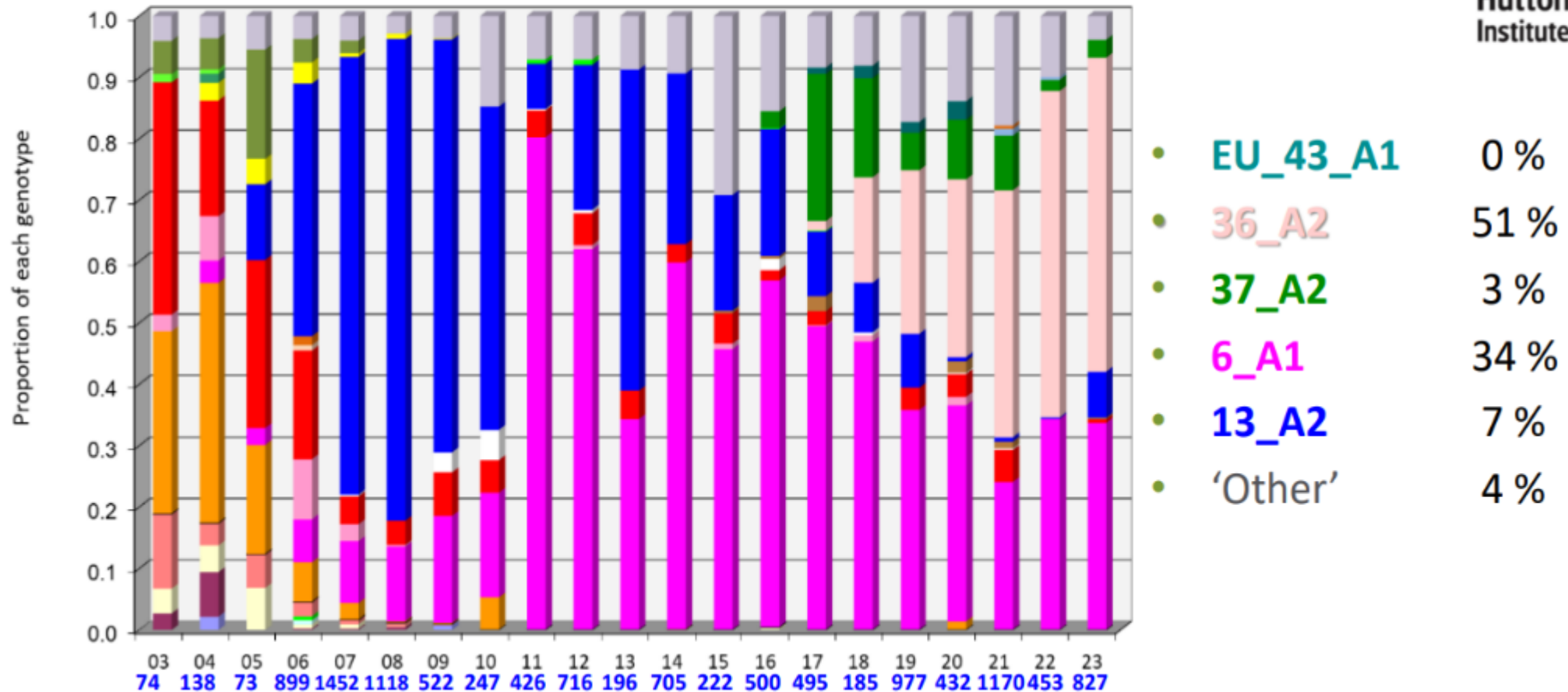
- Does not mean you can't protect performance & manage resistance.
 - Act quickly
 - Decision trees
 - Modify recommendations to slow resistance
 - Adjust user dose
 - Reduce total number of applications
 - Change application criteria: blocks vs alternation
 - Change mixing partners and position in programme
 - Continue to monitor and research
 - Label changes (can be slower)
- Communicate widely recommendations
- Ensure advice is actioned at farm level!

Pytophthora infestans: The pathogen which keeps on giving...



Changing genetic diversity of *P. Infestans* in UK

UK *P. infestans* population change

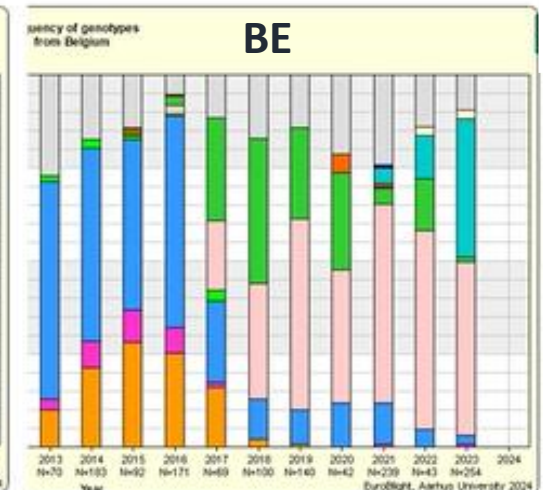
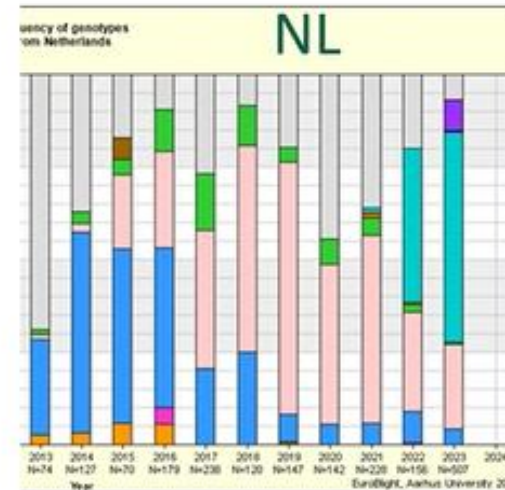


FRAG-UK potato late blight guidelines (April 2024).pdf

2023 Expansion of EU43



- EU_43_A1 increased >40%
- Single case in Ireland
- Additional related strain EU_46_A1
- Resistance to CAA continues to 2023
- Blight management issues in 'low countries'



Stewardship: Best Practice Advice

- Publicised from Autumn/Winter 2023
 - Direct communication with sector stakeholders:



- Social media to promote stewardship continued through June.
- Seasonal soundbite to field team supporting stewardship message.
- Arable Update content focused on Zorvec™ active and Zorvec Entecta™.
- Promotion of the UK portfolio offer document now underway through our own channels.
- Promotion of Zorvec active on UK and IE website homepages.
- Best practice application advice printable document hosted on website.
- Upcoming potato events: Potatoes in Practice and Eurofins Blight Open Day.



UK topic sheet



2024 Zorvec™ active application advice for potatoes.

Products containing Zorvec™ active deliver highly effective disease control against potato Late Blight.

Corteva strongly advise following the 2024 application advice when recommending and applying Zorvec products.

Best practice application advice for 2024

1. Apply Zorvec products in strict alternation with effective chemistry of a different mode of action, other than CAA (benthiavalicarb, mandipropamid, dimethomorph).
2. The post-Zorvec application interval to the following non-Zorvec containing spray should not exceed 7 days.
3. In curative situations (disease evident or confirmed in local area) Zorvec co-formulations should be applied in tank-mix with a partner fungicide containing a curative active ingredient e.g. cymoxanil or propamocarb.
4. Sprays containing Zorvec should not exceed 20% of the total number of sprays applied to a crop.
5. 2 sprays per crop if the expected programme is less than 15 sprays.
6. A single crop should not receive more than 3 sprays containing Zorvec products.
7. Whilst still available, tank-mixing Zorvec products with mancozeb is recommended.

Additional advice for seed crops and home saved seed

1. Zorvec applications must always be applied with a full rate of a curative fungicide e.g. cymoxanil.
2. A single crop should not receive more than 2 sprays containing Zorvec products and these 2 sprays should not exceed 20% of the total late blight programme.

Resources to help you

- Visit our Zorvec active hub to go back to basics on why this chemistry and its application advice is so important: www.corteva.co.uk/zorvec
- Discover Corteva's range of products to help you maximise your potato yield at: www.corteva.co.uk/crops/potatoes

Need further advice?

Speak to your advisor or our Technical Services team who are always at hand to help answer any questions you may have.

Technical hotline:
0800 689 8899

Email:
ukhotline@corteva.com

Zorvec™ active

Products containing Zorvec active include:	Zorvec Endavia™ FUNGICIDE	Zorvec Entecta™ FUNGICIDE
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USE PLANT PROTECTION PRODUCTS SAFELY. Always read the label and product information before use. For further information including warning phrases and symbols refer to label. Corteva Agriscience UK Limited, Unit H6, Building H, Melsoun Science Park, Cambridge Road, Melsoun, Cambridgeshire SG8 6RH. Tel: 01462 452722. © 2024 Corteva. Zorvec Endavia™ contains benthiavalicarb and oxathiaprolin. Zorvec Entecta™ contains amibutolam and oxathiaprolin.

Learnings from 2024

- High Disease Pressure Year
- Successful control programmes
- Widespread Mancozeb use has supported all fungicide chemistry
- Adhering to manufacturer & FRAG-UK advice was key to managing UK *P.infestans* pop.
 - Early applications to contain non-OSBPI curative AI
 - Strict alternation of chemical groups with differing MoA
 - Stick to 7-day interval throughout the blight programme
 - Avoid application of single MoA fungicides by mixing with a multi-site or alternative MoA fungicide
 - Include mancozeb at regular intervals

Looking towards 2025

- Mancozeb last year of use!
 - On farm stock only in 2025
- Know National and local late blight challenge
- UK remains dominated by EU36 A2
- Resistance to Metalaxyl present in EU13 & EU41
- Resistance to Fluazinam in EU37
- 1 UK sample confirmed EU46 (OSBPI res.)
- No EU43 A1 detected in 2024
- Stick with 'Best Advice' for 2025
 - Review & re-enforce the message from 2024 experience
 - Maintain vigilance and best practice
 - Fight Against Blight (FAB) importance underlined by 2024

The Future of Stewardship for Disease Management

- Not total dependance on fungicides but they will still be needed
- Regulatory landscape (enabling)
- New Technologies embraced
- Build in resilience
- Embrace the value of stewardship in managing resistance

Integrated solutions to support the farmer



What is Disease Stewardship & Why Does it Matter?

- Stewardship is an active process under constant review
- Better to predict, monitor and moderate resistance before it happens
- When it happens: critical to manage resistance to maintain performance
- Support an Enabling Regulatory Framework in GB:
 - Critical to preserve and continue to build diverse chemistry MOA's
 - Integrate with IPM and other control measures including new technologies
 - Follow label and advice and use fungicides diligently
- Effective stewardship requires all stakeholders to take responsibility

Stewardship: We are ALL in it together!





Questions

THANK YOU

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