Products (ai's): Threats and Opportunities

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Introduction

Threats

- Legislation
- Public perceptions
- Resistance
- Sub optimal practices
- Knowledge gaps
- Slow up take of new solutions

Opportunities

- New actives
- Better stewardship to retain existing actives
- Sustainable practices with market premiums / public good support
- New, smarter tools and solutions

Pesticides going forwards – uncertainty prevails

- Pesticide use is contentious
- Scrutiny and restrictions on use are increasing
- e.g. EU losses / pending losses on metaldehyde, chlorothalonil, cypermethrin, neonicotinoids, diquat
- No full consideration of resistance issues in withdrawal decisions
- Reduced number of options increases reliance on remaining actives and further increases selection for resistance
- New actives - need stewarding and carry additional costs

Photo: FWI

Photo: Stewardship Comminity.com

Pesticides going forwards

- Changing perceptions and attitudes
- Public increasingly care about how food is produced – but they also care what it costs
- Public and political pressure to reduce emissions
- Urgent need to develop and take up new technologies
- Win: wins in more sustainable use
- Opportunities to innovate and to add value to produce

Opportunities in more sustainable production

- Impact of climate change is clear and demands urgent action
- UK first major economy to legislate for net zero emissions by 2050

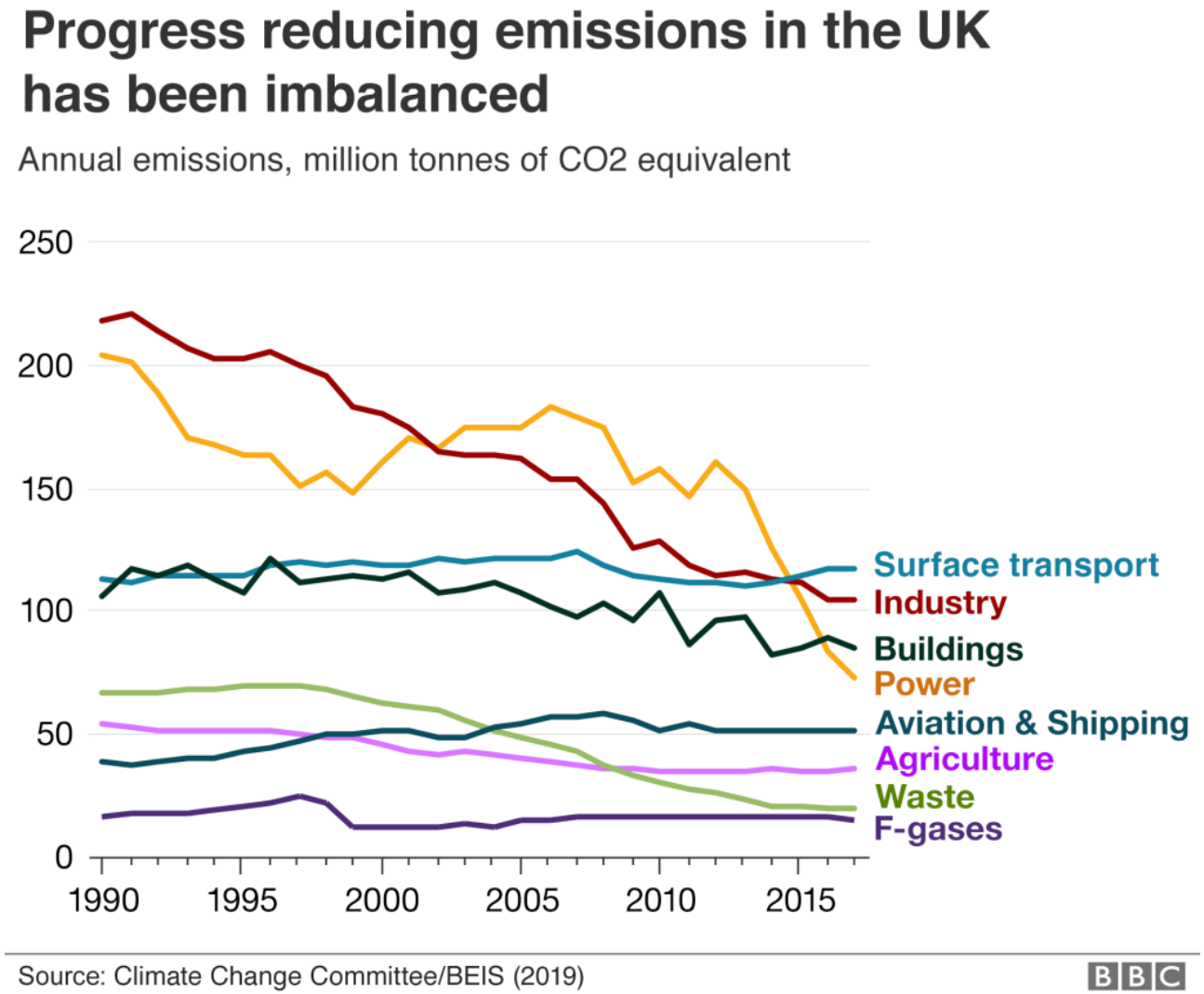
- May "That's why we're reforming farming policy to reward environmental actions, reviewing our food system to ensure it is more sustainable, taking steps to accelerate tree-planting and peatland restoration, and introducing a flagship Environment Bill to address the biggest environmental priorities of our age."

- Prof Ian Boyd former Chief Science Adviser Defra

- “optimising government to essentially maximise economic growth…optimise government around other objectives, which are more about health and welfare”.

Opportunity?
Net zero by 2050

SRUC



New tools are coming

- Inatraq
- Revysol
- New QoIs
- New SDHIs
- New biologicals
- More joint actives and cooperation
- Elicitors

Recent product losses

- Chlothianidin
- Large number of seed treatments

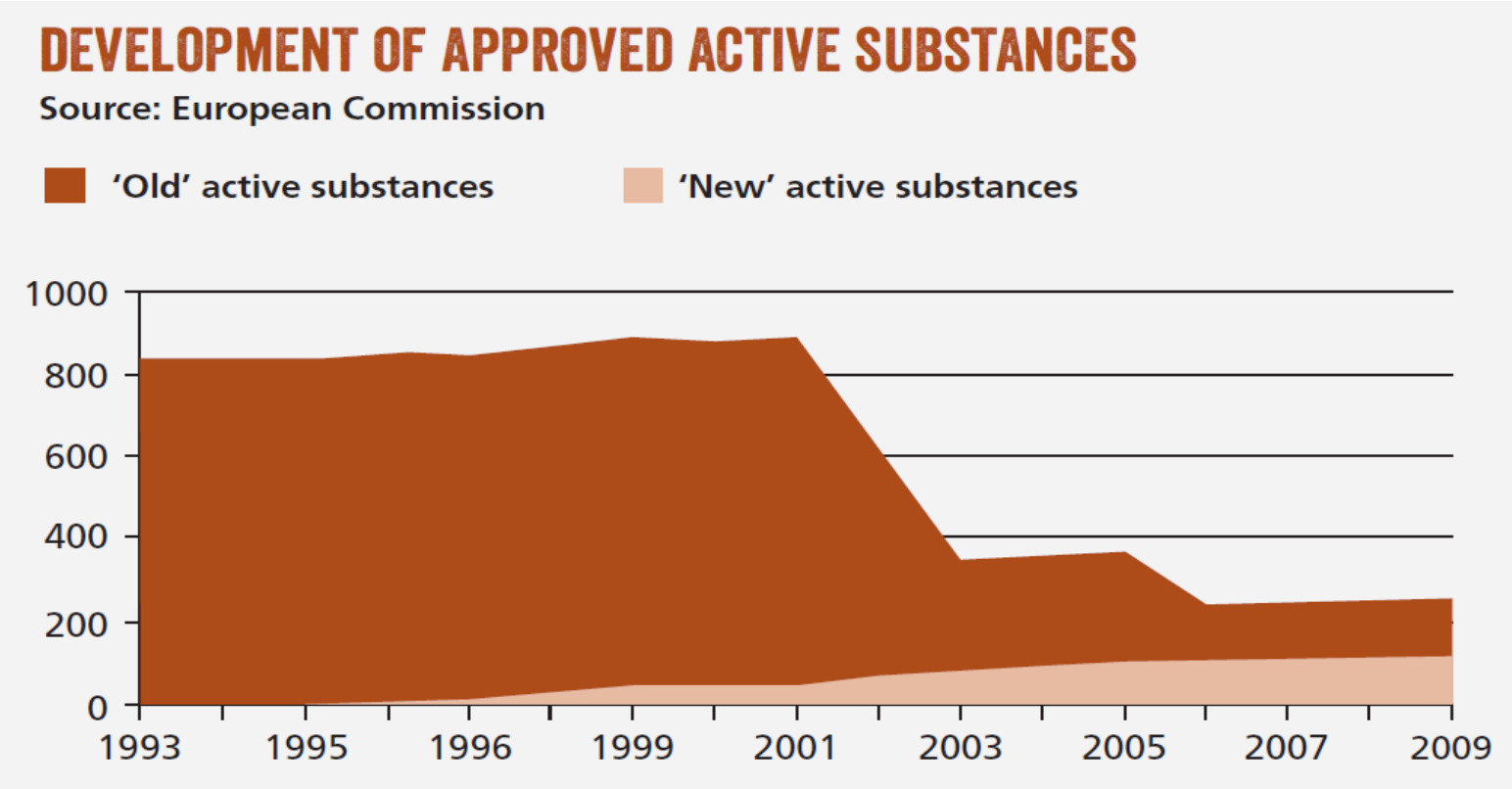
Pending losses

- Chlorothalonil
- Metaldehyde
- Diquat
- Older azoles

Anticipated restrictions

- Multisites
- Glyphosate

Threats and opportunities in a reduced pipeline of products

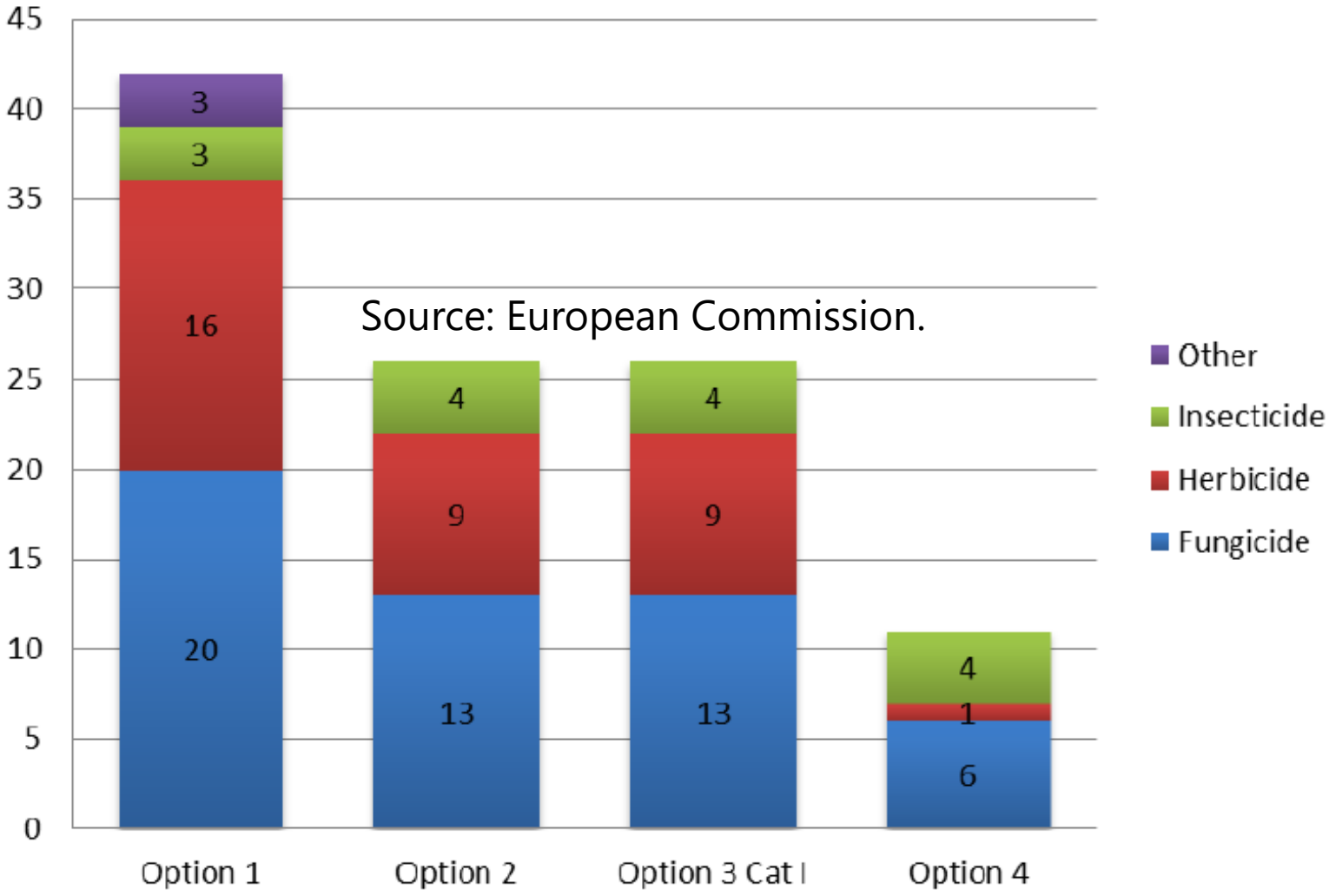


Healthy Harvest: The impact of losing plant protection products on UK food and plant production
https://www.nfuonline.com/healthy-harvest-report/

Background to pesticide withdrawals

- EU Plant Protection Products (PPP) Regulation (1107/2009) - ensures a high level of protection for both human and animal health, and the environment.
- ‘Cut-off criteria’, active substances not approved in cases where they are (i) mutagenic, (ii) carcinogenic or present reproductive toxicity, (iii) have endocrine disrupting properties, (iv) persistent organic pollutants, (v) persistently bio-accumulative and toxic and (vi) very persistent/very bio-accumulative.
- Any active substance with endocrine disrupting properties that may cause adverse effects in humans or non-target populations cannot be approved unless the exposure is minimal

Number of substances classified as potential ED by PPP major group, excluding substances that are classified as C1 or R193



16 actives at most risk

- For seven key staple crops in the EU (potatoes, barley, wheat, sugar beet, rapeseed, maize and grapes) they contributes 34 - 69 million tons or €4.1 - €8.3bn of crop value:
- Wheat, barley, maize could face 1-7% lower yield if the 16 substances were no longer available;
- Yield for rapeseed, potatoes, sugar beets and grapes might decrease by between 5% to 31% without them;
- At the current speed of technological progress, it would take 5-8 years to make up for this loss;
- With the 16 substances, overall farm profitability is up to 20% higher (€8.3bn of a total of €44bn);

Steward Redqueen (2017). Broader impact of criteria for endocrine disrupting properties for crop protection products in Europe (https://www.ecpa.eu/reports_infographics/broader-impact-criteria-endocrine-disrupting-properties-crop-protection)

Potential loss of pesticides – likely impacts

- Best case scenario
  - Cereals, oilseeds, potatoes – relatively unscathed
  - Edible and ornamental horticulture sector badly hit
- Worst case scenario
  - Cereals, oilseeds, potatoes – significant impact
  - Edible and ornamental horticulture sector severely affected

Resistance - threat of additional losses

- Fungicide resistance is eroding established actives and threatening newer ones
- Current resistance status for major arable crops is building
- Adds to input costs and reduces outputs

- What are the principals of resistance management?
- What information is available and useful
- How can we apply it?
- Opportunity and necessity to improve practice

Cereals: resistance issues

Fungicide Group	Diseases affected
Strobilurins	mildew (wheat and barley), septoria, net blotch, tan spot, ramularia, rhynchosporium, M. nivale
Azoles	mildews, septoria, ramularia, rhynchosporium, tan spot
SDHIs	net blotch, septoria, ramularia, tan spot
MBCs (no longer used)	eyespot, septoria, M. nivale, ramularia
Quinoxyfen	wheat mildew, barley mildew
Metrafenone	wheat mildew, barley mildew
Chlorothalonil	None
Folpet	None

Resistance management issues

- Stewardship measures based on reduced reliance
- Heavy usage of an a.i. confers a massive advantage to any resistant individuals
- Advice is to use all available methods to reduce pressure on chemistry – mix, alternate, use low-risk multisites
- Difficulties in motivating industry to be collectively responsible
- Complex science, confused messages

Opportunity: Better stewarding

Challenges in driving good resistance management practice

- More evidence?
- Better understanding?
- Fewer mixed messages?
- Barriers?
- Legislation?

Fungicide Resistance Action Group - UK

25 Members - Independent researchers, Crop Protection Association, Fungicide Resistance Action Committee, agronomists, regulator.

- Gather and interpret reports of fungicide resistance issues and arrive at UK consensus view
- Promote practical guidelines on status and management of fungicide resistance in UK
- Produce, publish and promote educational material that will assist in the understanding of and reduce the incidence of resistance in plant pathogens.
  - Website and Guidelines
  - Recommendations for label restrictions / changes

https://cereals.ahdb.org.uk/frag

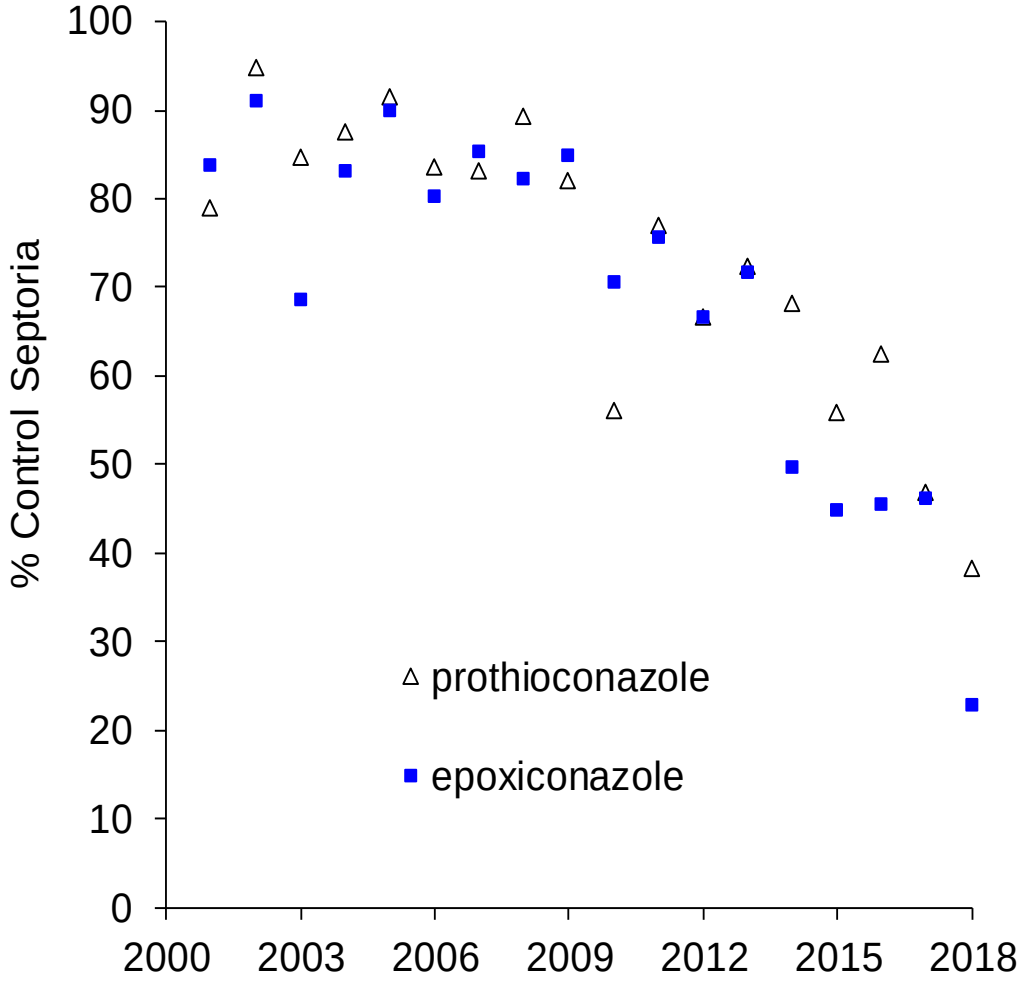
Case study 1: Wheat / Septoria

- History of high yielding but susceptible varieties
- Multiple applications of limited number of chemical groups

- Resistance to QoIs since 2003
- Declines in azole sensitivity
- Issues with SDHIs emerging 2018 and 2019
- New chemistry is exciting but also needs protecting

New variant strains of Septoria

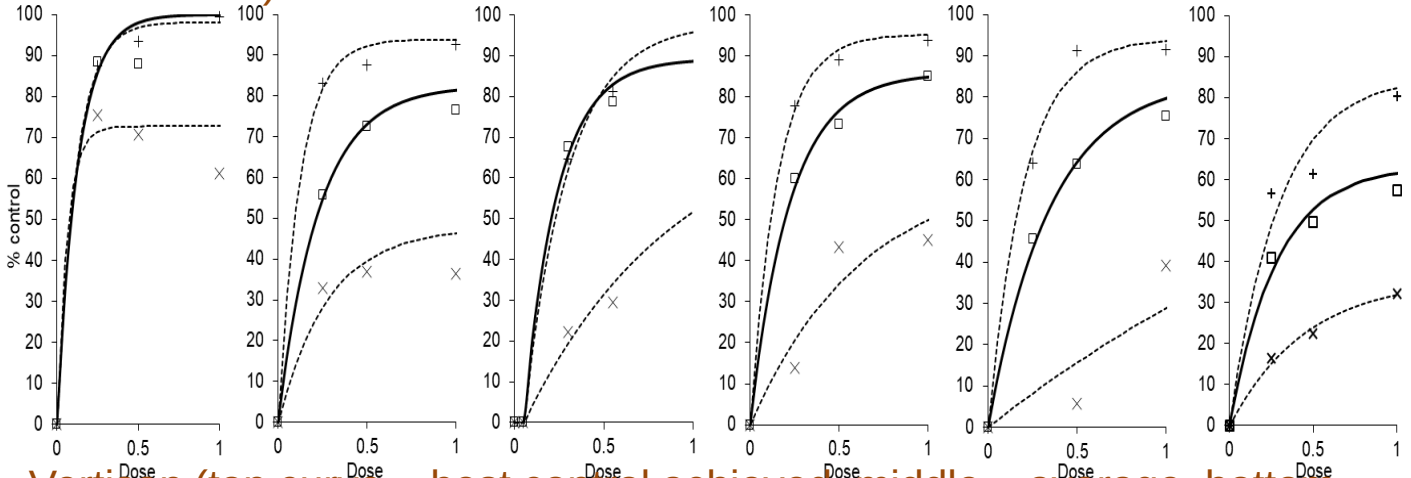
Declines in azole performance over time (protectant, full label dose)



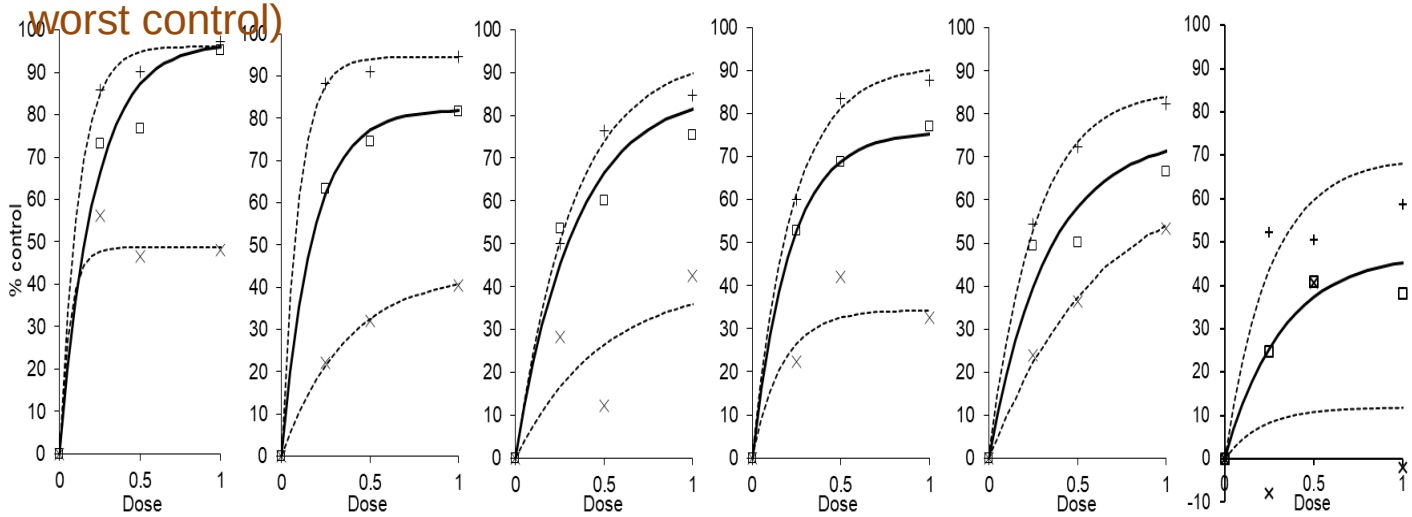
New variant strains of Septoria: SDHI performance over time

2013 2014 2015 2016 2017 2018

Imtrex (top curve = best control achieved, middle = average, bottom = worst control)

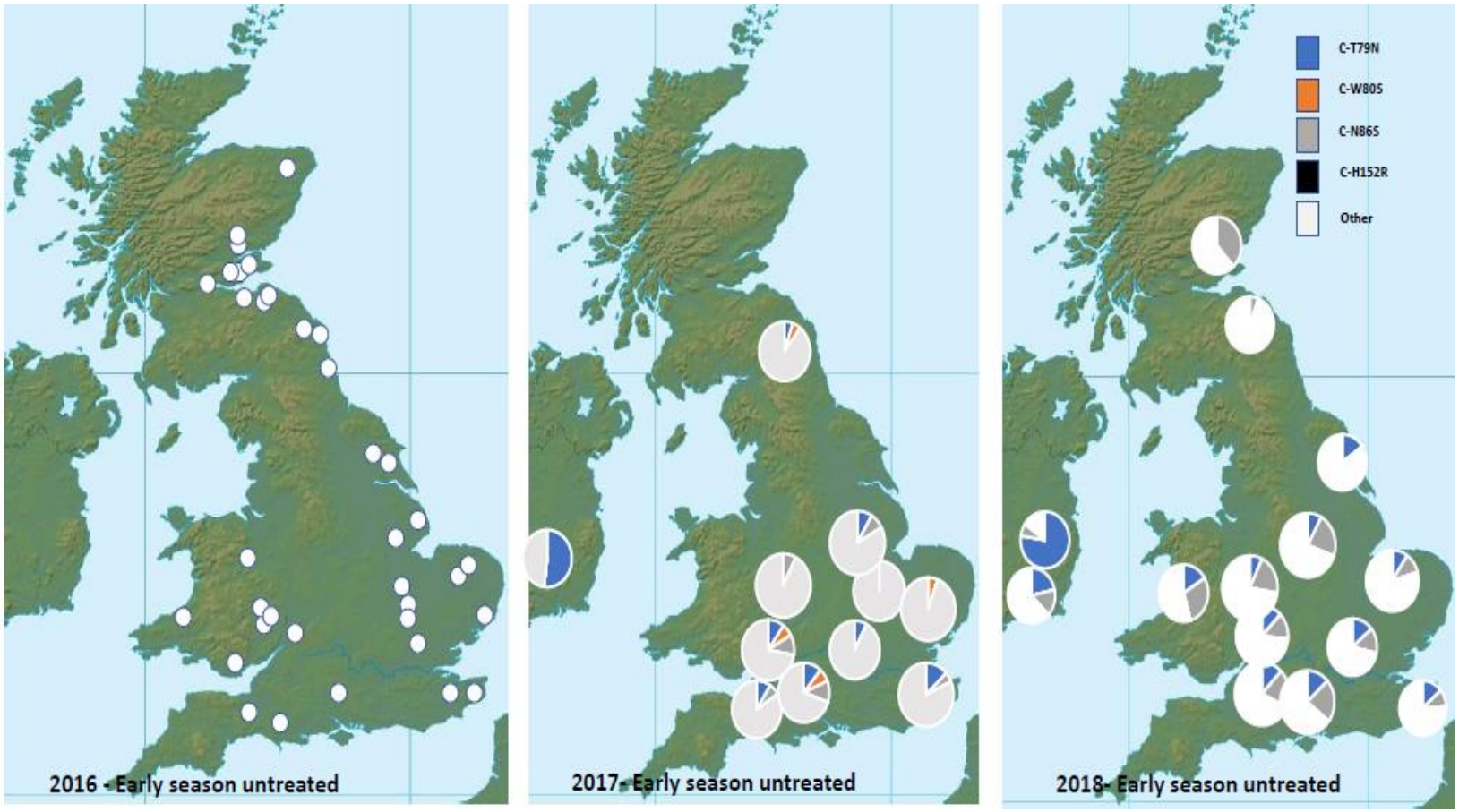


Vertisan (top curve = best control achieved, middle = average, bottom = worst control)



Septoria: monitoring of Sdh mutations

2016 2017 2018



Quantitative detection of frequently occurring Sdh mutations in UK field populations of *Zymoseptoria tritici*. No mutations were detected in early 2016 (detection threshold 3-5%)

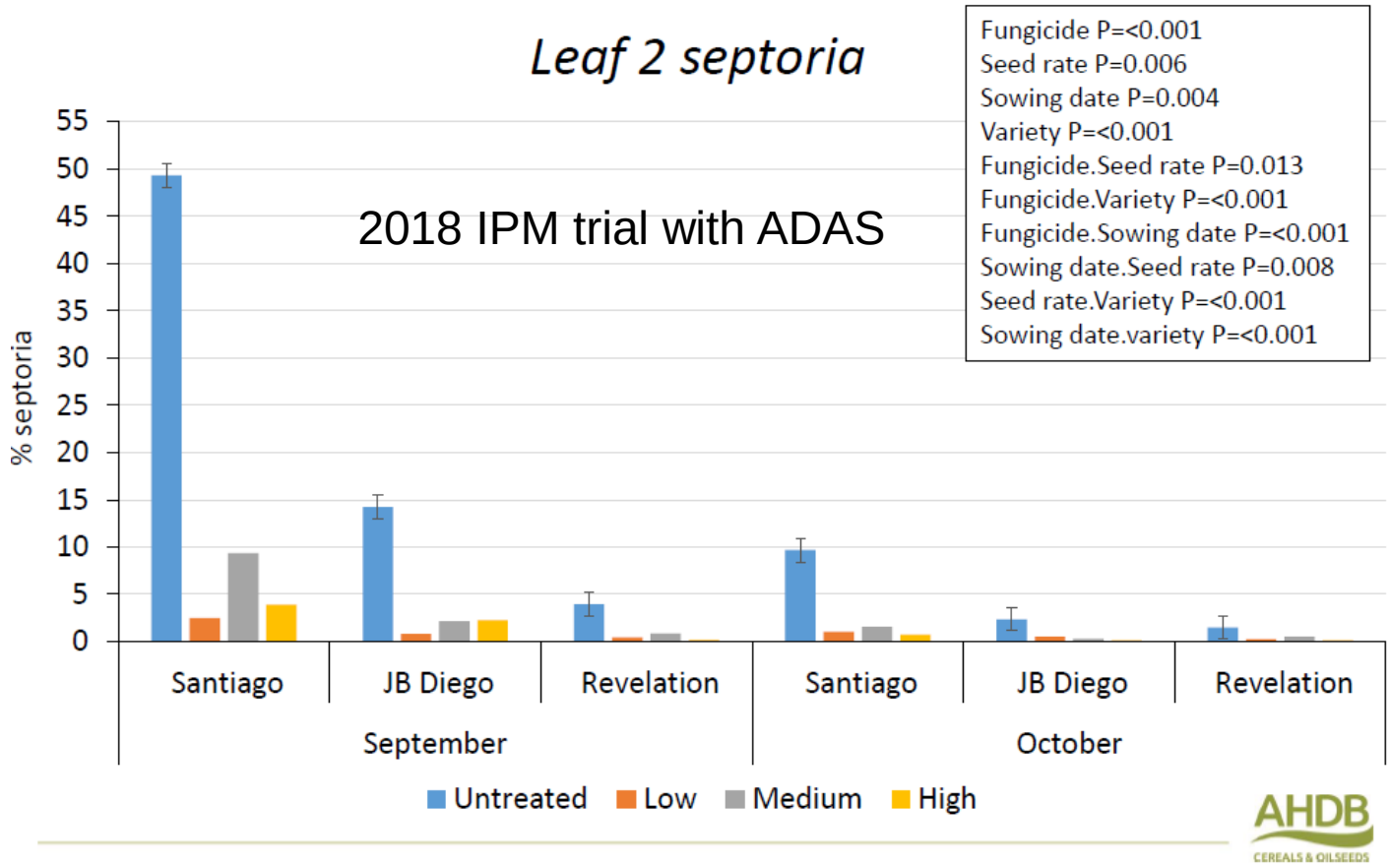
Wheat programmes – what do we **really** need?

- T minus – autumn or winter clean up
- T0 – early rust protection
- **T1 – stem-base disease and protection of yield important leaves**
- T1.5 – protection of leaf 2 is gap between T1 and T2 is stretched
- **T2 – protection of yield important flag**
- T3 – continued green leaf retention and protection from ear diseases
- T4 – continued ear disease protection

- Can we reduce use of more marginal sprays?

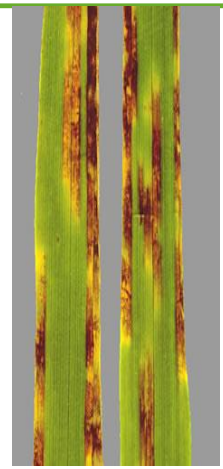
Opportunity: Valuing varietal resistance

Disease assessment T2 + 3-4 weeks
18th June



Case study 2: Barley

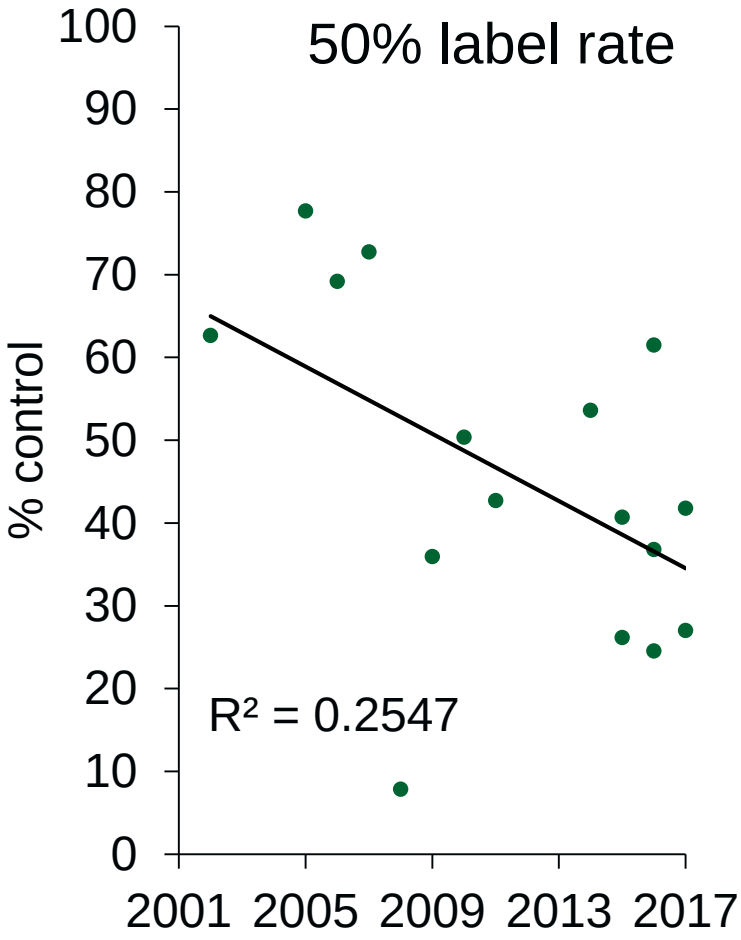
- Multiple disease targets
- Greater number of active groups
- Lower inputs
- History of slow uptake of more disease resistant varieties
- Issues with net blotch, mildew and rhynchosporium

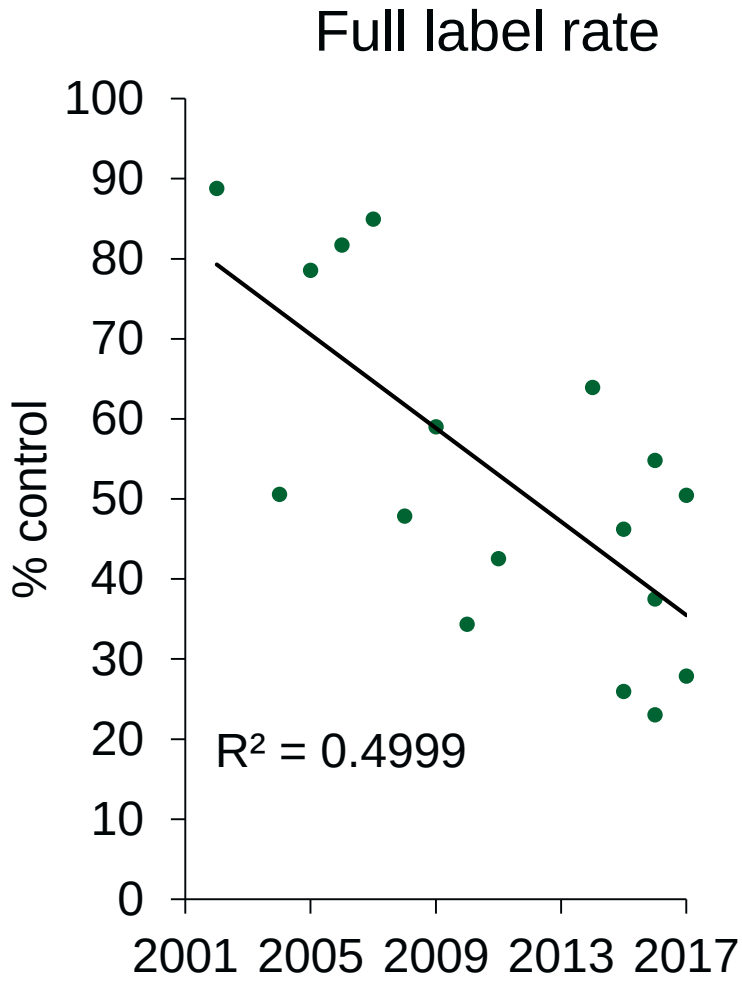


Ramularia – evolving picture

- QoI resistance since 2002
- MBC resistance (2 forms)
- Emerging issue with SDHIs 2014
- Field failures with azoles and SDHIs
- 2017 Fall off in field performance

Declines in QoI (strobilurin) efficacy on Rhynchosporium (2001 – 2017)

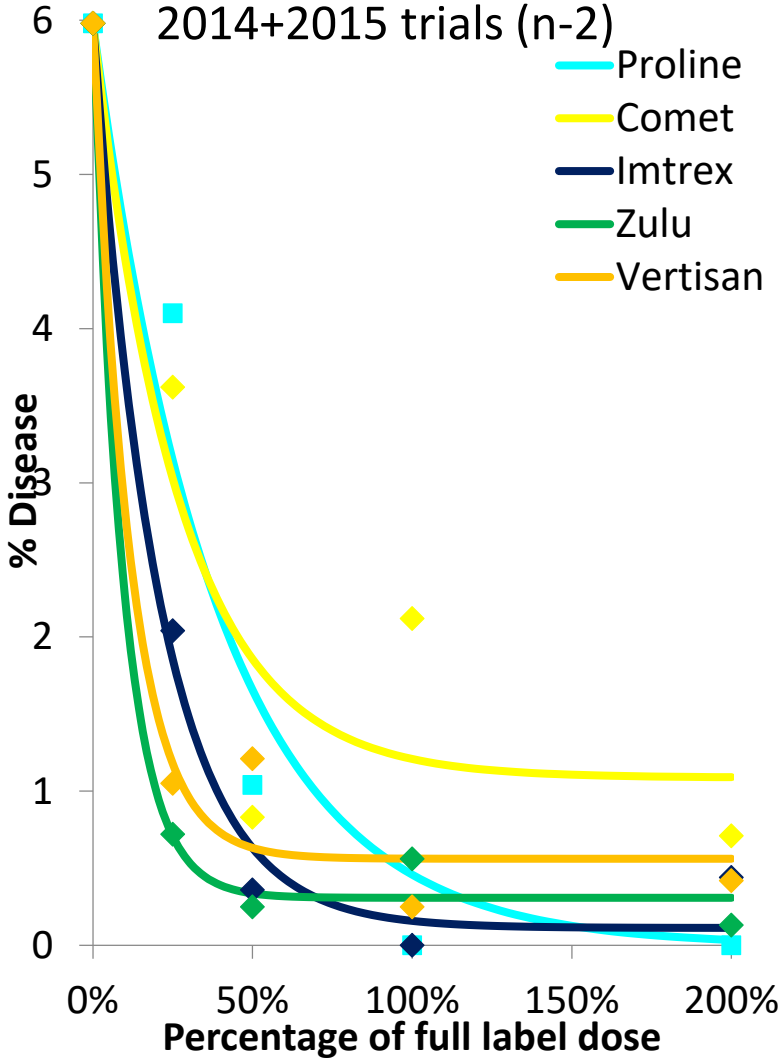


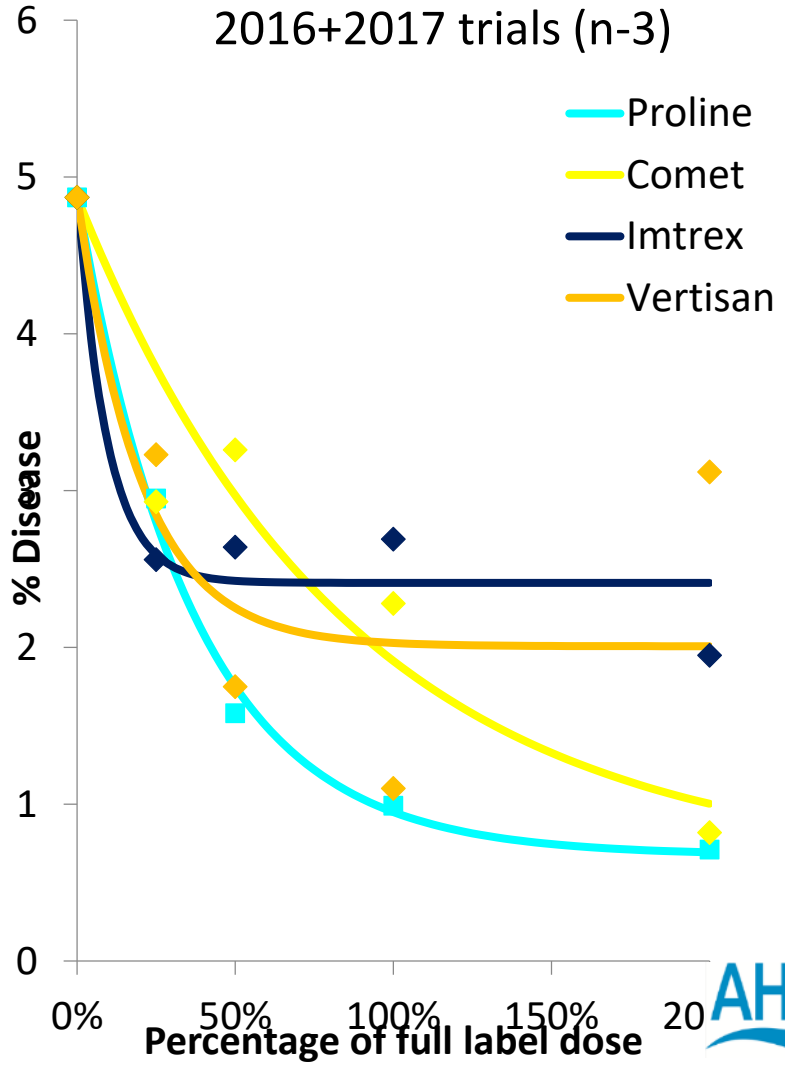


Data based on efficacy of Comet (pyraclostrobin)

Net blotch - changes in efficacy in recent seasons

Mixture products still work well





Ramularia – a lesson in ‘how not to’

- Varieties to date have been weak so reliance on fungicides
- End user (malting) preference for consistency - majority of area often a single variety
- Fungicide resistance developments have changed the game

Ramularia – current advice for UK growers

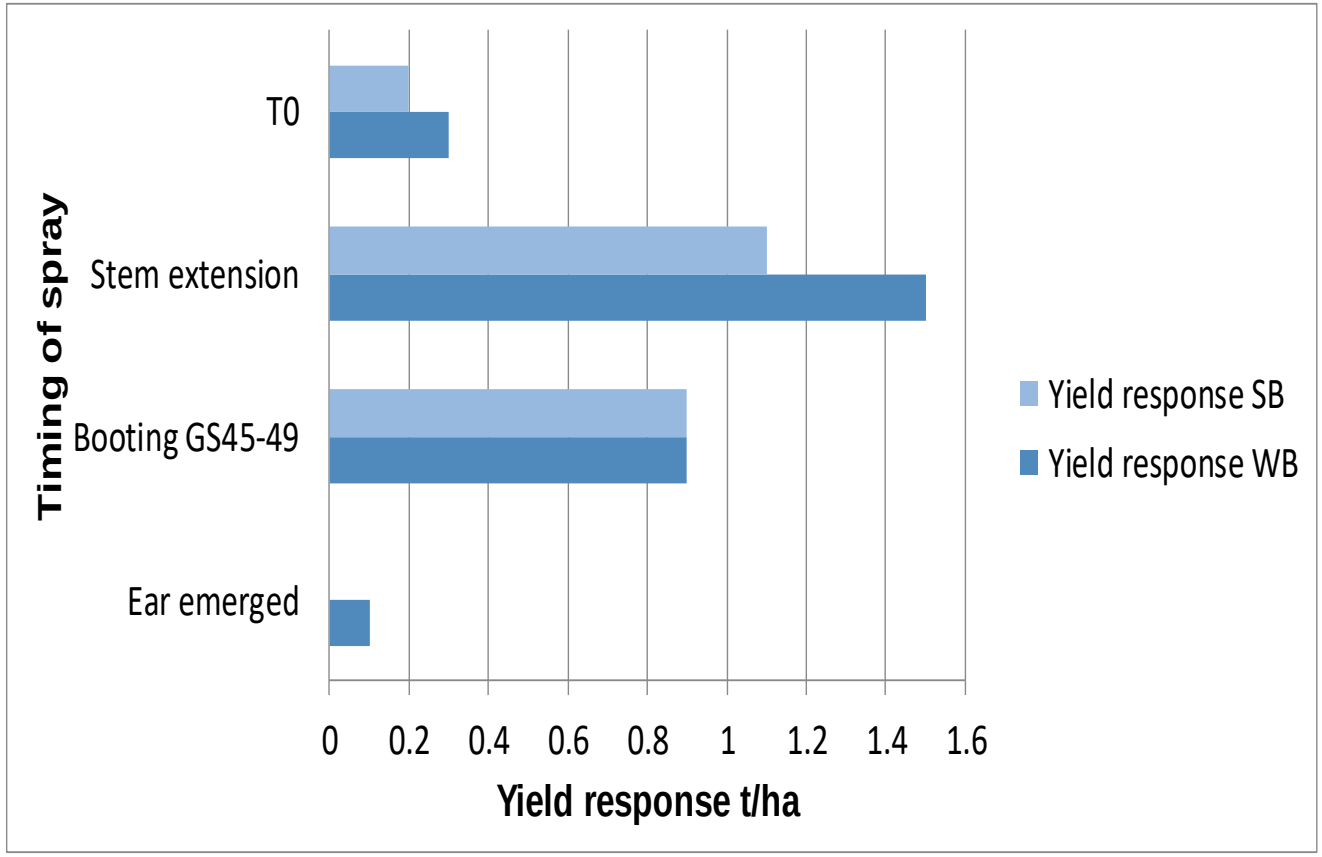
- Varietal ratings for ramularia withdrawn
- Breeding solutions are a longer game
- Use multisite chlorothalonil to manage ramularia risk at T2 (banned in EU from May 2020)
- Minimise crop stresses
- Folpet, biostimulants / micronutrients may play greater role

Advice should be centred on efficient and targeted use

Understanding principles of fungicide use

- Manage crop to maximise grain number and potential grain size
- Early T1 sprays retain healthy tillers hence more ears where disease pressure threatens
- A T2 application at GS49 gives sufficient protection of canopy post-anthesis to ensure grains fill to their storage capacity
- Later sprays don’t yield and could be omitted from recommendations

Optimising timings Yield responses in barley to fungicides



SRUC data 2009 - 2018

Have we learned anything???

- Before launch the base-line sensitivity and normal range determined
- Risk assessment made and resistance management plans put in place and assessed by approving authority
- Mix of statutory and stewardship measures
- Decisions will impact on grower profit and industry return on investment so evidence has to be both robust and pragmatic
- Monitoring part of conditions of approval for higher risk products

Generic anti-resistance strategies

- Follow IPM principles and use pesticides in targeted and sustainable ways
- Make full use of alternatives
- Reduce reliance on fungicides
- Use as little fungicide as necessary to do the job (both dose and number of applications)
- Use balanced mixtures of products
- Alternate products
- Avoid multiple repeat dose programmes
- Utilise low risk fungicides (multisites)

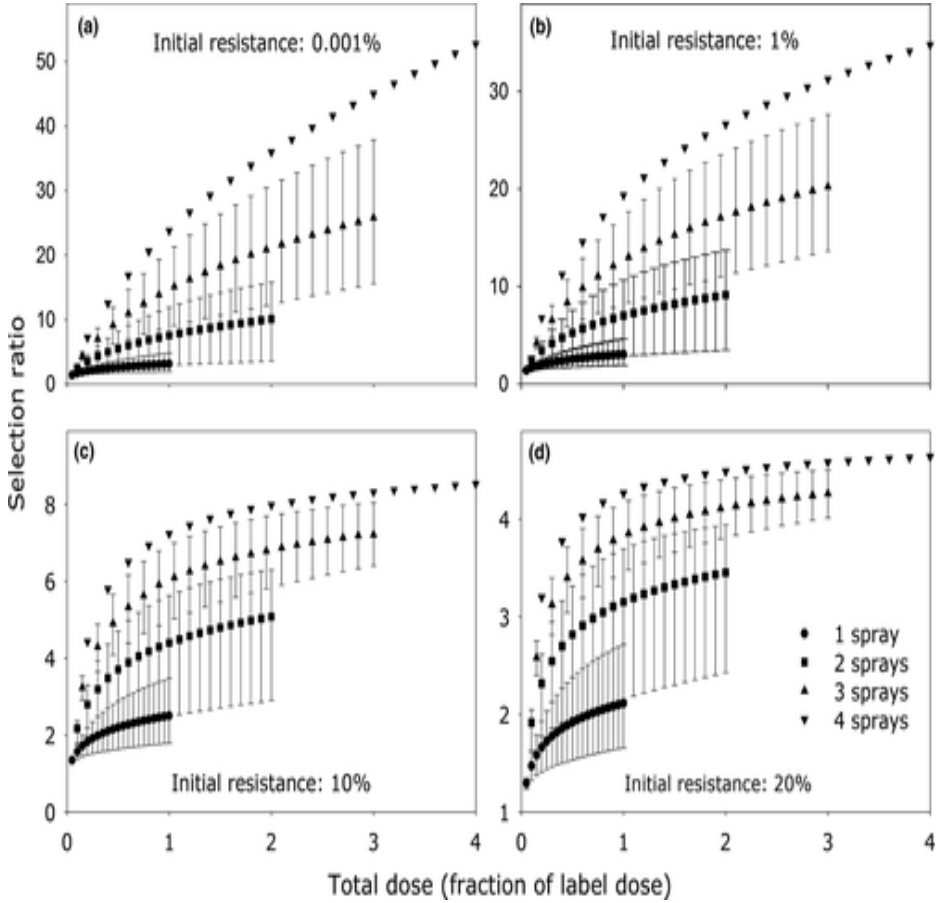
- Difficulties in getting stewardship principles taken up in practice
- Difficulties in motivating industry to take responsibility

What's the evidence?

	Increase selection	No effect	Decrease selection
Increase dose	16	1	2
Increase spray number	6	0	0
Split the dose	10	0	1
Add mixture partner	1	6	46
Alternate (replace sprays)	1	2	9
Adjust timing	3	1	2

van den Bosch et al. 2014 Governing principles can guide resistance management tactics
Annual Review Phytopathology

Dose and number of applications that maximize fungicide effective life - exemplified by Zymoseptoria tritici on wheat

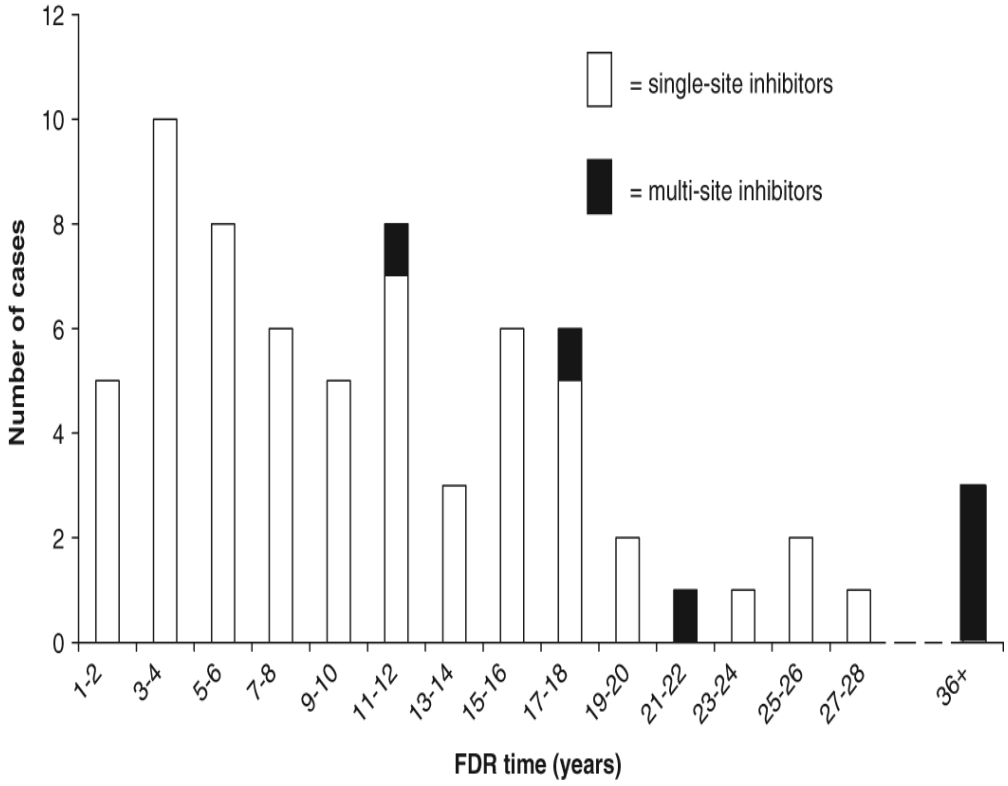


- A model analysis for a fixed number of applications,
- Selection ratio increases with the total dose in the spray programme.
- Selection is greatest at highest total dose

Plant Pathology, Volume: 65, Issue: 8, Pages: 1380-1389, First published: 23 May 2016, DOI: (10.1111/ppa.12558)

Frequency distribution of time from fungicide introduction to first detection of resistance (FDR time) for 67 cases of resistance in plant pathogens in Europe.

Evaluation of a matrix to calculate fungicide resistance risk



Pest Management Science, Volume: 70, Issue: 6, Pages: 1008-1016,
First published: 06 September 2013, DOI: (10.1002/ps.3646)

The effect of mixing a low-risk and a high-risk fungicides on the number of growing seasons before resistance to the high-risk fungicide emerges in a population of M. graminicola on winter wheat.

Dose rate of the low-risk fungicide[d]	Dose rate of the high-risk fungicide[d]									
	10	20	30	40	50	60	70	80	90	100
0	46[e]	21[e]	15[e]	13[e]	11	10	9	9	9	8
10	55[e]	23[e]	17[e]	14	13	11	11	10	10	9
20	65[e]	25[e]	18	14	13	12	11	11	10	9
30	73[e]	27[e]	19	15	13	12	11	11	10	10
40	78[e]	27[e]	19	16	14	13	12	11	11	10
50	78[e]	29[e]	20	16	14	13	12	11	11	10
60	82[e]	29	20	16	14	13	12	11	11	11
70	80[e]	28	20	16	14	13	12	12	11	11
80	81[e]	28	20	16	15	13	12	11	11	11
90	81[e]	28	20	16	14	13	12	12	11	11
100	81[e]	28	19	16	14	14	12	12	11	11

[a]The low-risk fungicide was assumed to be not at-risk of resistance development, but unable to provide sufficient disease control when used alone. The resistant strain was assumed to be completely insensitive to the high-risk fungicide.
[b]The resistant strain was considered to have emerged when the number of resistant lesions reaches or exceeds a threshold (see text).
[c]The emergence times in the table were calculated for the default scenario, which assumes that i) fitness costs of resistance reduce the infection efficiency of the resistant strain by 10%, ii) resistance to the high-risk fungicide is complete and iii) a mutation probability amounting to $1.13 \cdot 10^{-16}$.
[d]Fungicide doses are expressed as a fraction of the label recommended dose.
[e]Combinations of dose rates of the low-risk and high-risk fungicide that do not provide sufficient control of an average epidemic of *M. graminicola* on winter wheat. Effective disease control was defined as a disease-induced loss of healthy leaf area duration during the yield forming period equal to or below 5% [18].
doi:10.1371/journal.pone.0091910.t002

Minimise use of high risk partner and maximise low risk partner

Hobbelen PHF, Paveley ND, van den Bosch F (2014) The Emergence of Resistance to Fungicides. PLOS ONE 9(3): e91910. https://doi.org/10.1371/journal.pone.0091910
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0091910

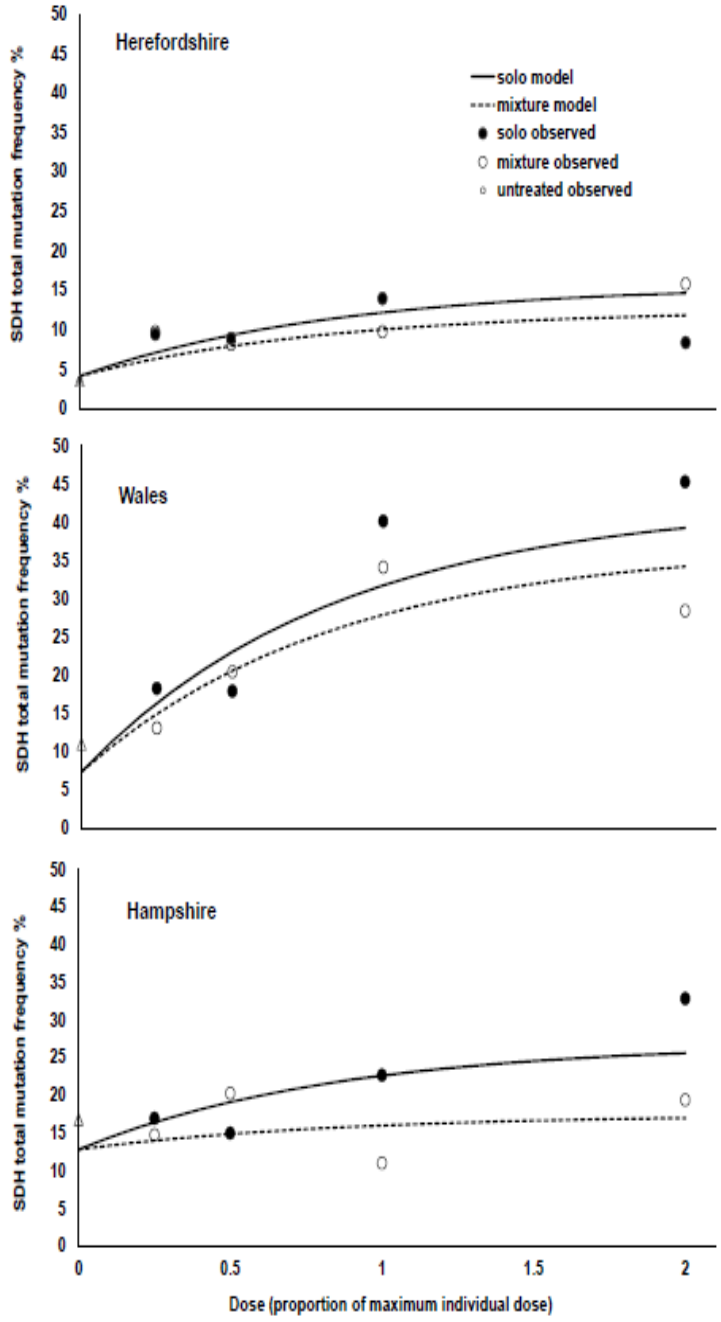
PLOS ONE

Confidence that:-

- Low dose rates of fungicides do not increase risk
- High doses do increase resistance risk
- Increased number of sprays does increase resistance risk

Reducing reliance on individual ai's

- Mixtures and alternations reduce risk



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Focus of current research

…..Stewarding SDHIs and azoles

Advantages and disadvantages of mixing two single-site acting fungicides

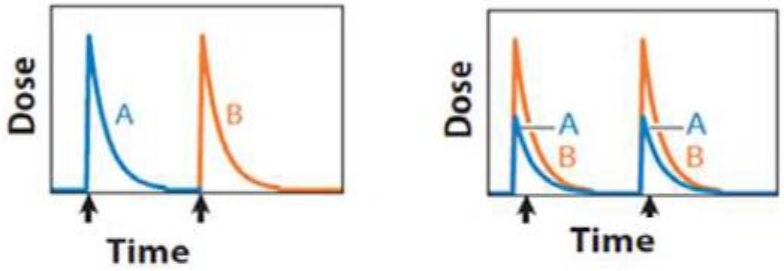
Plant Pathology. Manuscript ID is PP-19-223.

.DMI mutation data, 2012 & 2013, from 'SDHI LINK' project 2010-2013, HGCA 3517, 'Improved tools to rationalise and support stewardship programmes for SDHI fungicides to control cereal diseases in the UK', from sites in Herefordshire and Perth.

.SDH mutation data, 2016, from AHDB fungicide performance trials sited in Herefordshire, Cardigan and Hampshire.

Gaps in knowledge

Mix or alternate?



Why choose – do both!

Mixtures compared to alternation ..... selection			
reduce	No-difference	increase	Total
4	1	2	7

van den Bosch *et al*. 2014. *Annual Review Phytopathology*

Known Unknown: Protectant vis curative

- Fungicide resistance guidelines previously discouraged curative / eradicant use. Logic is if you are treating a large population you are likely to have many survivors that may be less sensitive.

- But this is unproven – a very small population with one fit survivor which could multiply rapidly is likely to be equally dangerous

- But pragmatically, protectant use offers you more choice of fungicides so is likely to be useful for that reason.

How will we retain efficacy in new and existing chemistry?

- Maximise use of low risk (multisite) fungicides as mixture partners
- Use minimum effective doses and balanced mixtures
- Limit use and alternate where possible
- If multiple applications of single-site fungicides are needed:-
- Limiting number of treatments of a MoA is a simple, practical message
- But may be unnecessarily restrictive or counterproductive (i.e. for multisites)
- Limiting by total dose may be effective and allow more flexibility
- Experimental evidence being obtained

AHDB Project No 21120058‘Managing resistance evolving concurrently against two or more modes of action, to extend the effective life of new fungicides’

Opportunities to improve:-

- Only a few major pests and diseases of major crops get any attention
- A reliance on industry supplied data on resistance issues
- No full consideration of resistance risk when products are withdrawn
- Less than ideal ‘coping’ mechanisms such as twin packs to get round difficulties in registering mixture products
- Launch of high risk actives as straights
- Little research on behaviours and attitudes to stewardship
- RAG guidance groups useful forums but have no formal funding
- A lack of biological data to inform models

Challenges of implementing advice

- Loss of active substances is a primary concern in having tools available to manage current and emerging resistance – evidence-based decision-making is vital.

- A major barrier is still uptake of existing knowledge and behaviour change.
- Gaps in knowledge, complex science, limited evidence, mixed messages – coordination and consensus needed
- Limited pipeline of new pesticides and pressures on existing actives – policy advice and coordination
- Alternative approaches and non-chemical solutions are needed
- IPM is challenging and research is often under funded

What can help our decisions?

- Best practice advice not followed
- Anti-resistance advice is not getting through to all parts of the industry

- More information?
- More engagement?
- More specific practical information?
- Simpler messages?
- Higher profile?
- Fewer mixed messages?

SRUC AHDB CEREALS & OILSEEDS

More practical messages and higher profile?

Fungicide Futures – supported by AHDB

- Combine anti-resistance management information, developed and published by FRAG-UK, with the power of AHDB's communications channels
- Stronger anti-resistance advice and consistent messages
- Focus on converting anti-resistance science into on-farm practice
- Putting anti-resistance at the heart of fungicide programme planning futures
- Messages timed with key growth stages
- Published on the AHDB website at cereals.ahdb.org.uk/fungicidefutures

Opportunity: Understand barriers to uptake

Co-construct anti-resistance strategies

Perception	Acceptable options
Increased uptake of IPM too complex	Increased varietal resistance React to weather, tillage and sow date
Not economic to reduce inputs	Keep inputs high but use mixtures and alternations Reduce use of marginal T0, T1.5 and T4 sprays Reduce use of high risk fungicides Increase use of lower risk / multisites
Fungicide resistance not important / not my problem	Label guidance Label requirements Statutory measures Public good for public money

Protecting products

- Do everything to reduce risk….rotation, variety, certified seed, sow date, monitoring, surveillance, crop walking, tailored sprays
- Value varietal resistance
- Don’t play fast and loose with new tools
- Take the risk of resistance in existing chemistry seriously
- Stick to guidelines and, obviously, to statutory limits

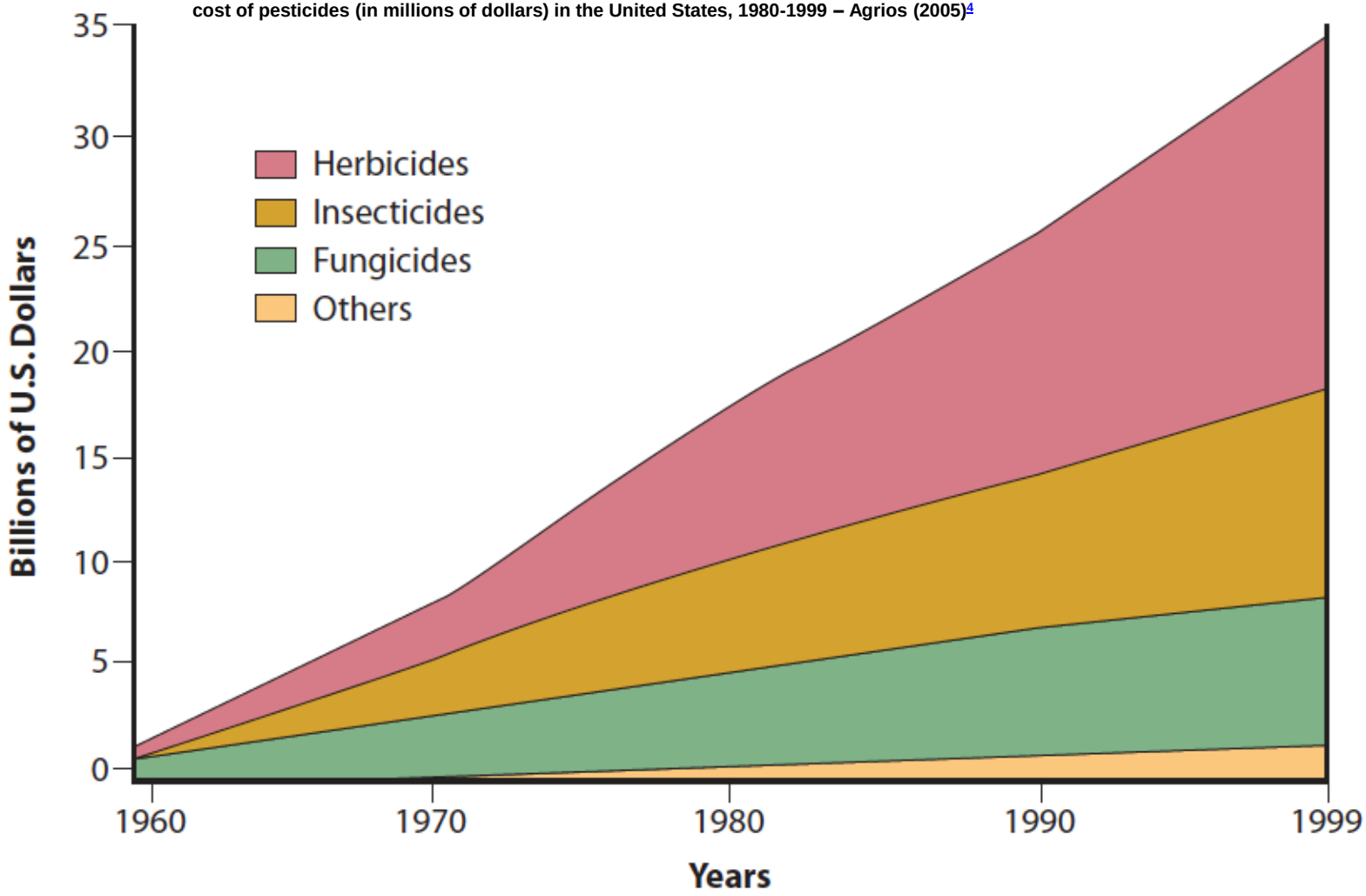
- Keep abreast of developments and follow the best technical advice
- Everyone wants new twists and clever pitches but this can leave individuals dangerously exposed and puts our whole industry at risk …. there are genuine win: wins.

Potential loss of pesticides – likely impacts

- Best case scenario
  - Cereals, oilseeds, potatoes – relatively unscathed
  - Edible and ornamental horticulture sector badly hit
- Worst case scenario
  - Cereals, oilseeds, potatoes – significant impact
  - Edible and ornamental horticulture sector severely affected
- Increased reliance on ‘alternatives’ to pesticides – IPM
- 5-8 years to develop alternative technologies

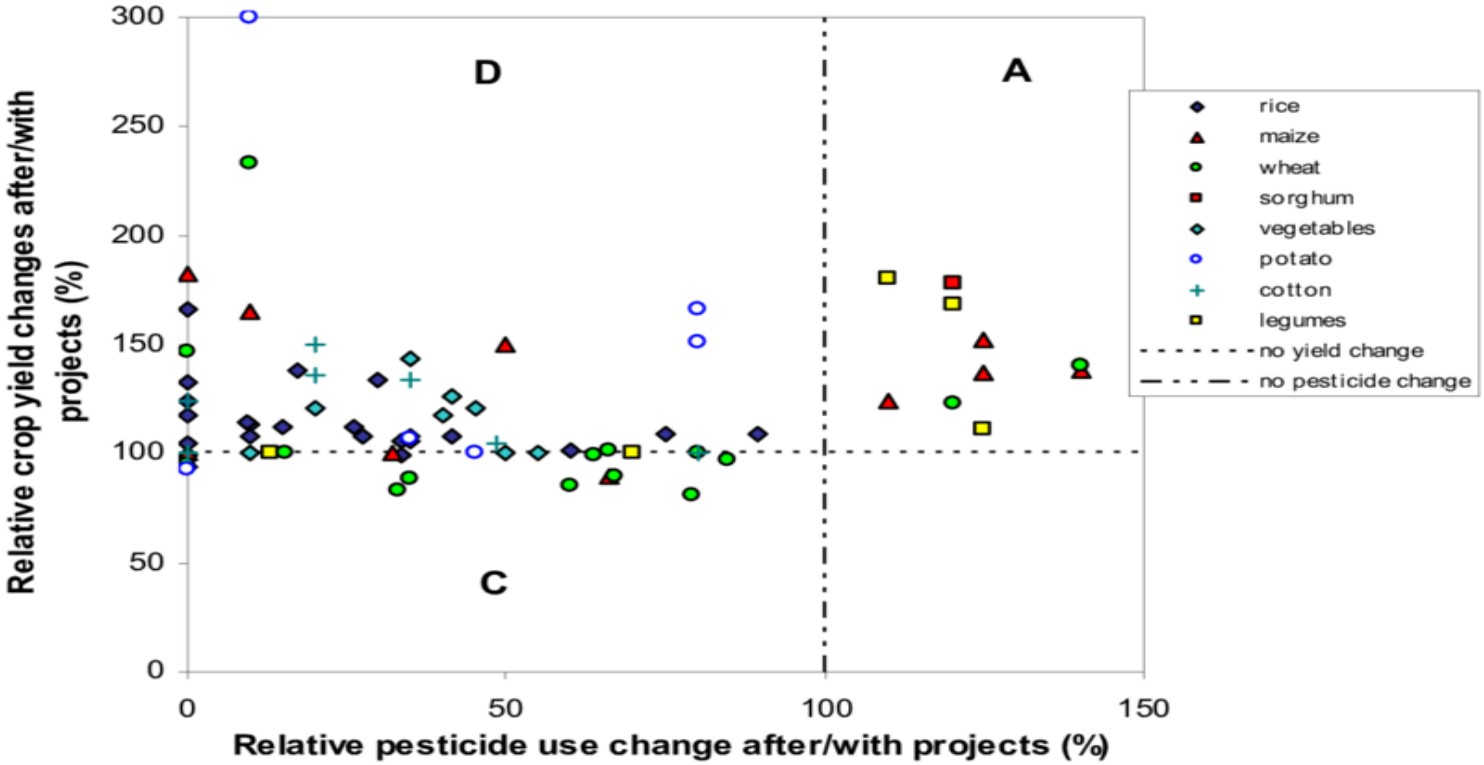
Pesticides aren’t the only answer

Annual usage of the various types of pesticides (in millions of pounds of active ingredient) and annual cost of pesticides (in millions of dollars) in the United States, 1980-1999 – Agrios (2005)[4]



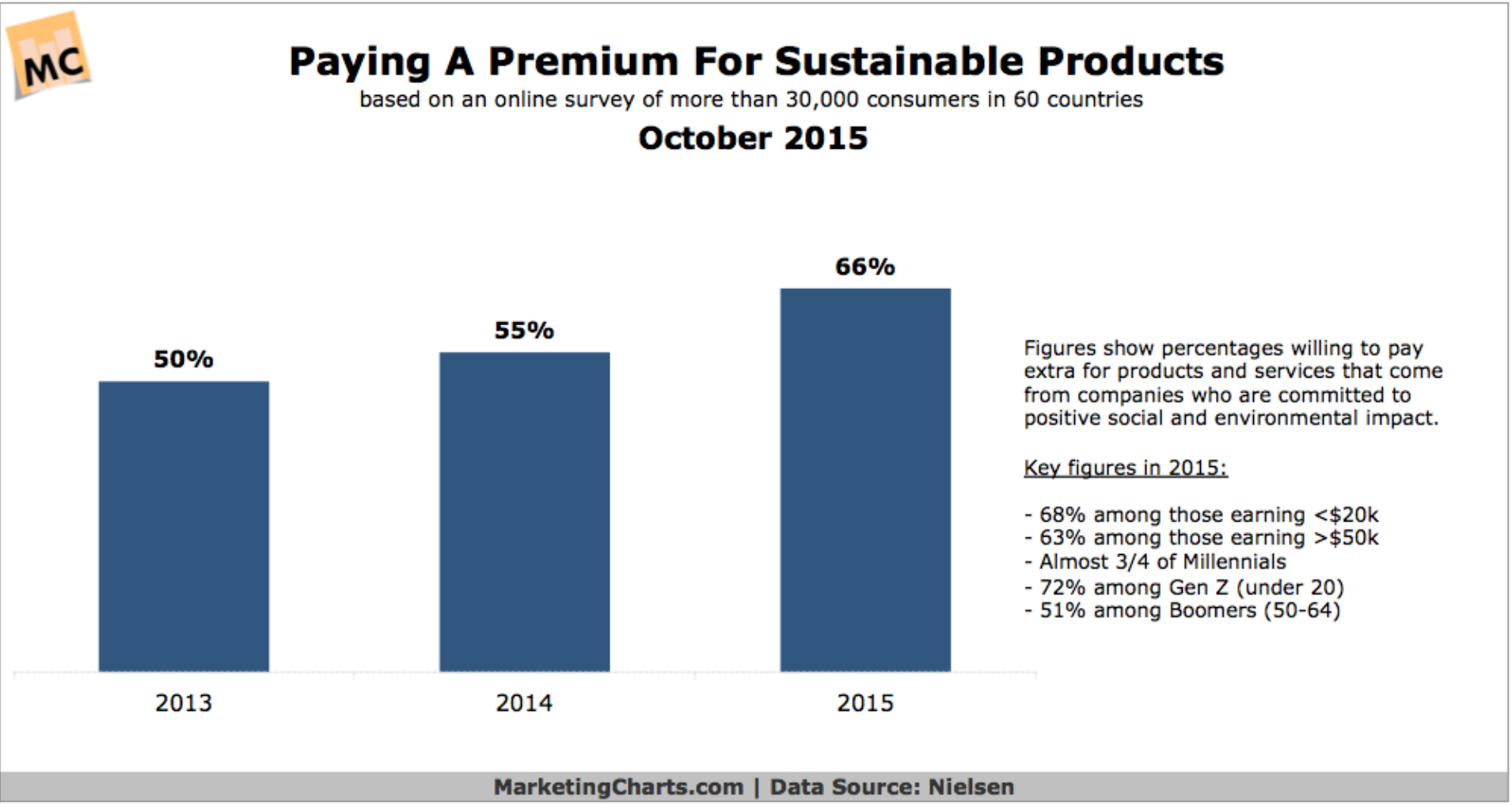
Maybe we aren't as reliant as we think…

i both pesticide use and yields increase (A);
ii. pesticide use increases but yields decline (B);
iii. both pesticide use and yields fall (C);
iv. pesticide use declines, but yields increase (D).



Association between pesticide use and crop yields (data from 80 crop combinations, 62 projects, 26 countries) Jules Petty – U of Exeter

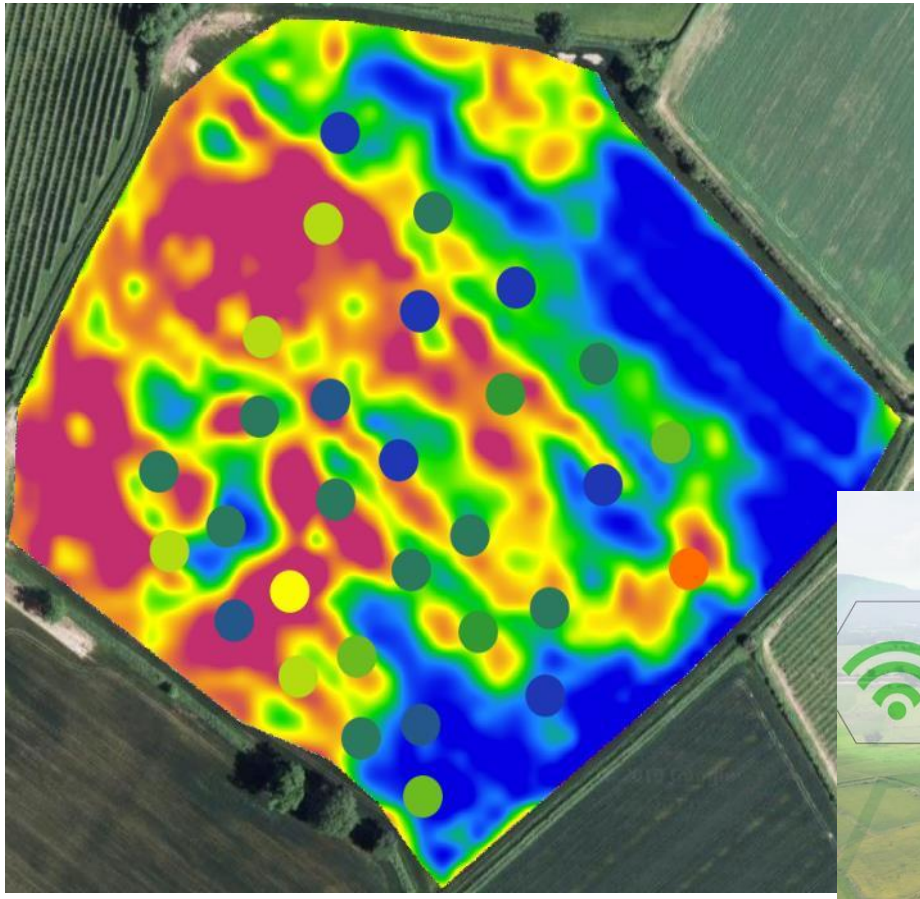
Changing demographics



Challenges are real but don’t be afraid….

- Huge innovations
- Massive potential in new technologies and information handling
- Faster breeding pipeline
- Untapped potential in classic IPM
- Smarter use of alternatives
- High potential in quality markets and premiums for sustainable produce
- Farmers have always innovated and succeeded

New technologies



Some solutions more acceptable than others

- Prepare for change
- Understand public perceptions
- Win:wins in smarter, more targeted crop protection
- Industry needs to play the long game
- Balance sustainability and profit

Thank you