

Exploring BYDV variation across the UK for improved knowledge and diagnostics



Department
for Environment
Food & Rural Affairs

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Rothamsted Research (RRes)
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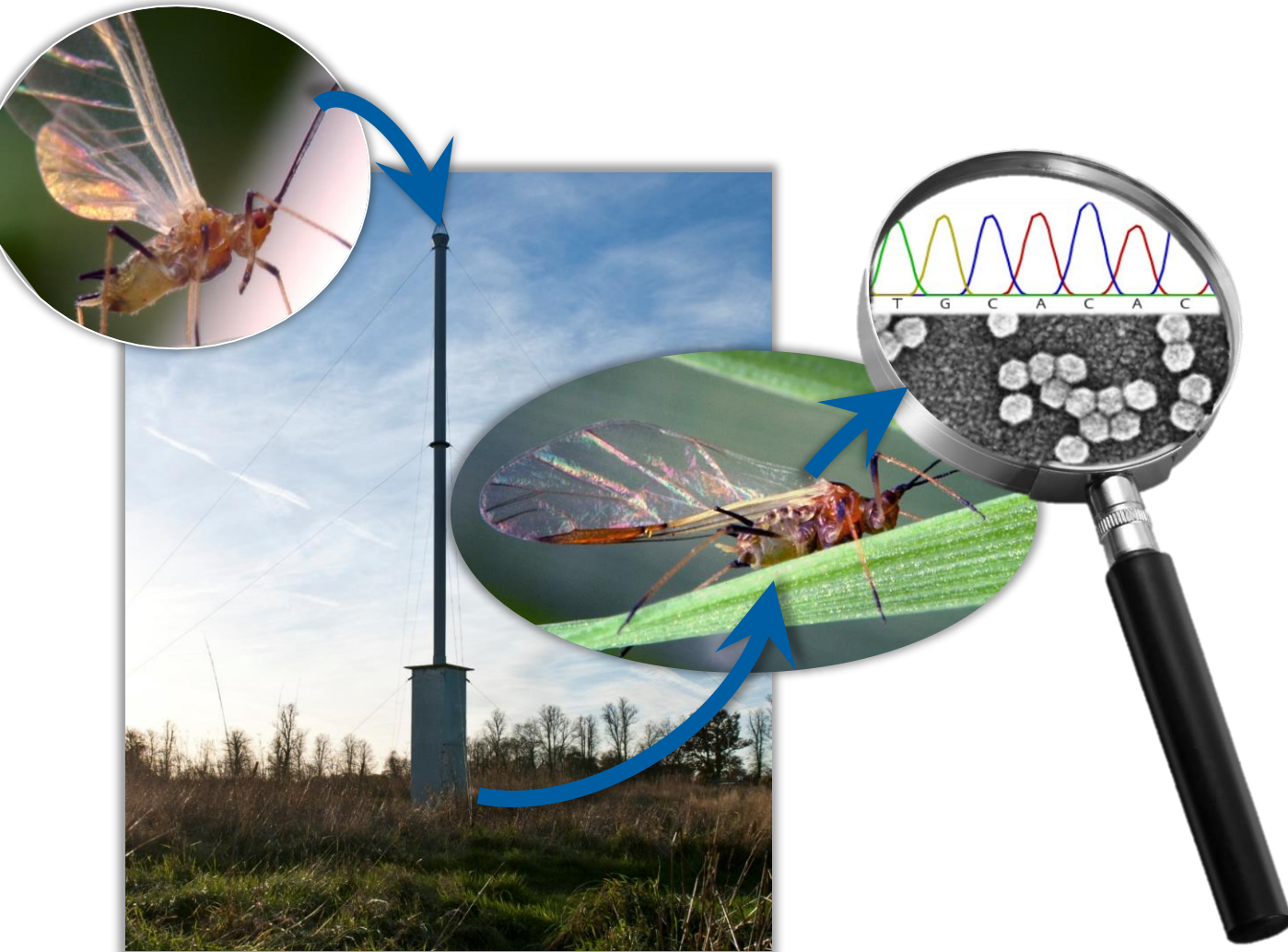
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Overview

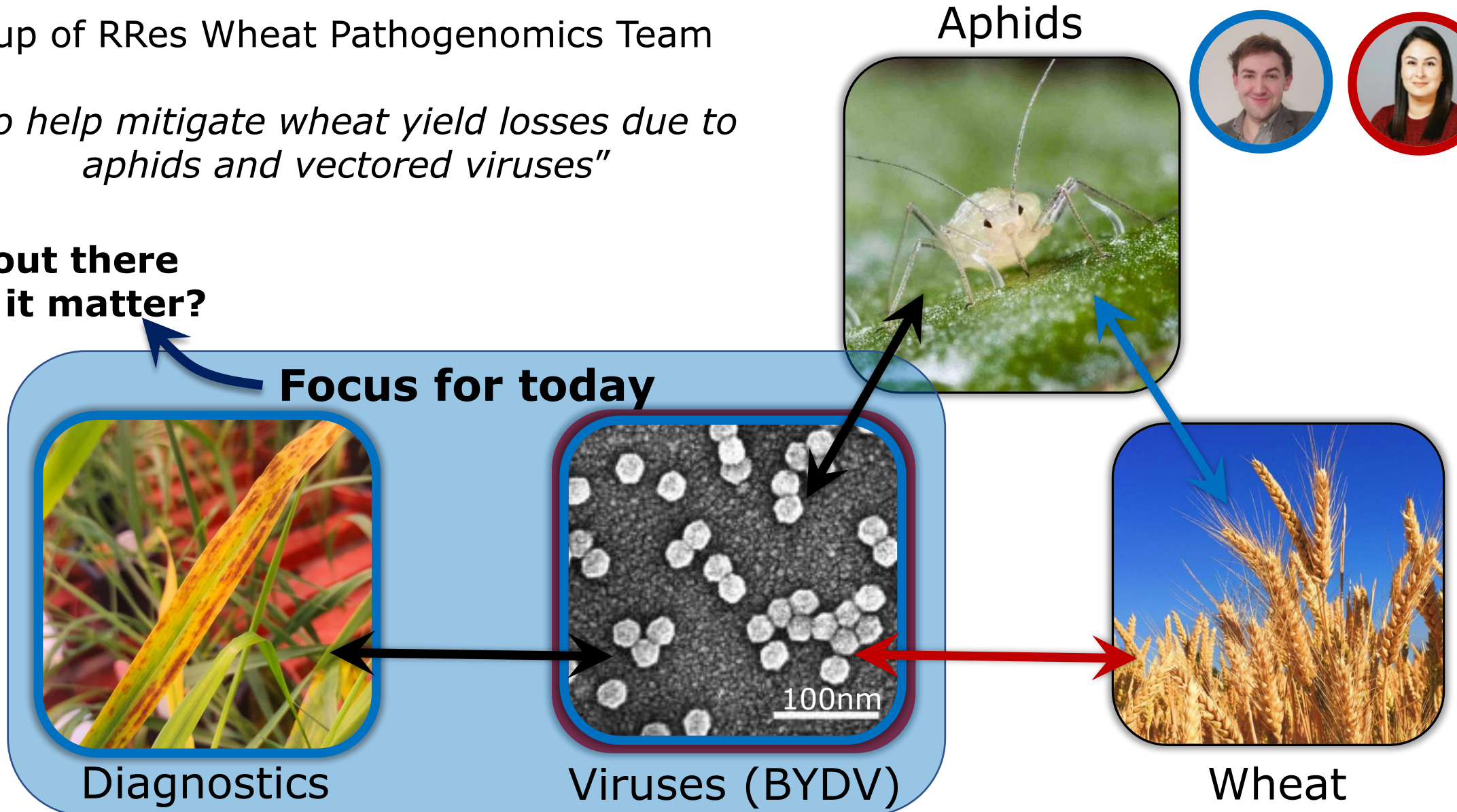


- Wheat-aphid-virus interactions subgroup
- Barley yellow dwarf virus (BYDV)
- Sampling for UK variants
- BYDV strain distribution
- UK BYDV assay development

Wheat-aphid-virus interactions

- Subgroup of RRes Wheat Pathogenomics Team
- Aim: *"to help mitigate wheat yield losses due to aphids and vectored viruses"*

**What's out there
and does it matter?**



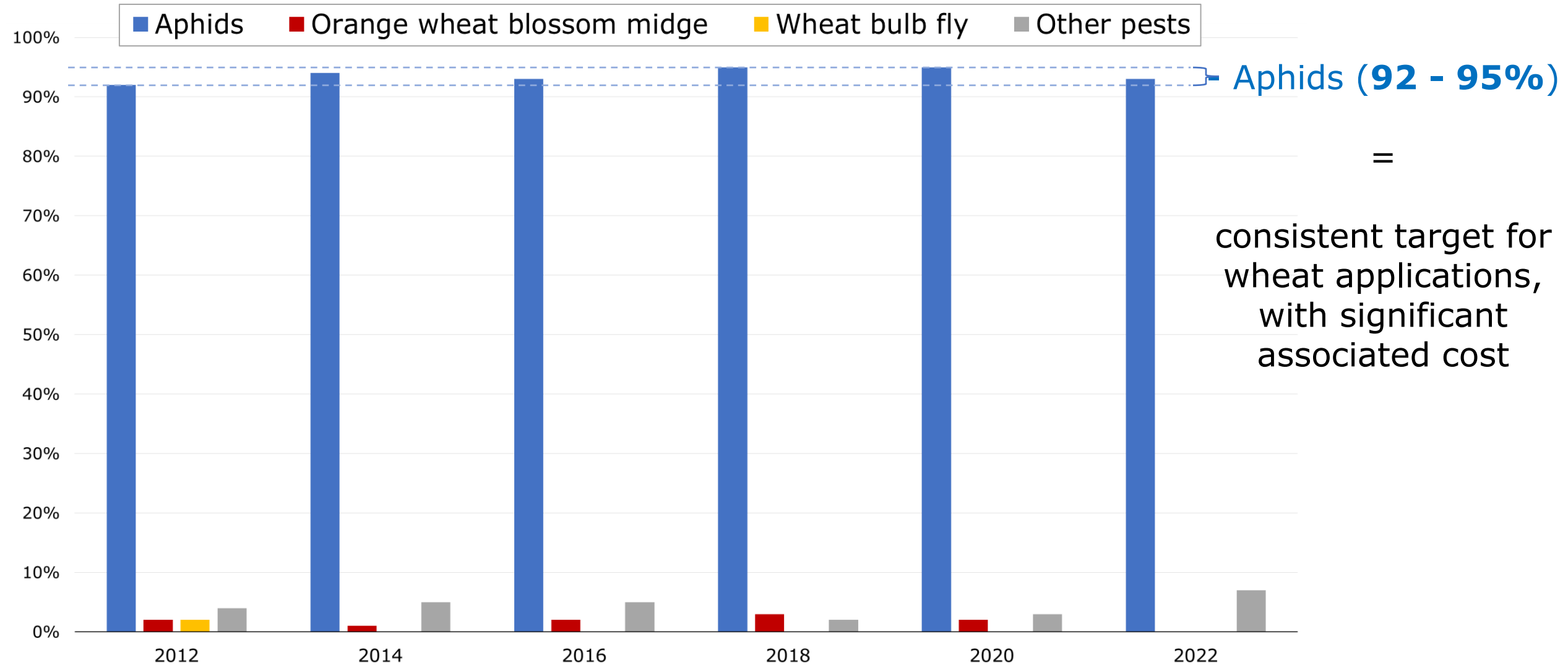
Barley yellow dwarf virus

- Harvest yield loss in wheat due to natural BYDV infection = **5 - 80%**, average of **30%***
- Indistinct disease phenotypes limits rapid diagnosis
- No practical virus-focussed chemical control
- Aphid vectors targeted, and BYDV-resistant cultivars developed



Aphids = key insecticide target

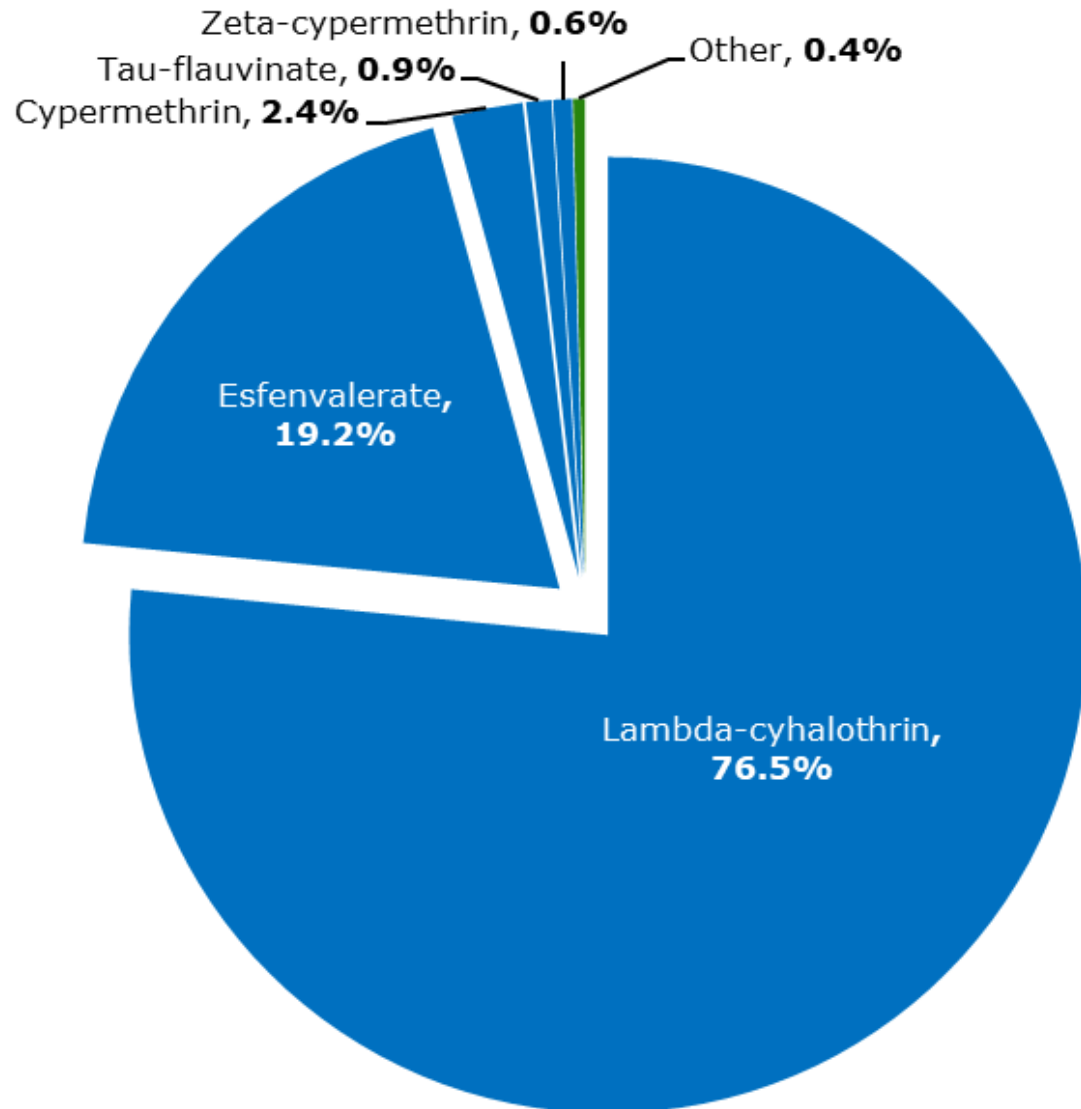
Insect targets, where stated, for foliar insecticide application(s) to wheat*:





*UK Pesticide Usage Survey Reports: 250, 263, 271, 284, 295 & 309

Aphids = key insecticide target

Main foliar insecticide AI formulations (most recent data available, 2022¹):



-  - Pyrethroid-based active ingredient (AI)
-  - Other

- Moderate pyrethroid resistance widespread across UK *Sitobion avenae*
- Evidence of pyrethroid tolerance in *Rhopalosiphum padi* in Ireland²

¹Ridley et al., (2023) UK Pesticide Usage Survey Report 309

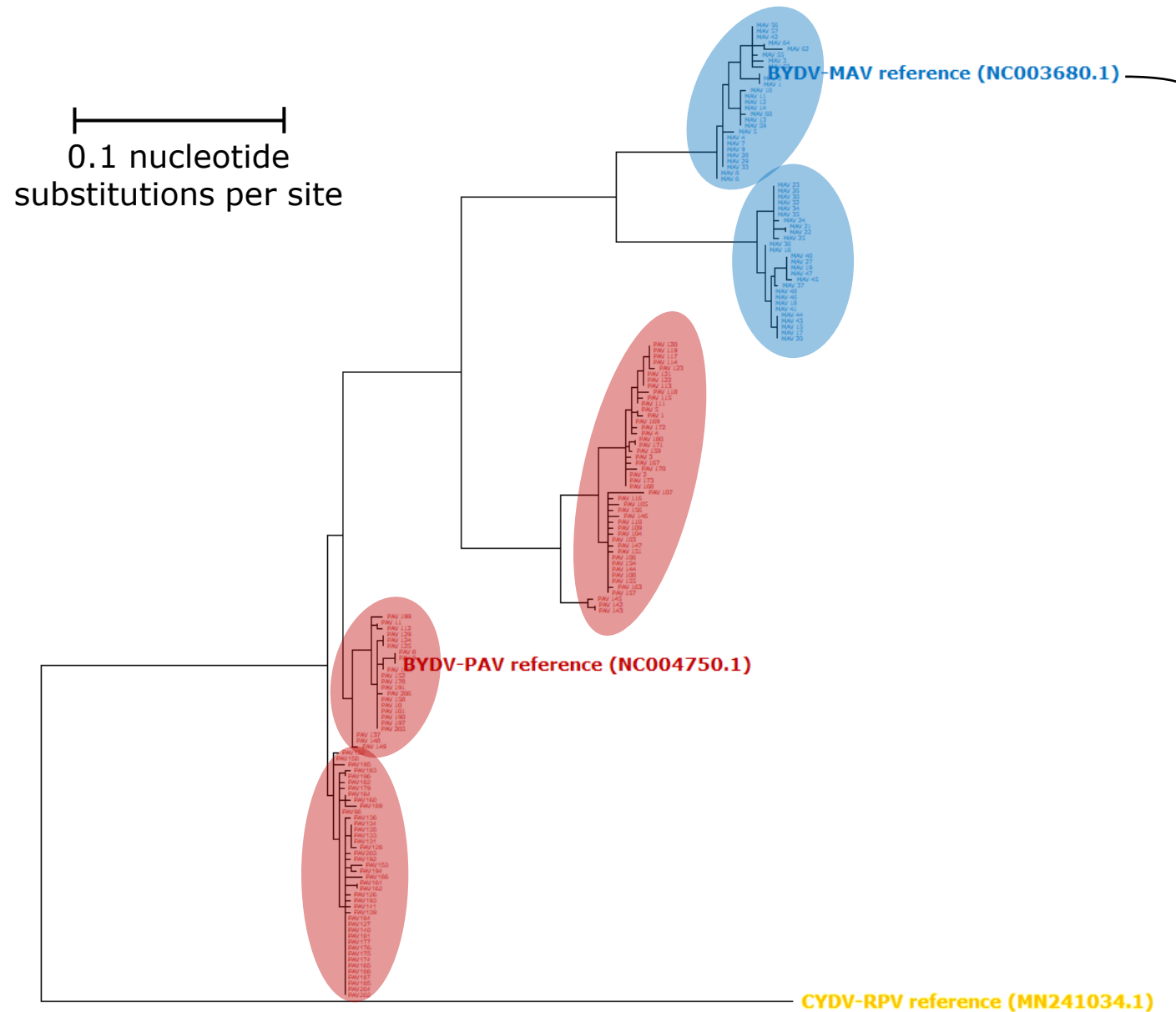
²Walsh et al., (2020). *Outlooks on Pest Management*, 31, 5-9

Challenges

- **Limited UK-specific BYDV sequencing data**
- **Diagnostics not strictly designed for UK variants**
 - potential for misdiagnosis
- **No established baseline for strain variation**
 - perhaps fundamental for monitoring resistance-breaking



Global BYDV strain variation



- Strains **BYDV-MAV** and **BYDV-PAV** considered most impactful for UK

- Global **MAV** and **PAV** diversity, based on subset of NCBI data

- Substrain variation suggested on global scale

- **Molecular BYDV diagnostics often based on limited data**

BYDV-MAV sequences from NCBI, n = 53

BYDV-PAV sequences from NCBI, n = 110

NCBI, National Centre for Biotechnology Information

UK aphid vectors of BYDV



Two main species
efficiently transmit
various strains of
BYDV across the UK



Rhopalosiphum padi
bird cherry-oat aphid



Sitobion avenae
English grain aphid

Yellow dwarf virus strains

Genus	Species	Strain	Known aphid vectors*
Luteovirus	BYDV	PAV	<i>R. padi</i> , <i>S. avenae</i> , <i>Metapolophium dirhodum</i> , <i>Schizaphis graminum</i> , <i>Sitobion fragariae</i>
		MAV	<i>S. avenae</i> , <i>M. dirhodum</i> , <i>R. padi</i> , <i>S. fragariae</i>
		PAS	<i>Rhopalosiphum maidis</i>
		GAV	<i>Scizaphis graminum</i> , <i>S. avenae</i>
Polerovirus	CYDV	RPV	<i>R. padi</i> , <i>S. graminum</i>



Rhopalosiphum padi
bird cherry-oat aphid



Sitobion avenae
English grain aphid

*Aradottir & Crespo-Herrera (2021). *Current Opinion in Insect Science.*, 45, 59-68

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Rhopalosiphum padi
bird cherry-oat aphid



Sitobion avenae
English grain aphid

Previously unreported and confirmed by recent work

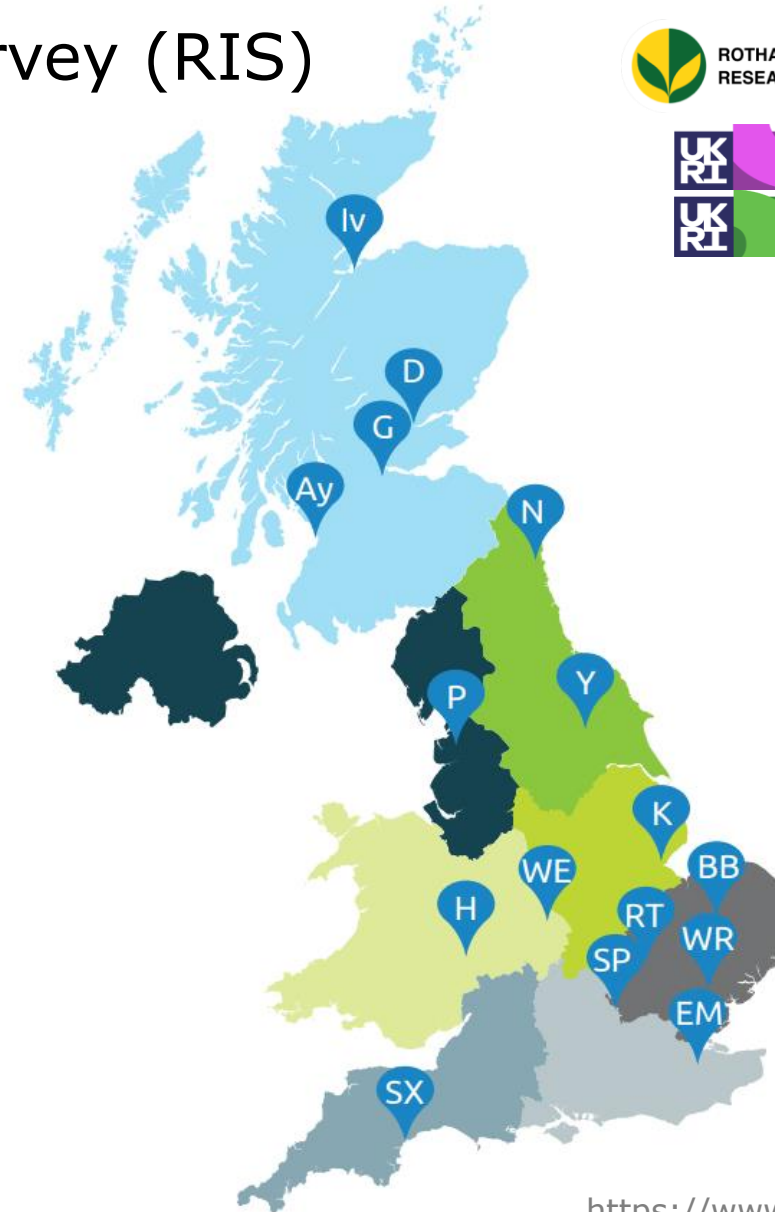
*Aradottir & Crespo-Herrera (2021). *Current Opinion in Insect Science.*, 45, 59-68

What's in the UK?

- Nationwide Rothamsted insect survey (RIS)
- Started in 1964



Suction traps (12.2m)



- Iv - Inverness
- D - Dundee
- G - Gogarbank
- Ay - Ayr
- N - Newcastle
- P - Preston
- Y - York
- K - Kirton
- We - Wellesbourne
- BB - Broomsbarn
- H - Hereford
- RT - Rothamsted
- SP - Silwood park
- Wr - Writtle
- EM - East Malling
- SX - Starcross

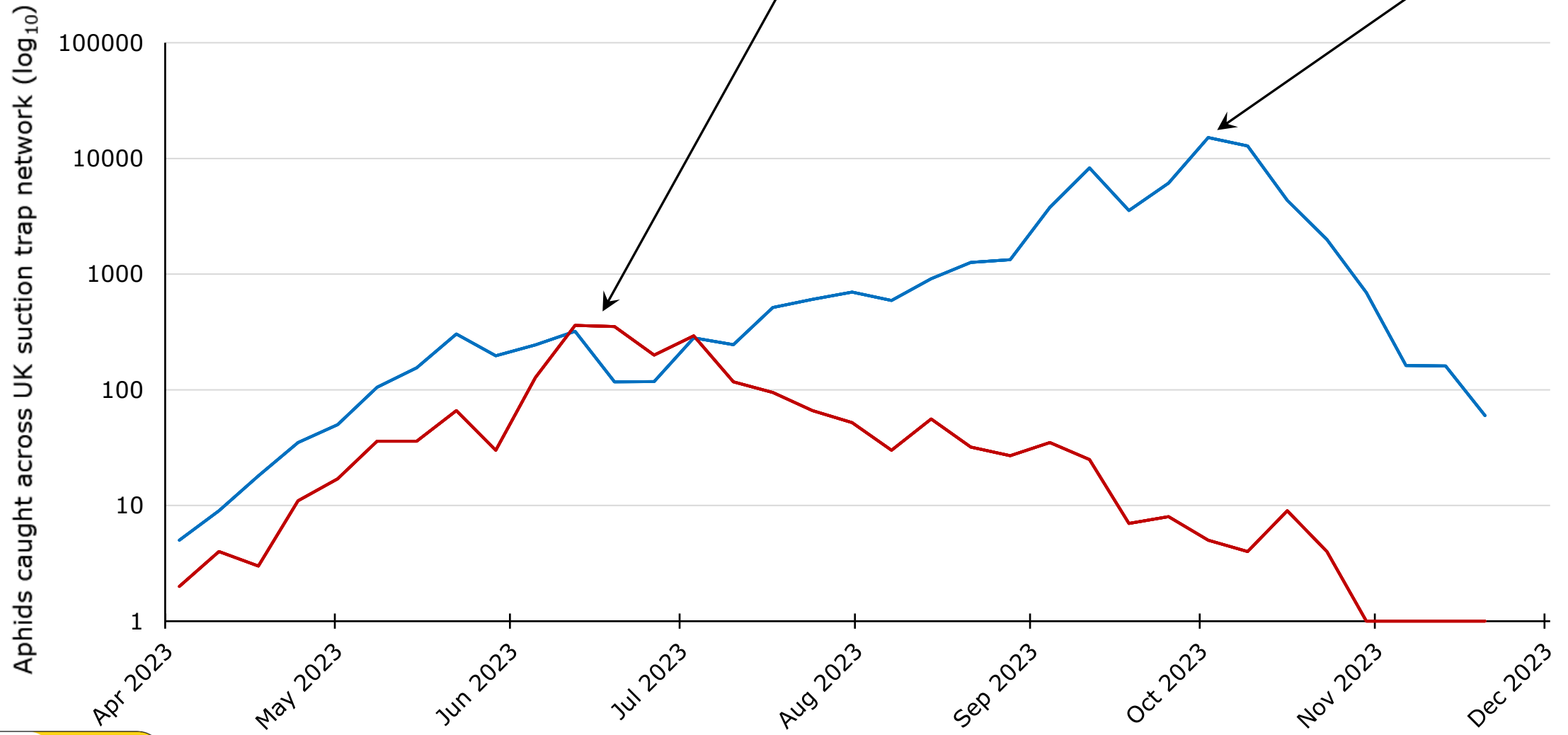




UK aphid pressure (2023)

S. avenae, peak n = 353

R. padi, peak n = 15,144



Routine BYDV detection



- BYDV consistently detected UK-wide

*

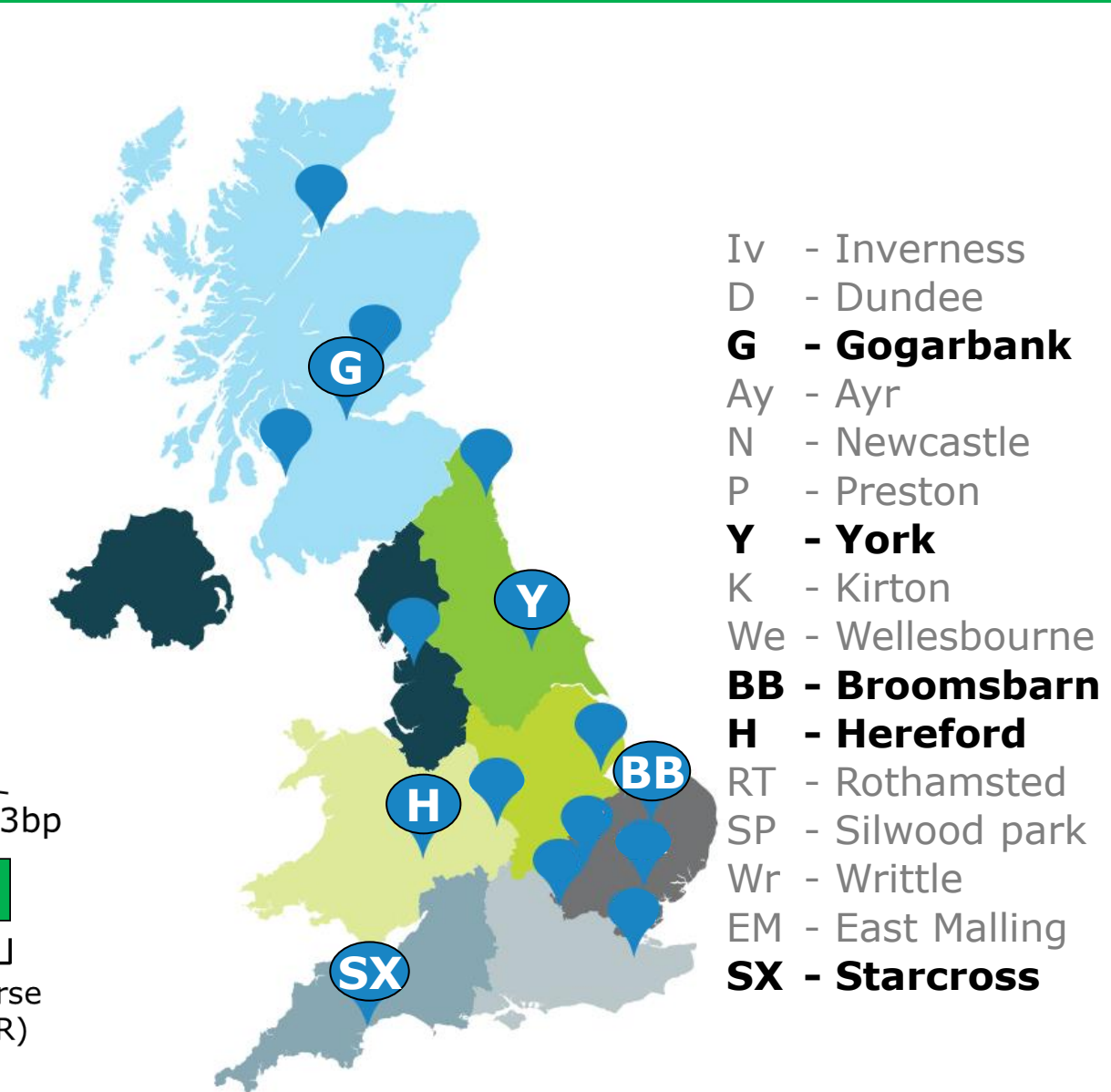
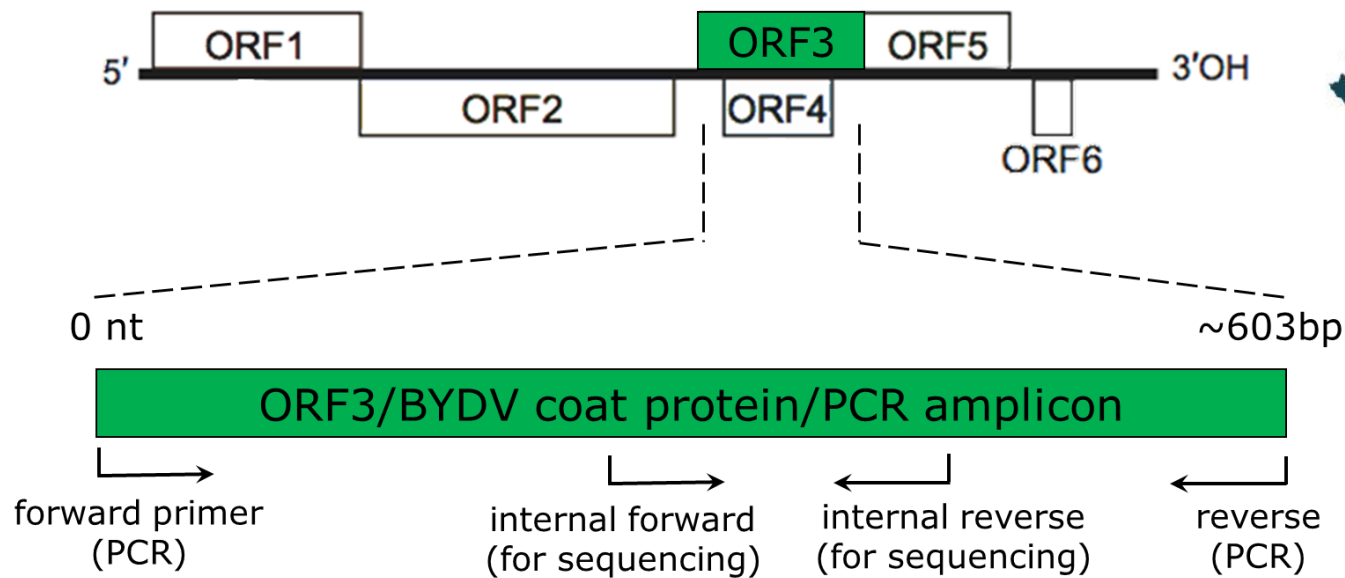
Year	<i>R. padi</i> carrying BYDV/total <i>R. padi</i> tested (%)	<i>S. avenae</i> carrying BYDV/total <i>S. avenae</i> tested (%)
2020	329/1509 (22%)	77/252 (31%)
2021	231/1342 (17%)	34/224 (15%)
2022	128/980 (13%)	20/108 (19%)
2023	147/920 (16%)	29/88 (33%)

- Highest incidence = 46% *S. avenae*, late July 2020

- lowest incidence = 5% *S. avenae*, early Aug 2021

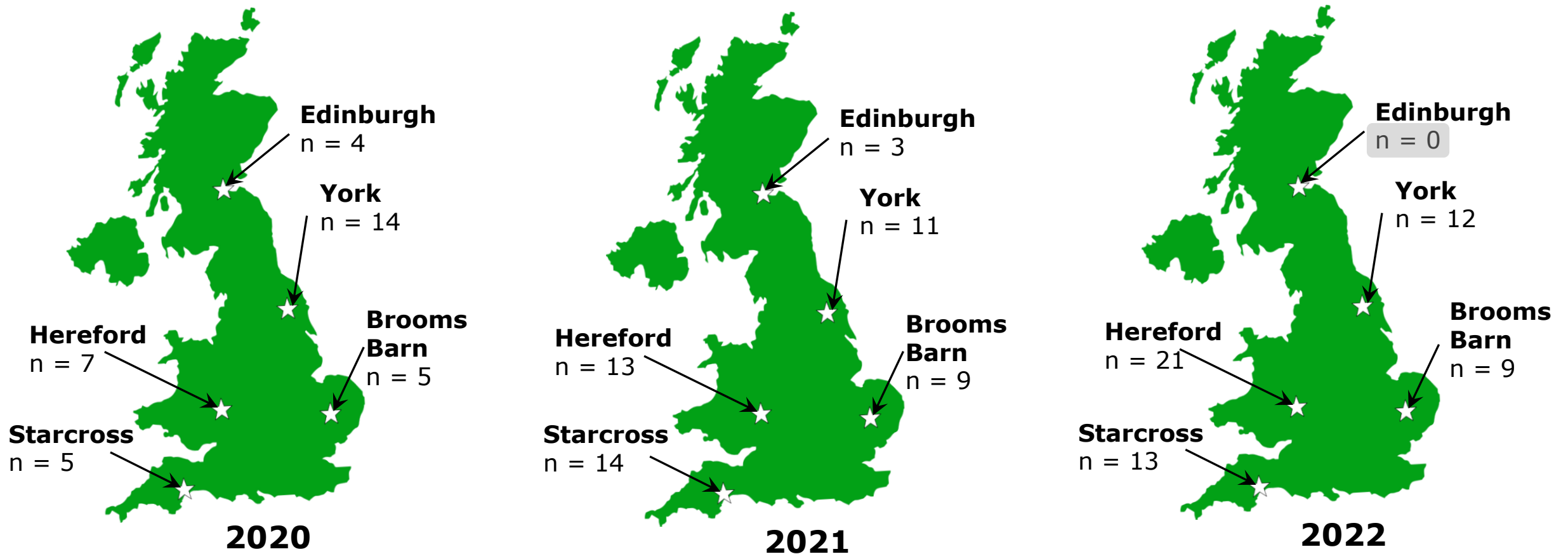
What's in the UK?

- BYDV strain variation explored across the UK (5 sites) over 2020, 2021, 2022 & 2023
- Partial BYDV genome sequencing performed from individual aphids:

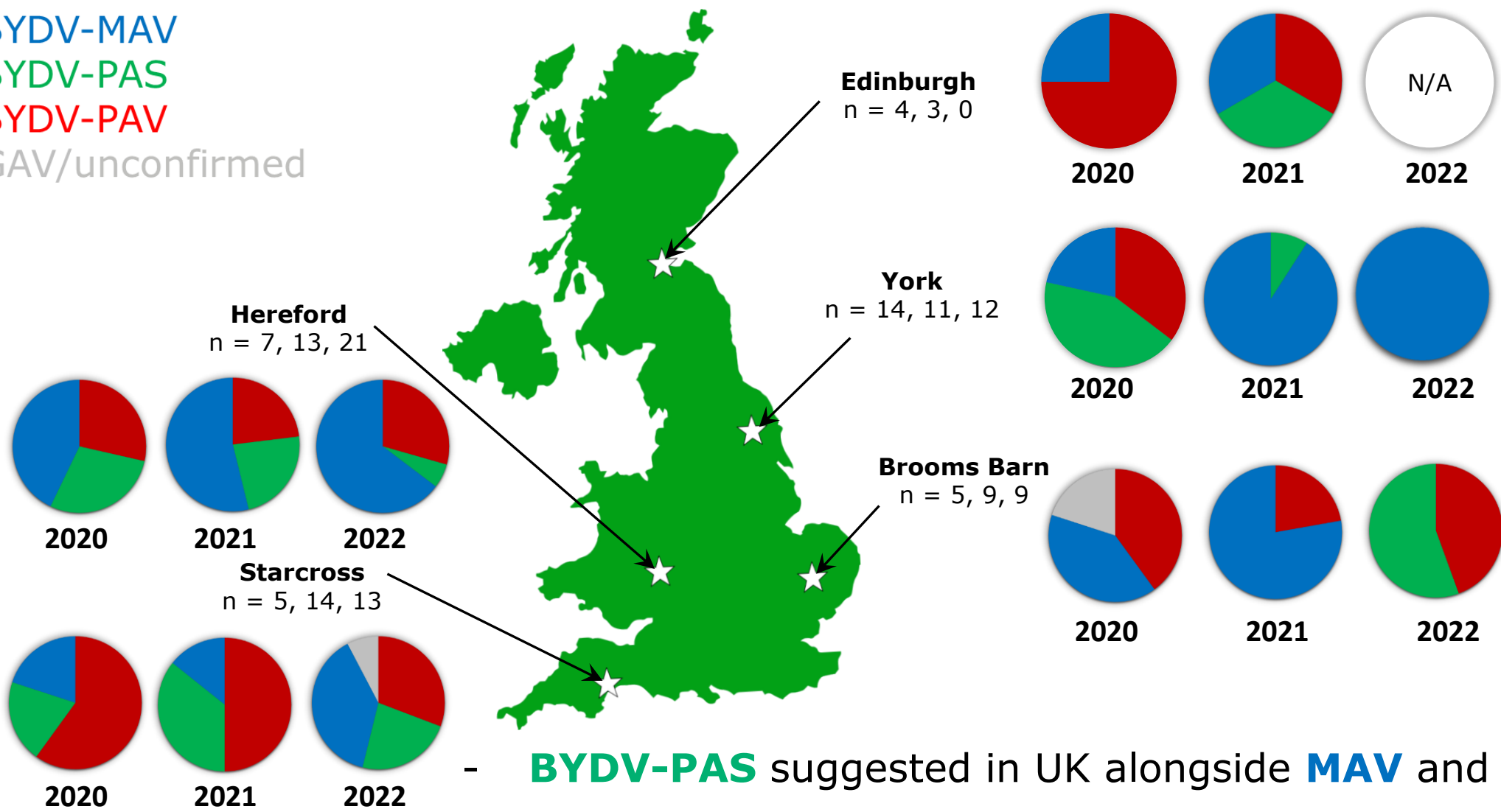


What's in the UK?

- >140 BYDV^{+ve} *R. padi* and *S. avenae* aphid samples processed
- Reasonable distribution across UK sampling sites



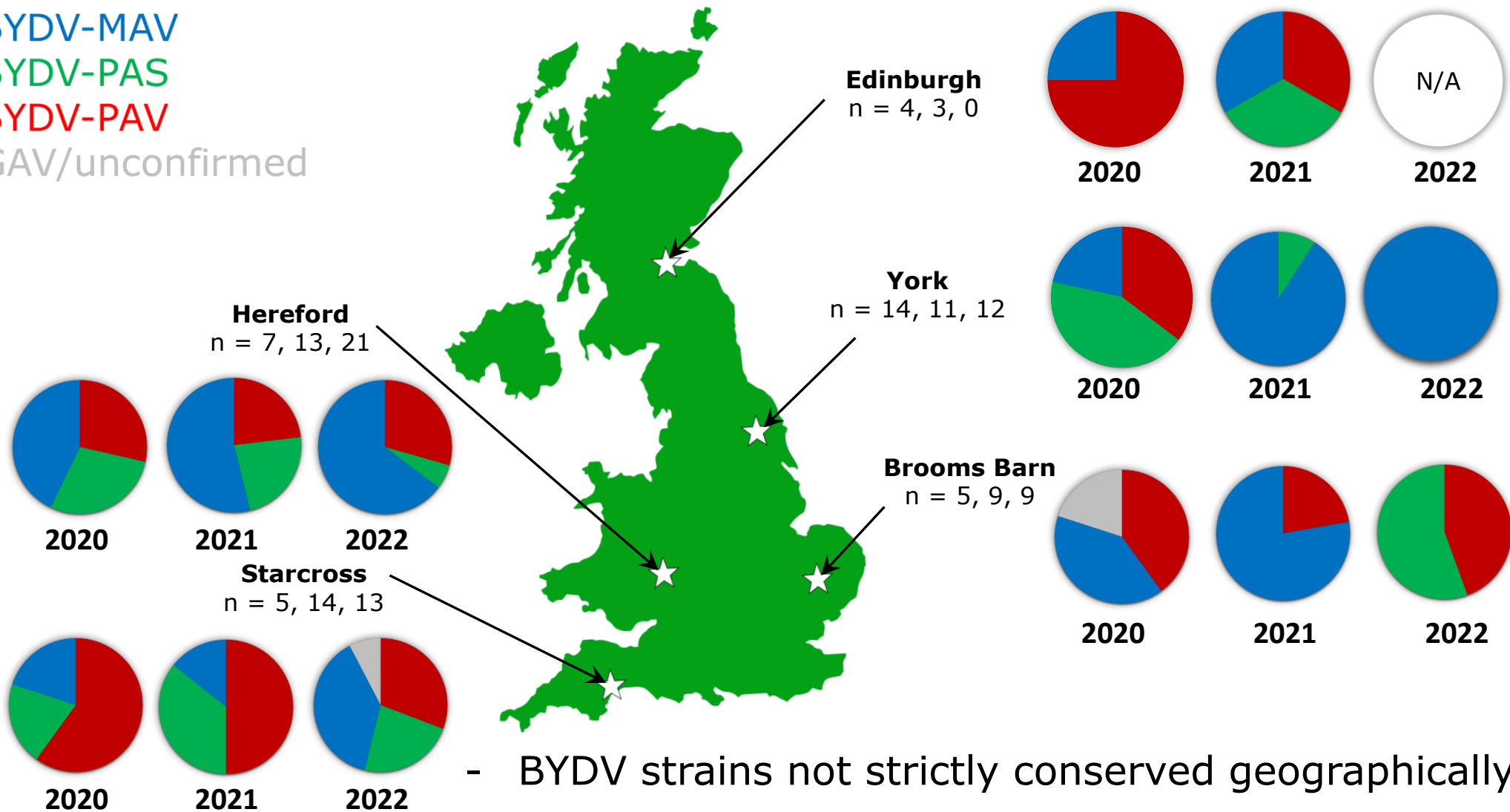
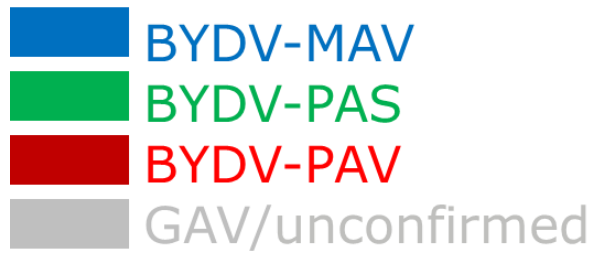
What's in the UK?



- **BYDV-PAS** suggested in UK alongside **MAV** and **PAV**
- PAS already predominant in other countries (e.g. Poland*)

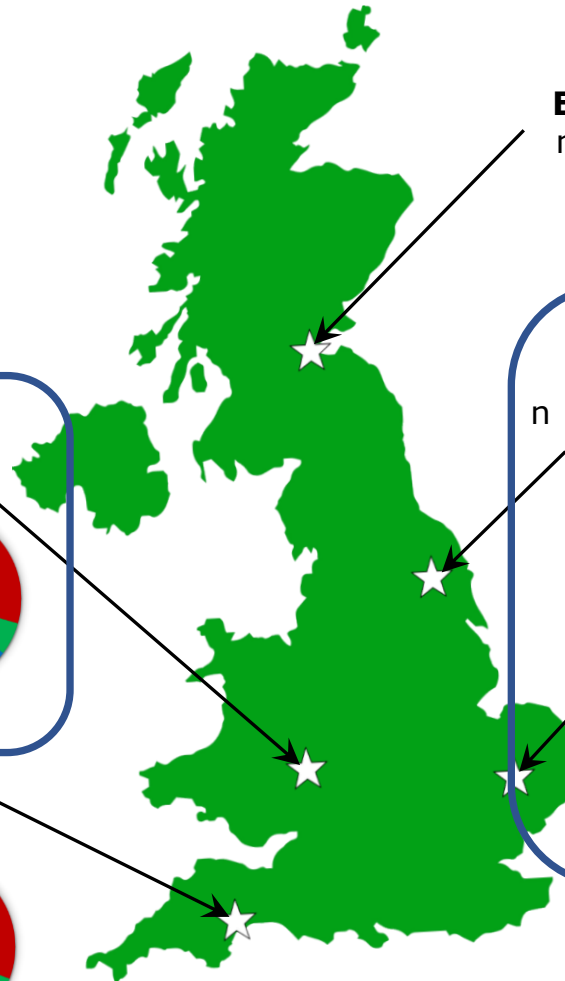
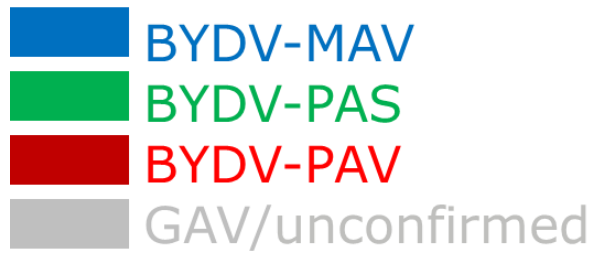
*Trzmiel & Hasiów-Jaroszewska (2023). *Plants*, 12, 3488

What's in the UK?

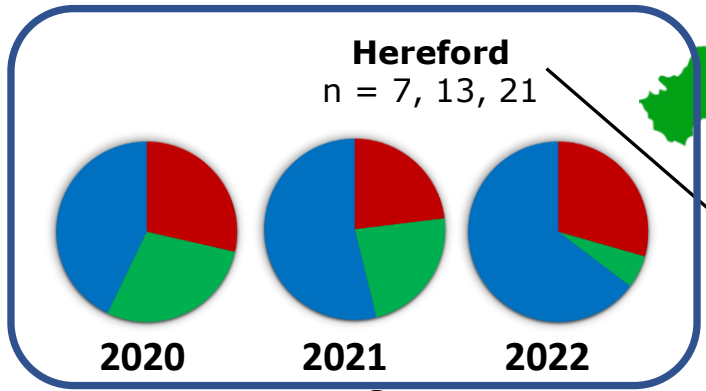
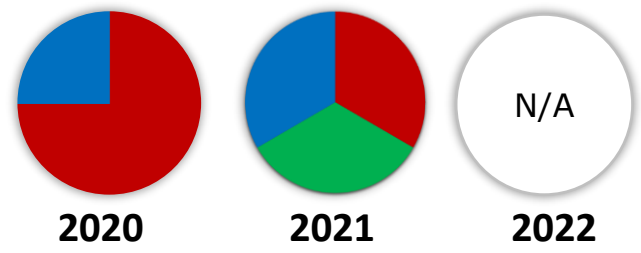


- BYDV strains not strictly conserved geographically
- Implications for resistance screening/germplasm deployment

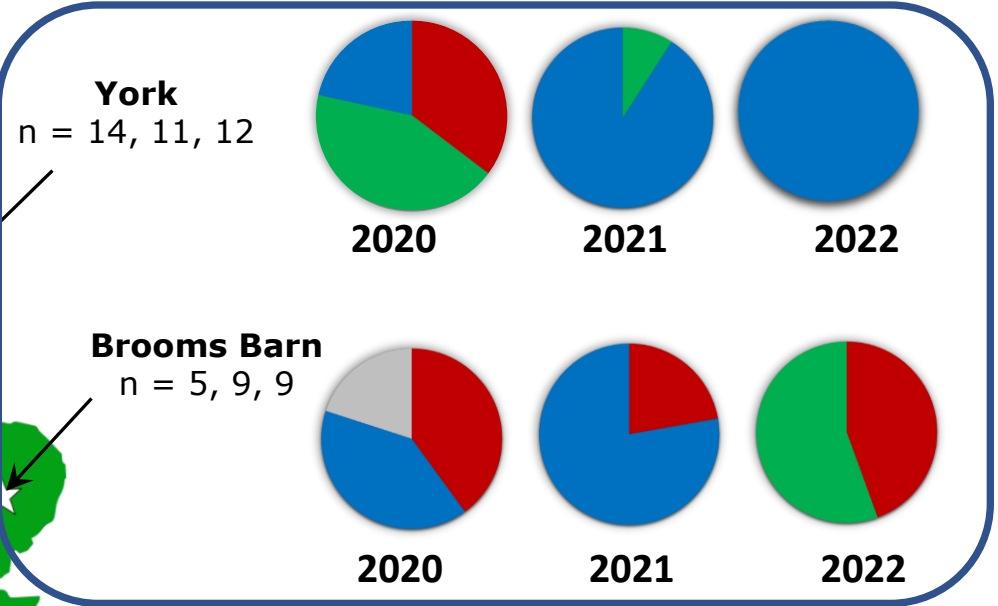
What's in the UK?



Edinburgh
n = 4, 3, 0

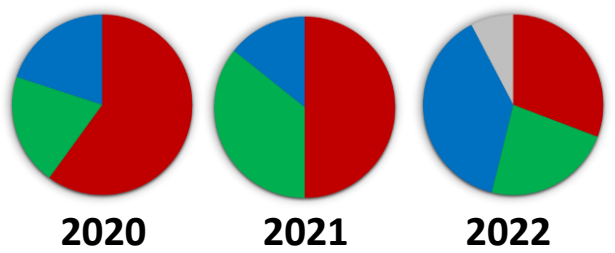


Hereford
n = 7, 13, 21



York
n = 14, 11, 12

Brooms Barn
n = 5, 9, 9



Starcross
n = 5, 14, 13

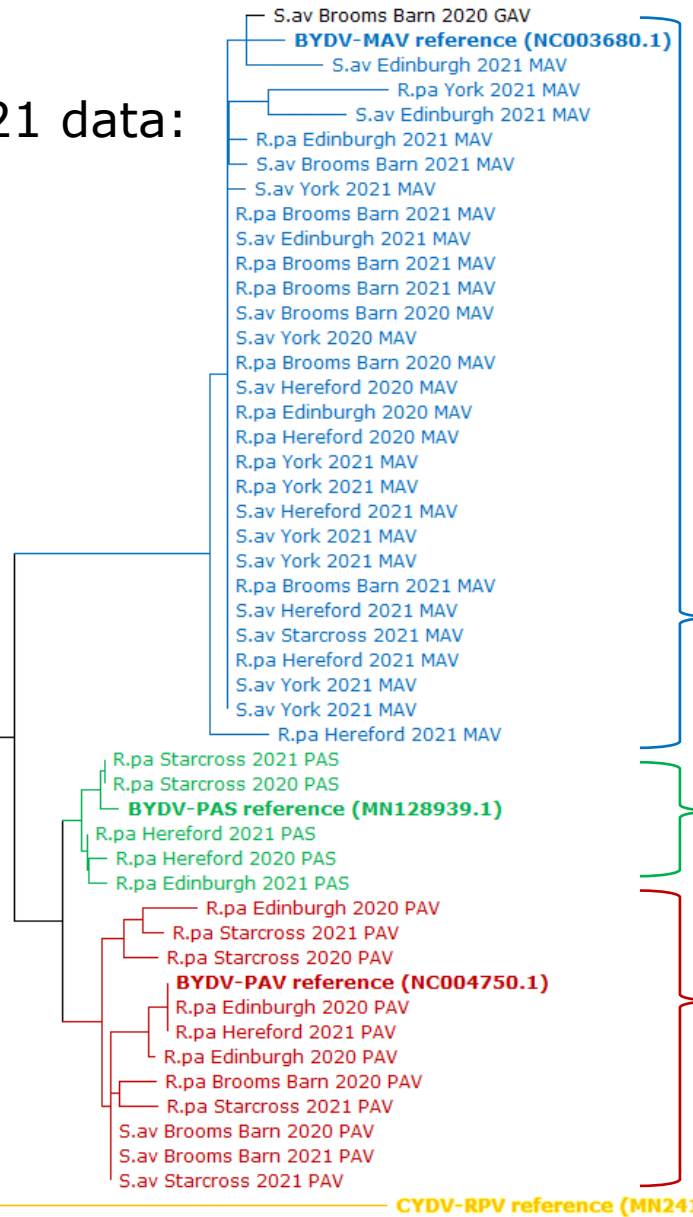
- Some regions not notably shifting (West England)
- Others changing drastically (East England)

UK-specific diagnostics

- Subset of 2020 & 2021 data:

- Sequencing information used to identify conserved, UK strain-associated polymorphisms

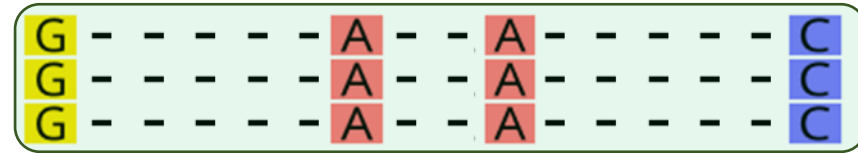
0.1 nucleotide substitutions per site



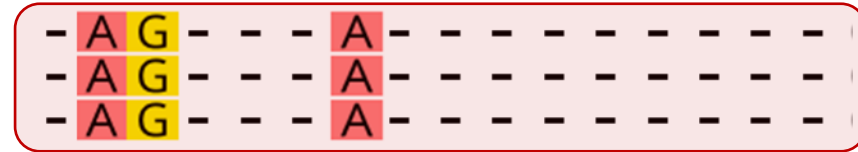
BYDV-MAV



BYDV-PAS



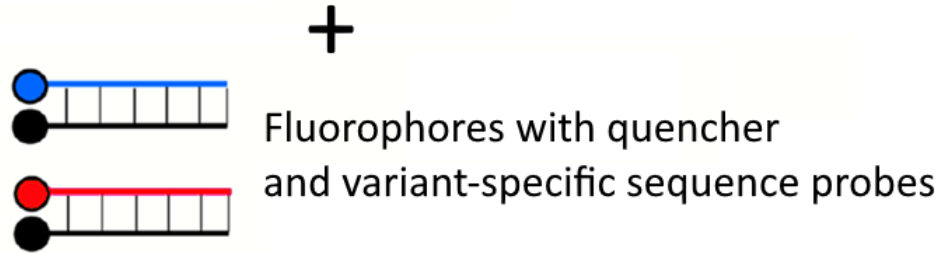
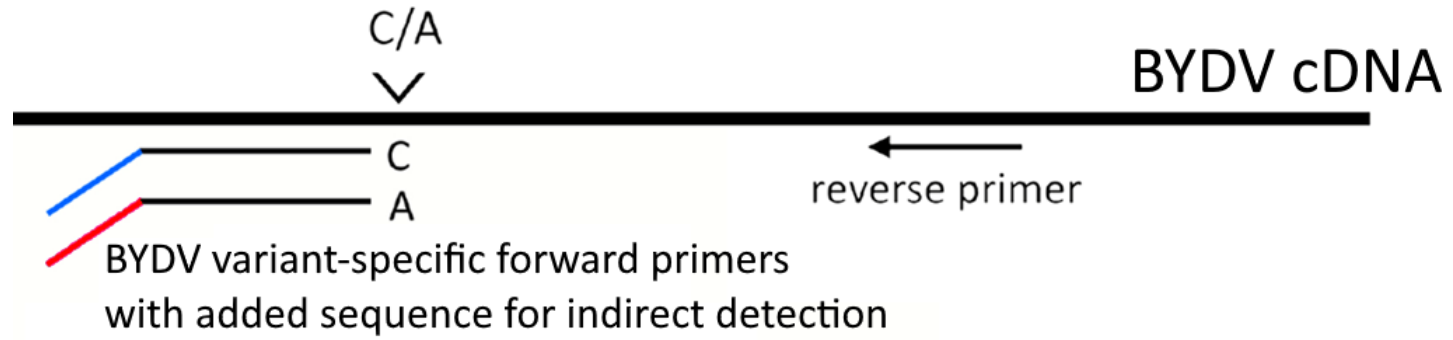
BYDV-PAV



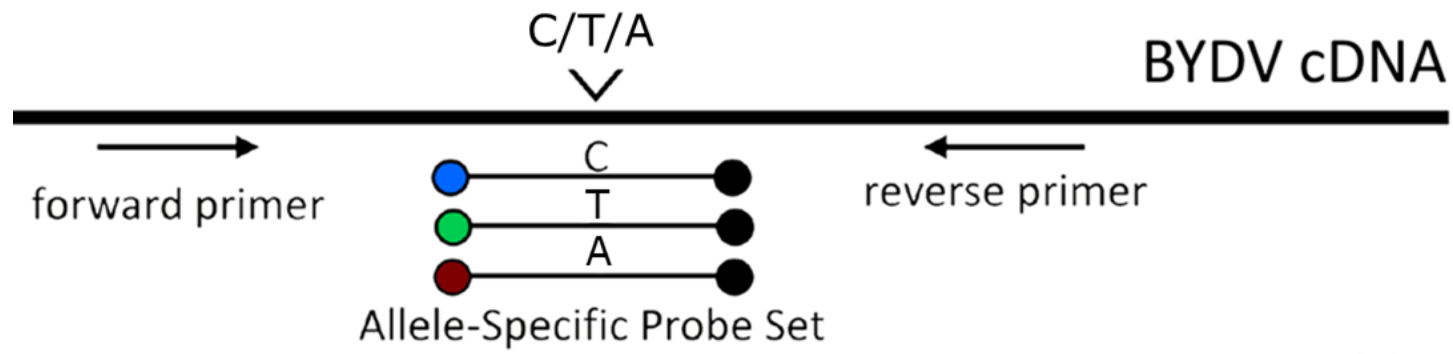
Sequencing data anonymised but representative

UK-specific diagnostics

- BYDV qPCR assays developed (MAV vs PAS vs PAV)



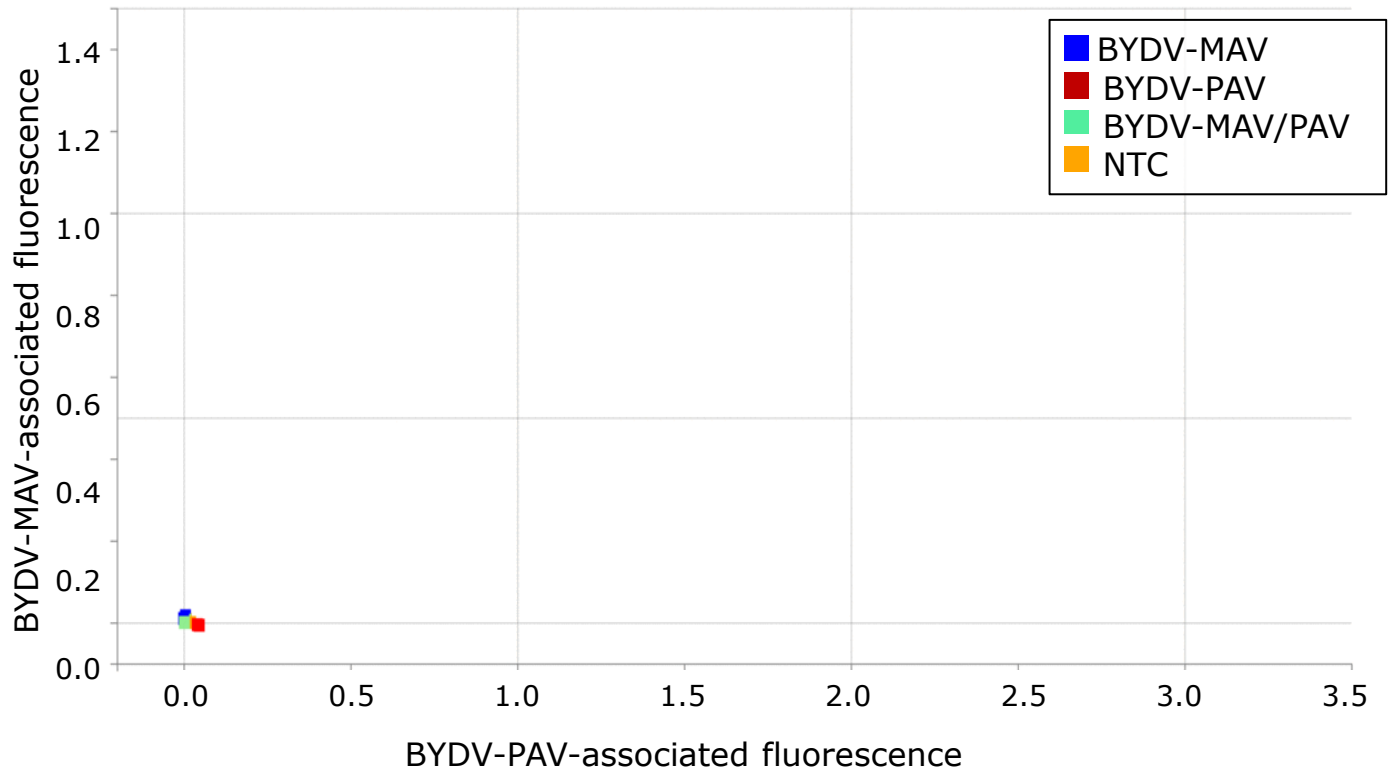
- **KASP genotyping chemistry**
more accessible for industry



- **Taqman chemistry**
robust diagnostic & valuable research tool

UK-specific diagnostics

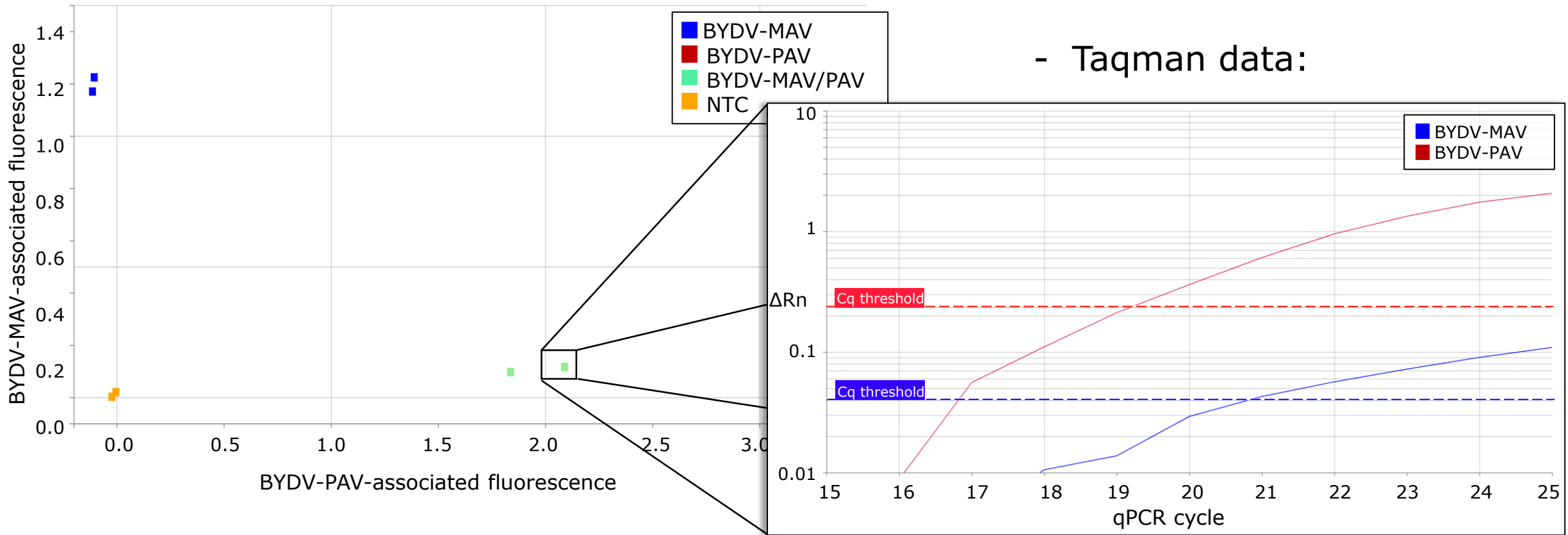
- Relative quantification of viral strains during mixed infections



- Natural and artificial BYDV strain co-infection can be dissected
- Long-term effectiveness of BYDV resistance(s) explorable

UK-specific diagnostics

- Relative quantification of viral strains during mixed infections



Summary



- **Improved UK-specific BYDV sequencing data resources**
- **New diagnostics developed**
- **Baseline for UK-wide strain variation established**
- **Intend to characterise germplasm for resistance(s)**

Many thanks to

- RRes Wheat Pathogenomics Team (PI, Kim Hammond-Kosack)
- RIS Team & Martin Williamson for sample access
- Continued assistance from the wheat and cereals community



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Any questions?



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