UKCPVS
Celebrating 50 Years of Research

AHDB
AGRICULTURE & HORTICULTURE DEVELOPMENT BOARD

March 2022

UKCPVS Stakeholders Meeting

Charlotte Nellist, Amelia Hubbard, Sarah Wilderspin

CEREALS & OILSEEDS

UKCPVS Stakeholders Meeting 2022

- Introduction – *Charlotte Nellist (Project Leader)*
- Wheat Yellow Rust – *Amelia Hubbard*
- Wheat Brown Rust – *Sarah Wilderspin*
- Wheat Powdery Mildew – *Sarah Wilderspin*
- Barley Powdery Mildew – *Amelia Hubbard*
- Genotyping – *Charlotte Nellist*
- RustWatch – *Charlotte Nellist*
- Sampling 2022 – *Charlotte Nellist*

Introduction

- UKCPVS – UK Cereal Pathogen Virulence Survey, established in 1967 following an outbreak of yellow rust on the previously resistant variety Rothwell Perdix
- Aims to identify changes in pathogen populations and detect new races that may have an adverse effect on cereal production in the UK
- Farmers, agronomists, trials staff, breeders and researchers send in infected leaf samples
- Jointly funded by AHDB and APHA

UKCPVS
Celebrating 50 Years of Research

AHDB

Animal & Plant Health Agency

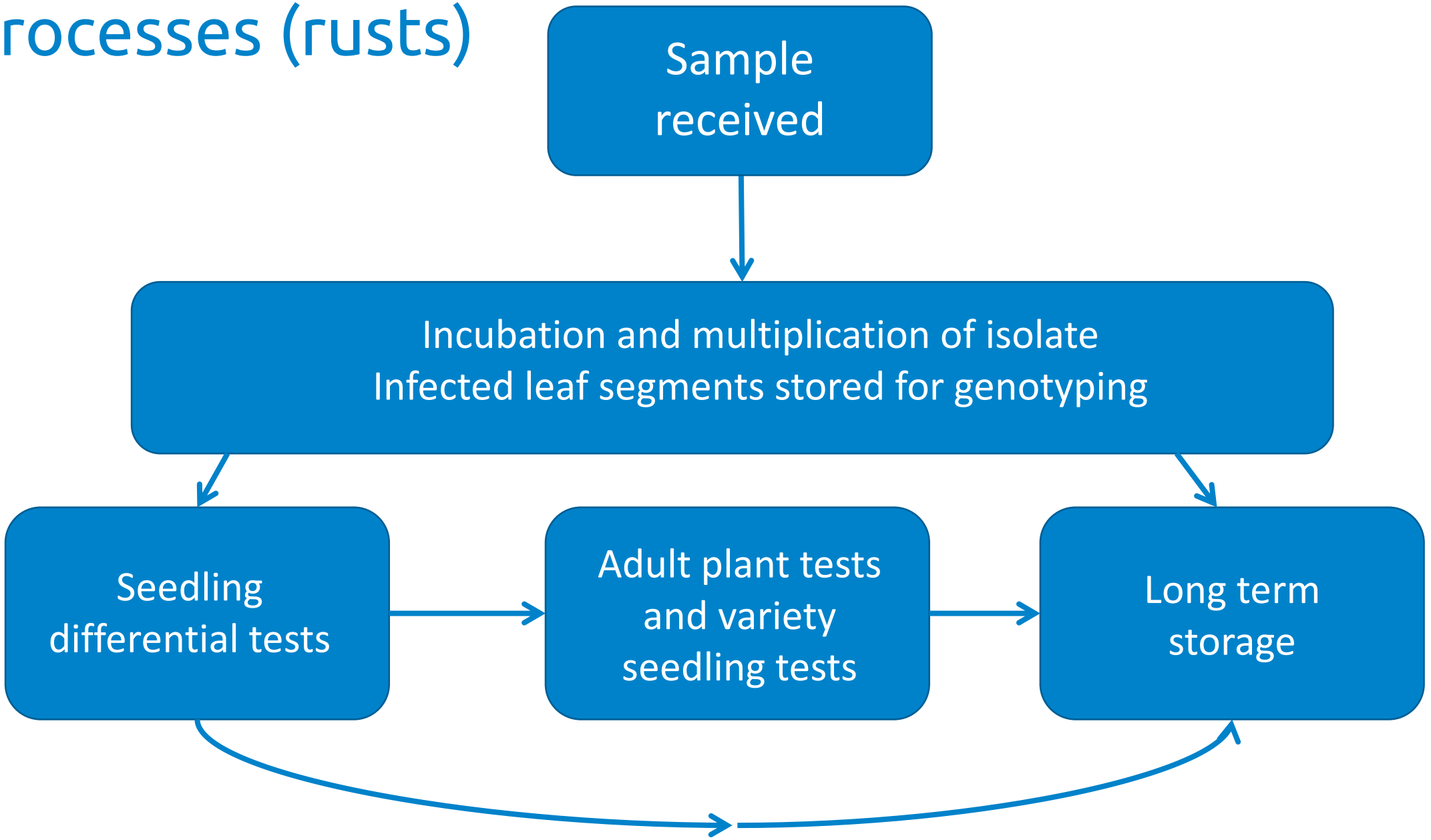
UKCPVS – Pathogens Surveyed

Puccinia striiformis f.sp. *tritici* (*Pst*), also known as wheat yellow rust or stripe rust

Puccinia triticina, also known as wheat brown rust or leaf rust

Blumeria graminis f.sp. tritici -wheat powdery mildew. *Blumeria graminis f.sp. hordei* – barley powdery mildew

Processes (rusts)



Identifying Changes in Pathogen Populations

- Step 1: Identifying any population change

Differential Tests

25 isolates selected for differential tests

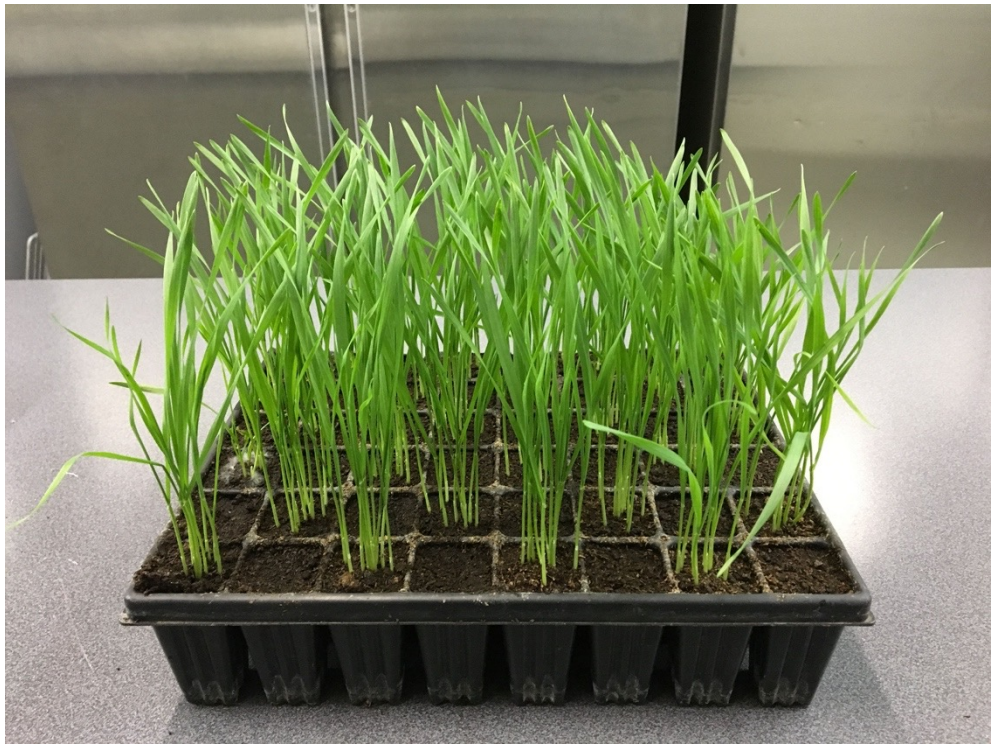
- Step 2: Identifying risk associated with change

Adult Plant Trials and Variety Seedling Tests

5 isolates go on to AP trials

Identifying Population Change: Differential Tests

Differential Cultivar	Resistance Gene
Chinese 166	*Yr1*
Kalyansona	*Yr2*
Vilmorin 23	*Yr3+*
Hybrid 46	*Yr4*
Heines Kolben	*Yr2, Yr6*
Avocet x Yr7	*Yr7*
Compair	*Yr8*
Kavkaz x 4 Fed	*Yr9*
Avocet x Yr15	*Yr15*
Avocet x Yr17	*Yr17*
Carstens V	*Yr32*



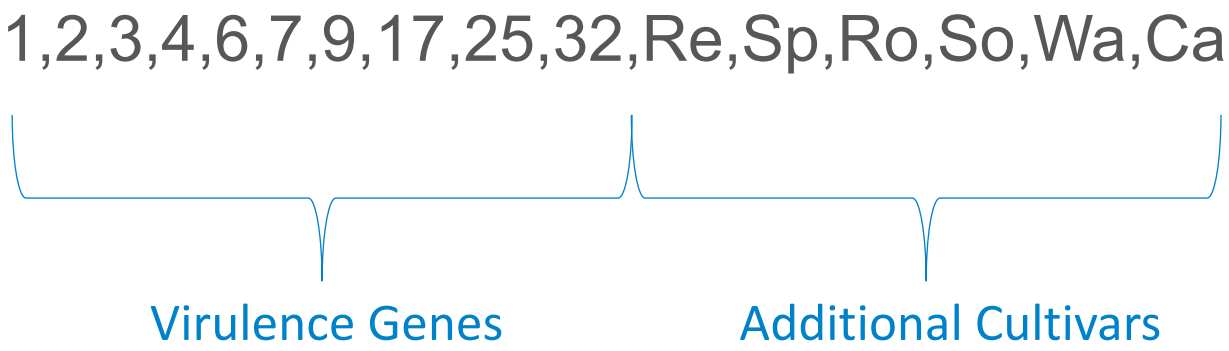
Identifying Change: Differential Tests

Isolate code	Host	Chinese 166 1	Kalyansona 2	Vilmorin 23 3a, 4a	Hybrid 46 3b,4b	Avocet Yr5 5	Avocet Yr6 6	Avocet Yr7 7	Lee 7,22, 23	Cadenza 6,7	Apache 7,17	Avocet Yr8 8	Compair 8,19	Avocet Yr9 9	Moro 10	Avocet Yr15 15
16/009	Reflection	3.0	3.0	3.0	3.0	0.0	3.0	3.0	2.9	3.0	2.9	0.0	0.0	4.0	0.0	0.0
16/019	KWS Target	3.0	4.0	4.0	3.0	0.0	4.0	4.0	3.0	3.0	2.9	0.0	0.0	3.2	0.0	0.0
16/035	Reflection	4.0	4.0	4.0	3.0	0.0	3.2	3.0	3.0	3.2	3.0	0.0	0.0	3.0	0.0	0.0
16/048	Myriad	3.1	3.1	4.0	3.0	0.0	3.0	3.0	3.0	3.0	2.4	0.0	0.0	3.0	0.0	0.0
16/135	Cordiale	3.0	4.0	3.5	3.0	0.0	3.0	3.0	3.0	3.5	3.0	0.0	0.0	3.0	0.0	0.0
16/144	KWS Gator	3.0	4.0	4.0	3.0	0.0	3.0	3.5	3.5	3.0	2.2	0.0	0.0	3.0	0.0	0.0
16/184	Zulu	3.0	3.5	3.5	3.0	0.0	2.8	2.0	0.3	0.2	0.1	0.0	0.0	3.0	0.0	0.0

Pathotype = Virulence Profile

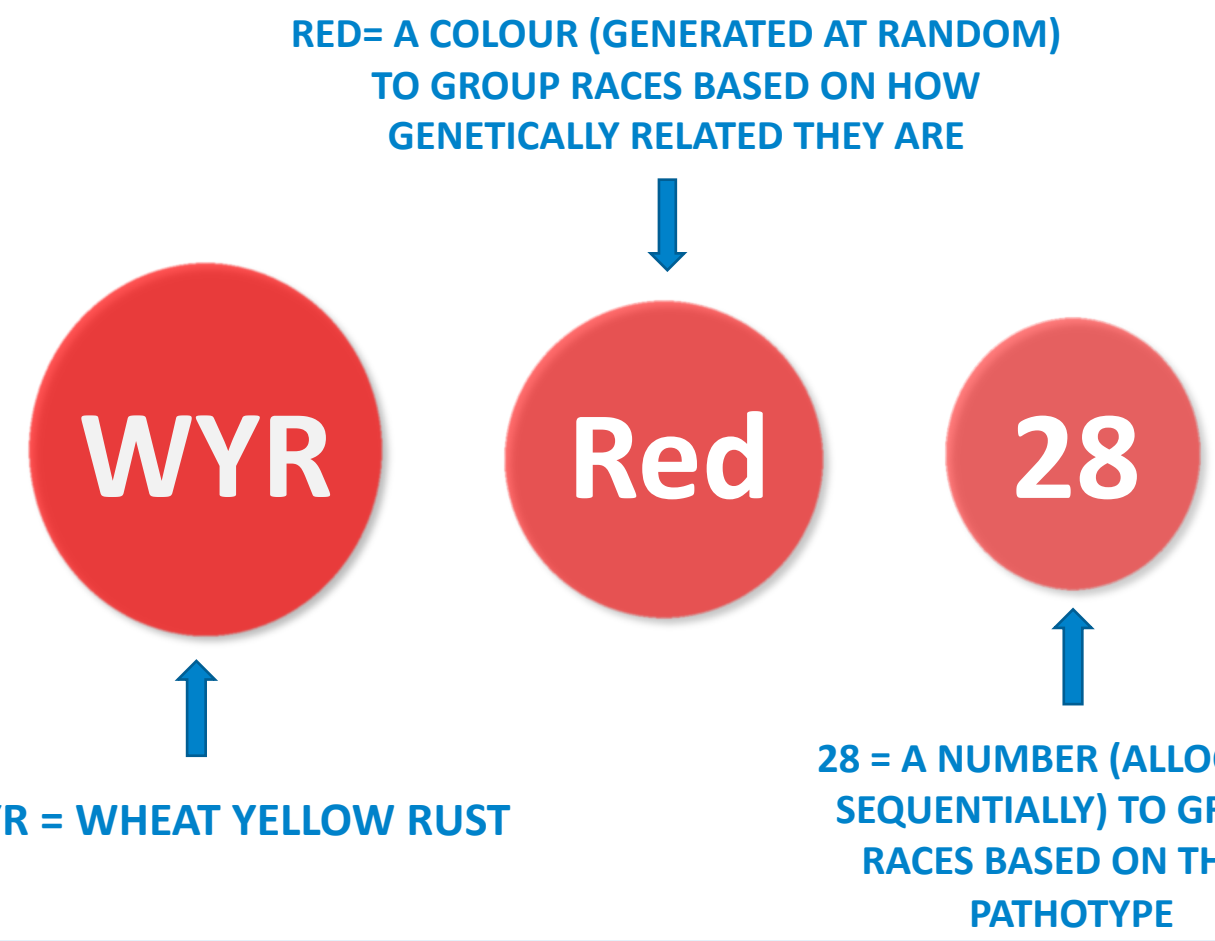
- Lists the virulence genes the isolate carries and key additional test cultivars infected at seedling stage

- For example



WYR Race Naming System: Colours and Numbers

How to decode the race naming system

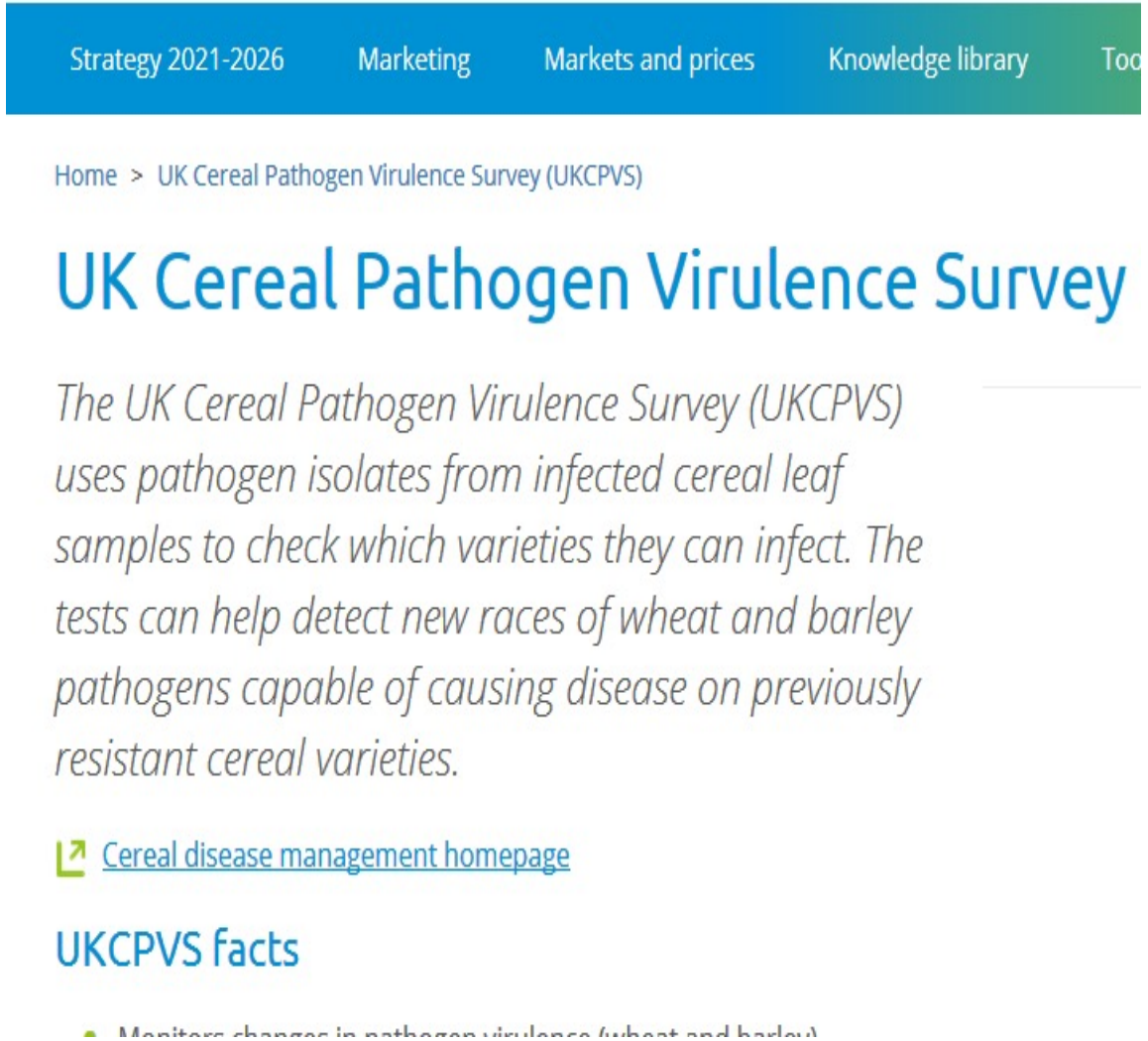


Identifying Risk: Adult Plant Trials

Five representative races trialled on RL varieties and candidates

Dissemination of Results

- UKCPVS Annual Report
- Stakeholders Meeting
- NIAB website
- AHDB website
- UKCPVS seedling test data used alongside the official AHDB RL disease resistance rating in AHDB young and adult plant resistance/susceptibility table
- AHDB topic sheets/press releases
- Cereals Event/NIAB Cambridge Open Day
- Presentations to agronomists
- Exhibit stands – AHDB Agronomy Conference



Wheat Yellow Rust

Amelia Hubbard

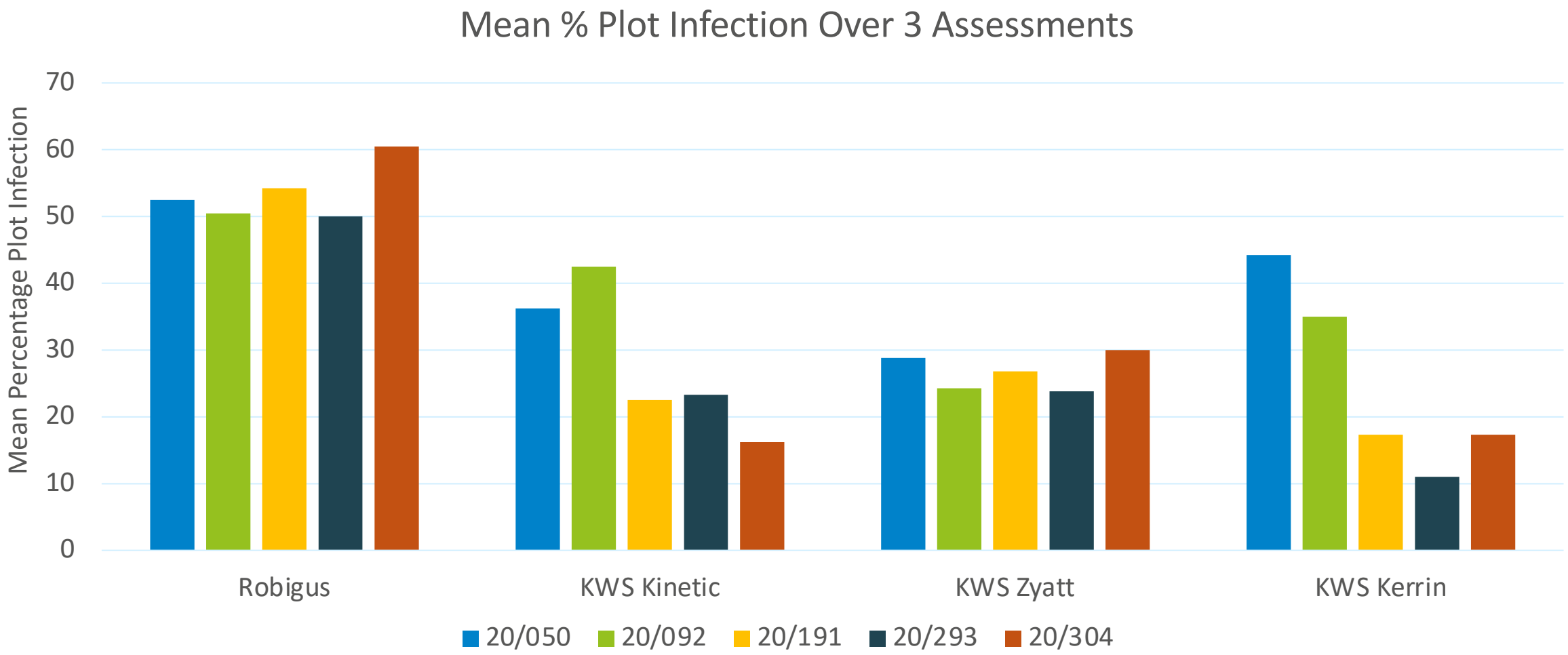
Wheat Yellow Rust Background

- Incursion of Warrior group in 2011 leading to highly diverse derivatives of this group
- Displaced our old UK population
- In 2019 more isolates identified carrying virulence for *Yr8*, Kranich and Crusoe
- Tumbling resistance ratings of some RL varieties under attack from these new strains

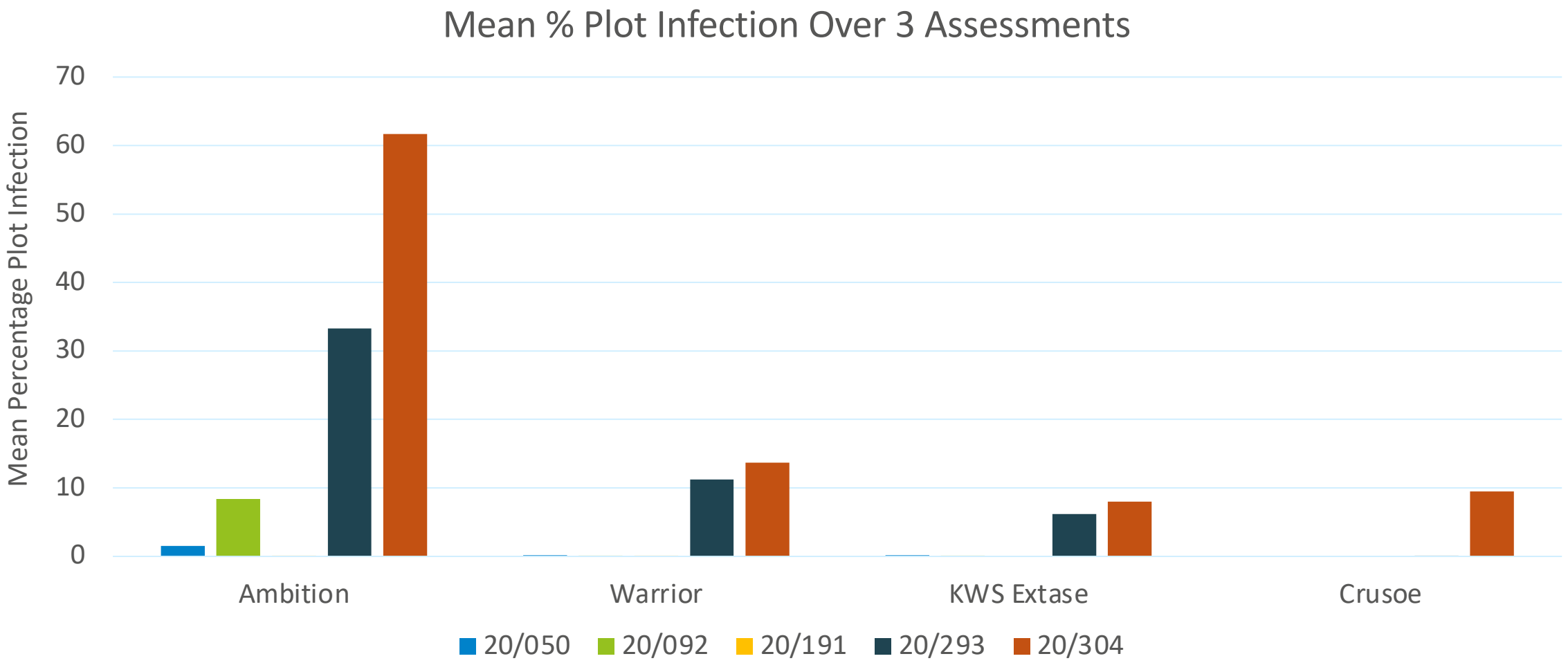
2021 Adult Plant Trials – wheat yellow rust

Isolate	Host Variety	Pathotype
20/050	KWS Siskin	1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Ca,St,Ap,Ev
20/092	LG Astronomer	1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,S[illegible],Kr,Ap,Ev
20/191	KWS Siskin	1,2,3,4,6,[illegible]7,8,9[illegible],17,25,32,Sp,Ro,So,St,Kr,Ap,Ev
20/293	KWS Extase	1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,St,Kr,Ap,Cr,Ev
20/304	KWS Extase	1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,St,Kr,Ap,Cr

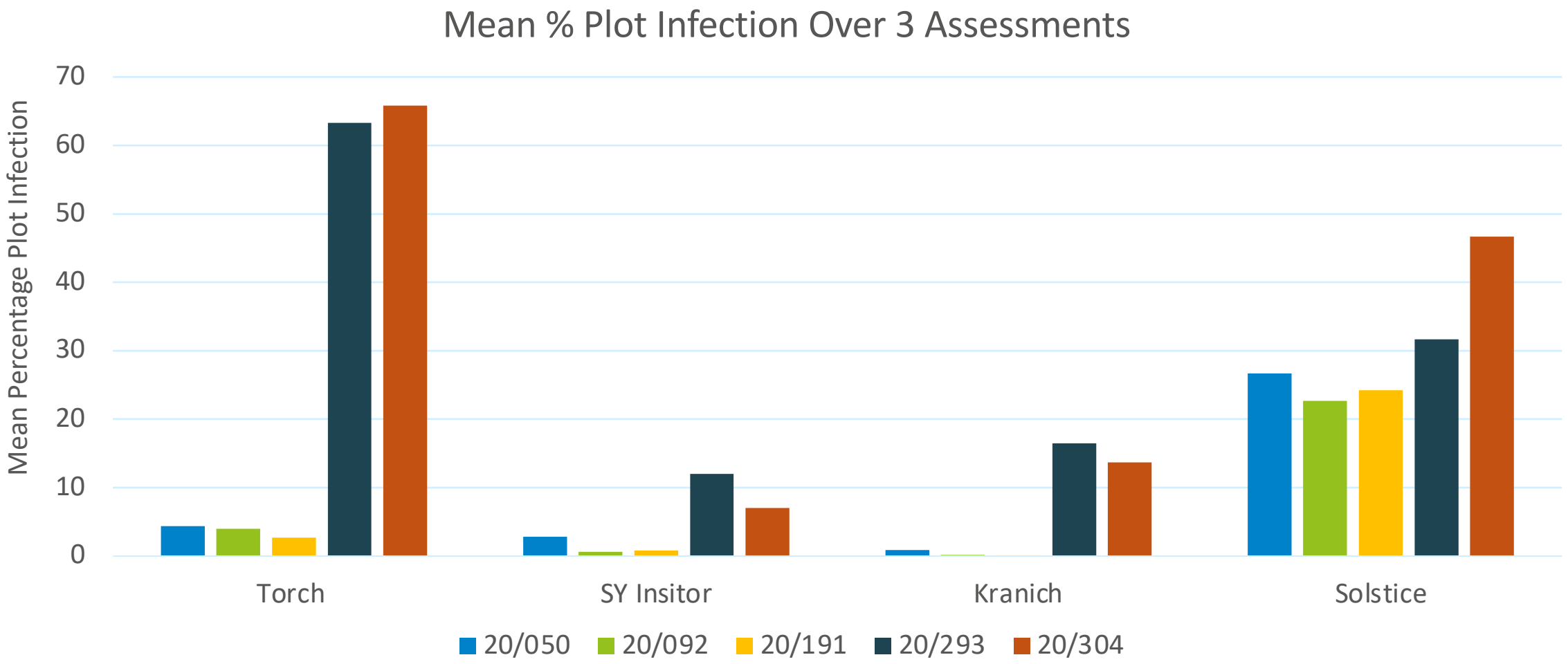
2021 Adult Plant Trials – wheat yellow rust



2021 Adult Plant Trials – wheat yellow rust



2021 Adult Plant Trials – wheat yellow rust



2021 Adult Plant Trials – wheat yellow rust

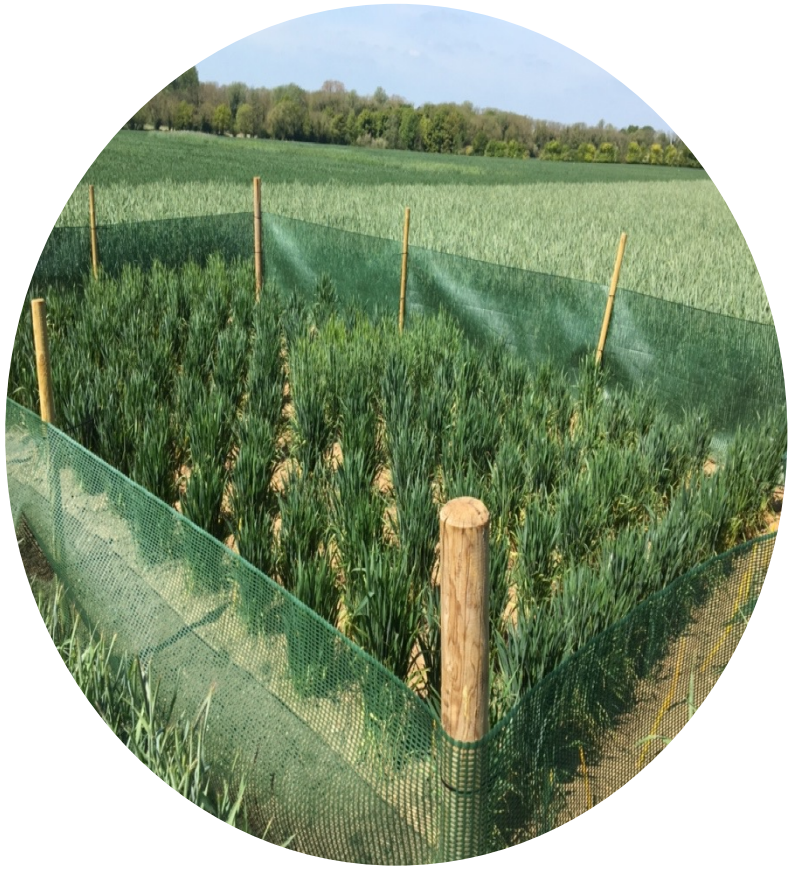
- Resistant to all 5 isolates (≤2% infection)

Astound	KWS Guium*	LG Typhoon
Champion	KWS Henum	Mayflower
Costello	KWS Jackal	Merit
Elation	KWS Palladium*	Rendezvous
Elicit	KWS Siskin	RGT Rashid
Graham	LG Astronomer	RGT Saki
KWS Brium	LG Farrier*	RGT Silversurfer
KWS Cranium	LG Illuminate	Theodore*
KWS Dawsum	LG Prince	

* Scored 0.0 across all isolates/assessments

2021 Adult Plant Trials – wheat yellow rust

- Good levels of infection achieved – inoculations successful
- Results confirm 20/293 is a Warrior (Pink) type isolate – shown in seedling virulence tests and 20/293 confirmed as Warrior isolate by SSR genotyping analyses conducted by GRRC. 20/304 very similar but identified as a red isolate
- Some varieties were clearly more susceptible/resistant to different isolates – e.g. KWS Extase, SY Insitor and Torch were more susceptible to 20/293 and 20/304
- Many of the 2021/22 RL varieties were resistant to all isolates



WYR Variety Seedling Tests ‘v’ Adult Plant Tests

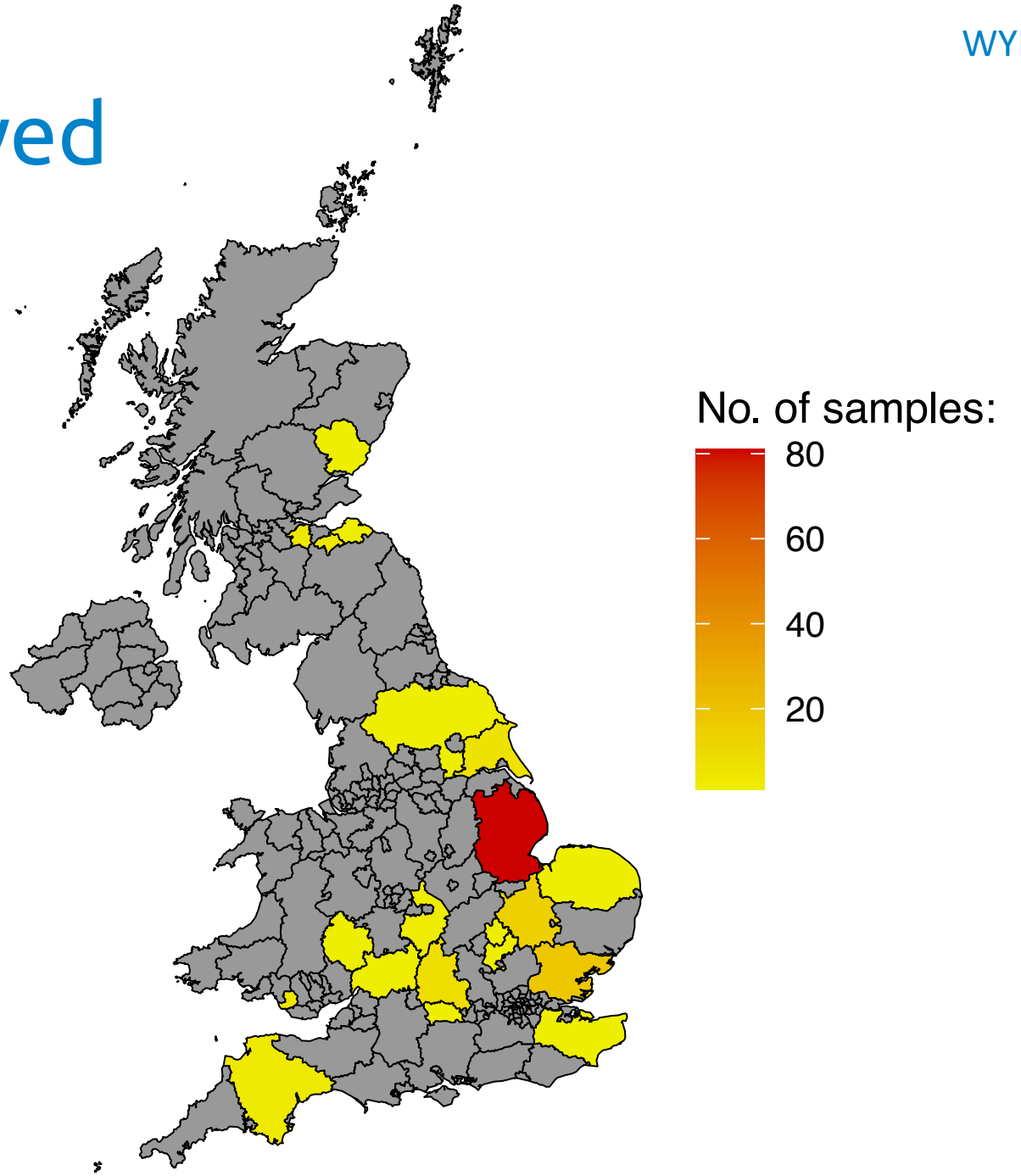
Variety	2021/22 RL Rating	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		20/050	20/092	20/191	20/293	20/304	20/050	20/092	20/191	20/293	20/304
THEODORE	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KWS SISKIN	9	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
LG ASTRONOMER	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
ELICIT	8	3.0	3.2	1.9	2.0	2.0	0.2	0.2	0.0	0.0	0.0
ELATION	8	3.0	3.0	3.0	3.0	3.0	0.1	0.1	0.1	0.1	0.1
KWS JACKAL	9	3.0	3.0	2.7	2.0	0.4	0.1	0.1	0.1	0.1	0.1
LG SKYSCRAPER	8	3.0	3.0	3.0	3.0	3.1	2.3	0.4	1.0	3.8	1.5
CRUSOE	9	0.0	0.3	0.0	2.1	3.0	0.0	0.0	0.0	0.1	9.5
KWS EXTASE	8	0.5	0.9	0.4	2.2	3.0	0.2	0.1	0.0	6.2	8.0
SY INSITOR	5	3.0	3.0	3.0	3.0	3.0	2.8	0.6	0.8	12.0	7.0
KRANICH		2.0	3.0	2.2	3.0	3.0	0.9	0.2	0.1	16.5	13.7
AMBITION		0.8	1.8	2.0	3.0	3.3	1.5	8.4	0.1	33.3	61.7
SKYFALL	3	3.0	3.0	3.0	3.0	3.0	20.8	24.3	14.7	26.3	26.2
KWS ZYATT	5	3.0	3.0	4.0	3.0	3.0	28.8	24.3	26.8	23.8	30.0
TORCH		2.5	3.0	3.0	3.0	3.0	4.4	4.0	2.7	63.3	65.8
KWS KINETIC	4	3.0	3.0	3.0	3.0	3.0	36.2	42.5	22.5	23.3	16.2
SOLSTICE *		3.0	3.0	3.0	3.0	3.0	26.7	22.7	24.2	31.7	46.7
ROBIGUS		3.0	3.0	3.0	3.0	3.0	52.5	50.4	54.2	50.0	60.4

2021 Samples

2021 WYR Samples Received

- 155 samples
- 19 counties
- 54 varieties

+ one unknown variety



2021 WYR Samples Received

2021 Cereal Disease Season

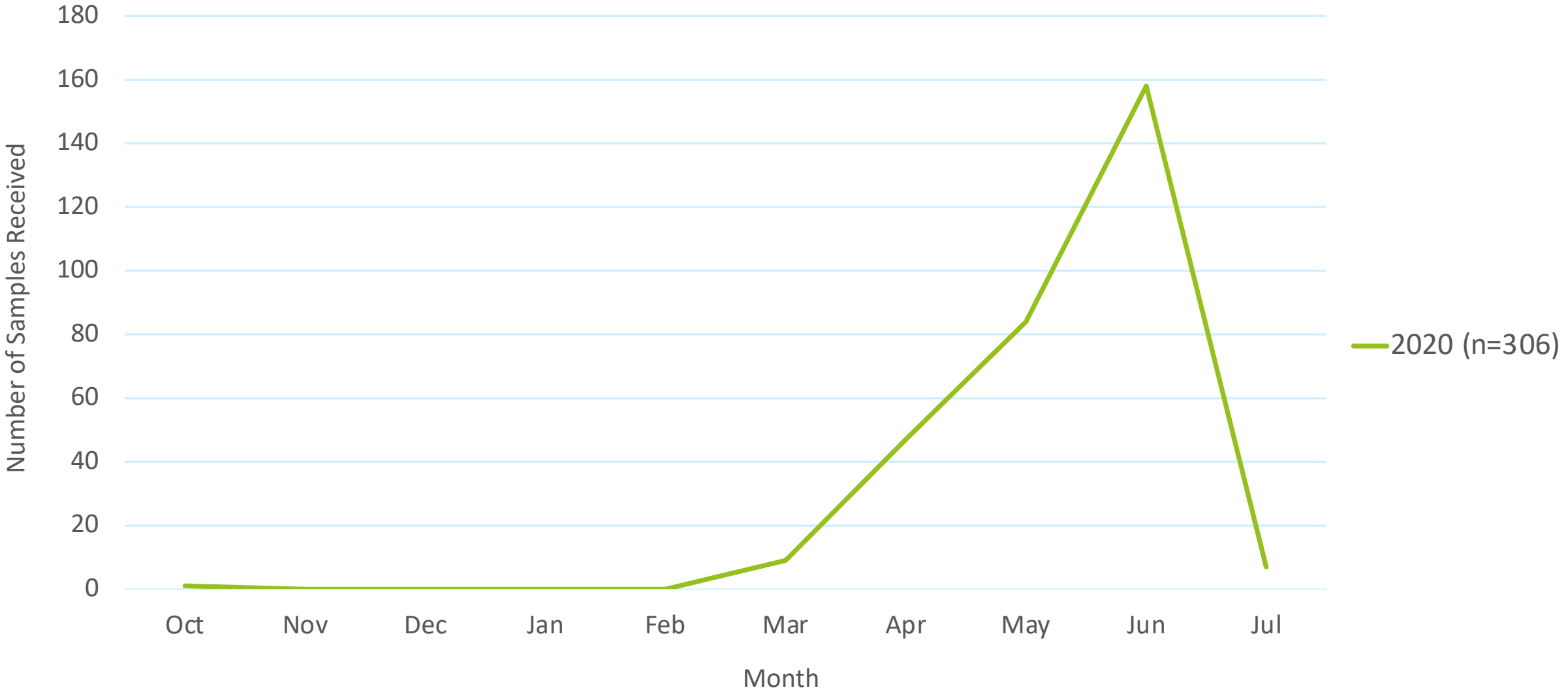
- Wet autumn in 2020, but mild winter
- YR started to develop in March
- Very dry April and temps 2 °C below average

  then rain/storms in May affected disease development in some areas

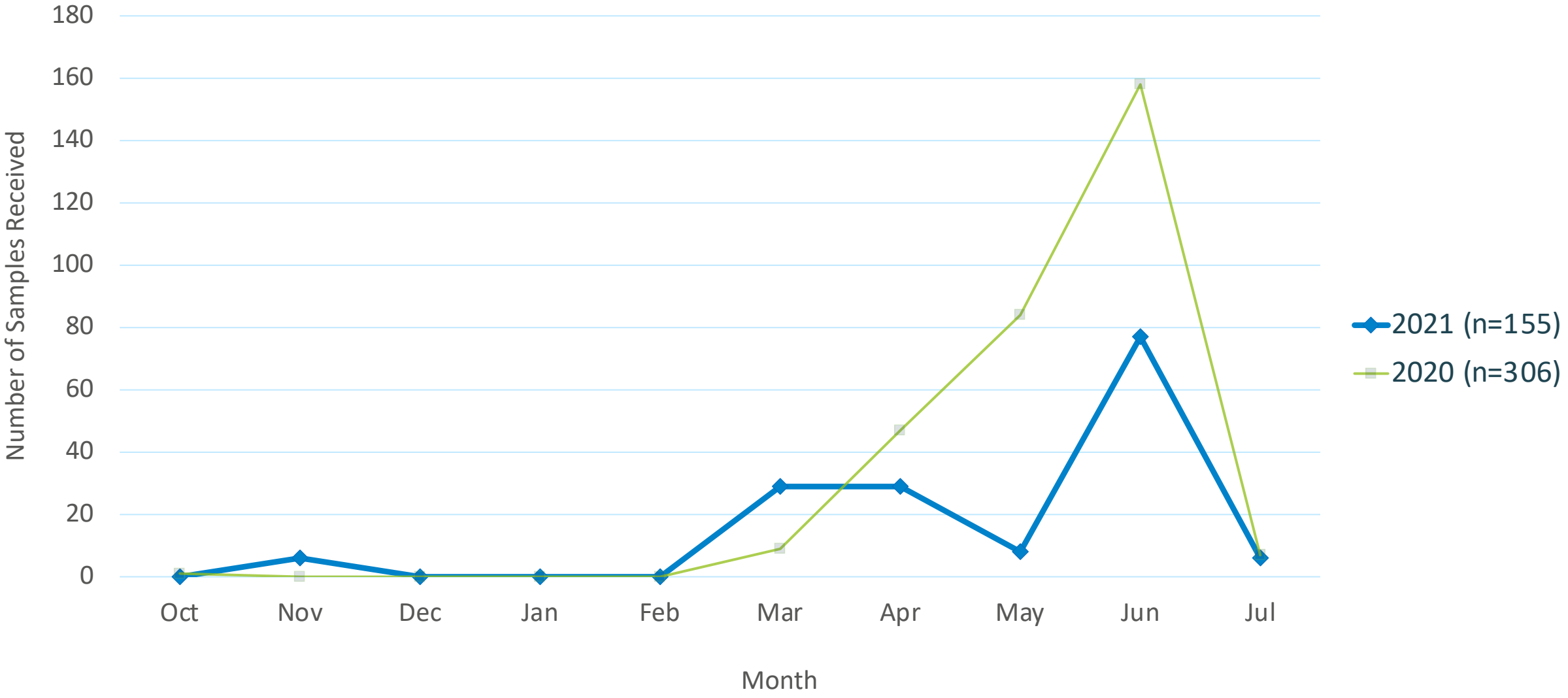
➢ Very short sharp disease season with yellow rust rapidly drying up and dying off by the end of June

➢ As a result sample numbers were much lower in 2021 compared to 2020 for both wheat rusts

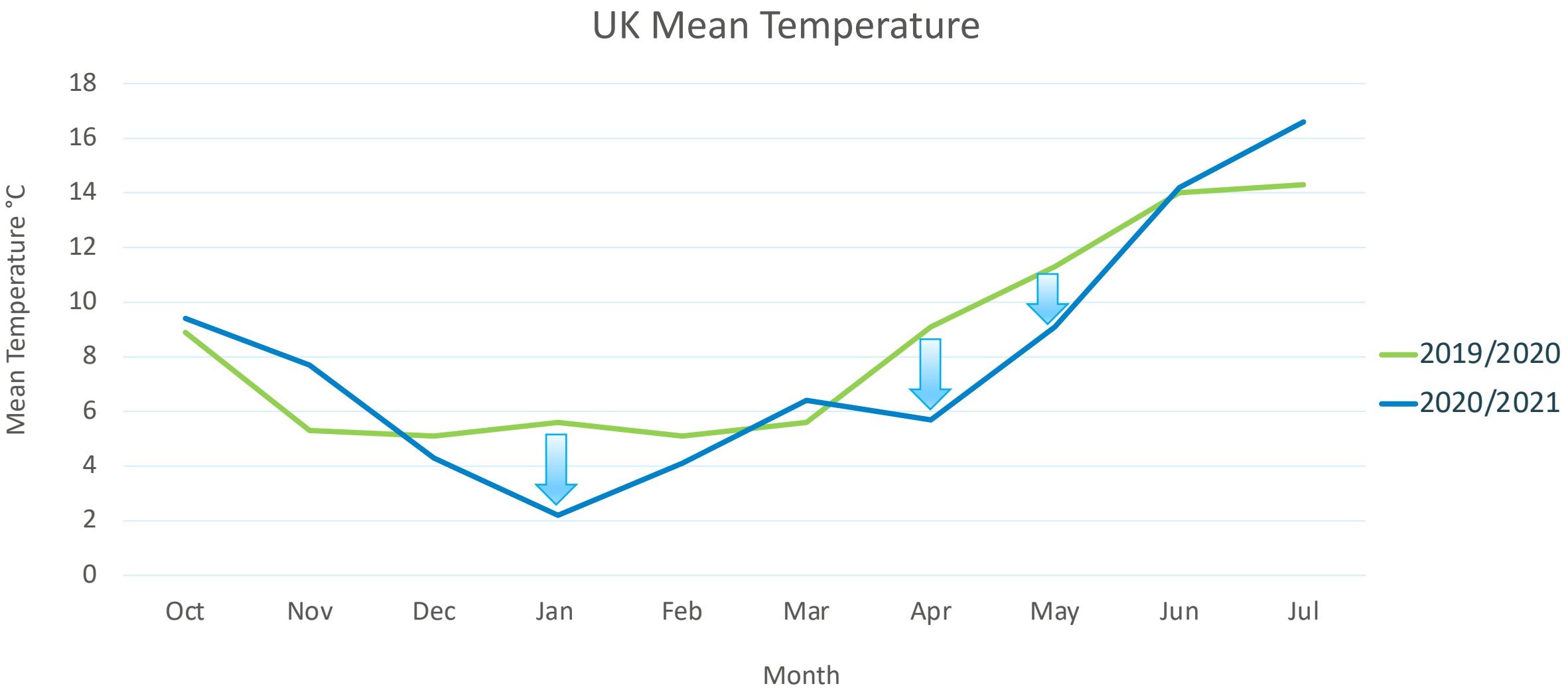
2020 WYR Samples Received



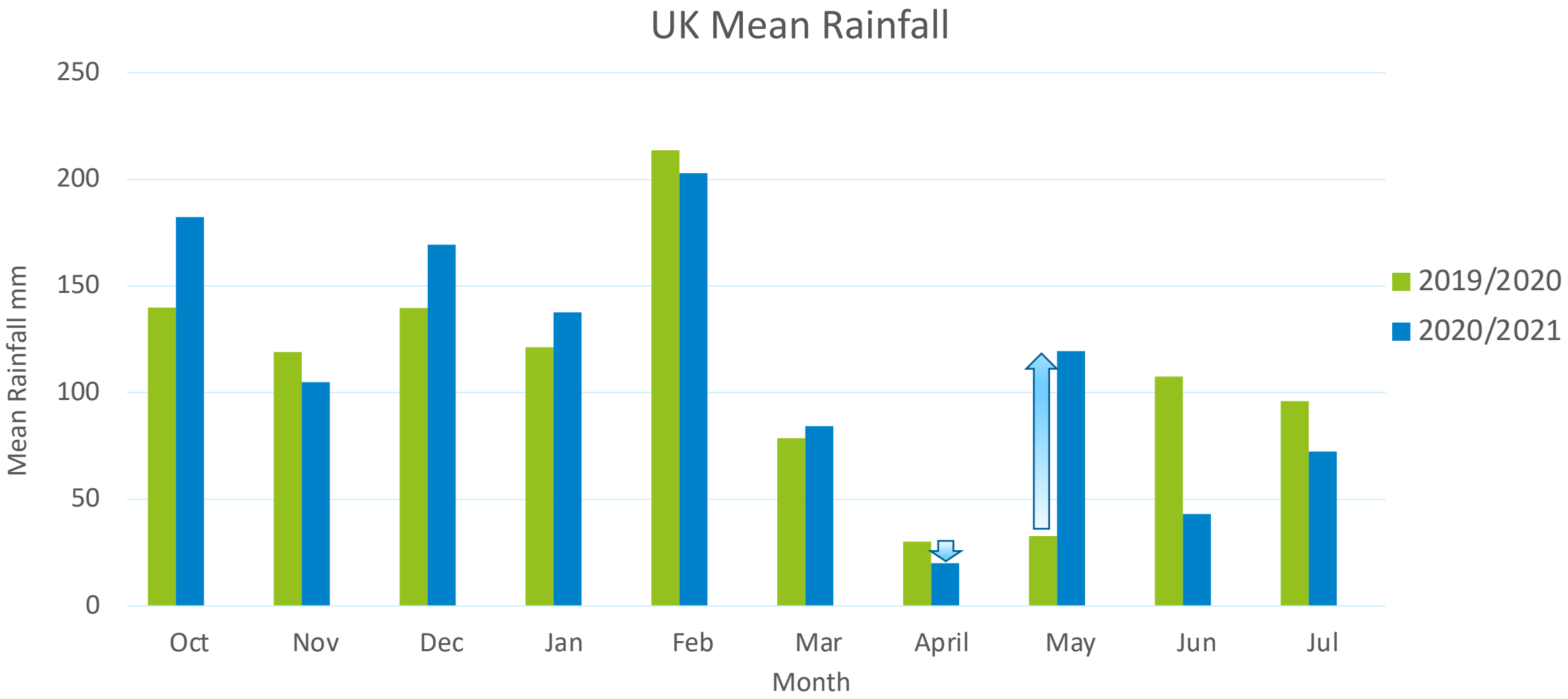
2021 WYR Samples Received



UK Climate


UK Mean Temperature
Mean Temperature °C
18
16
14
12
10
8
6
4
2
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Month
2019/2020
2020/2021

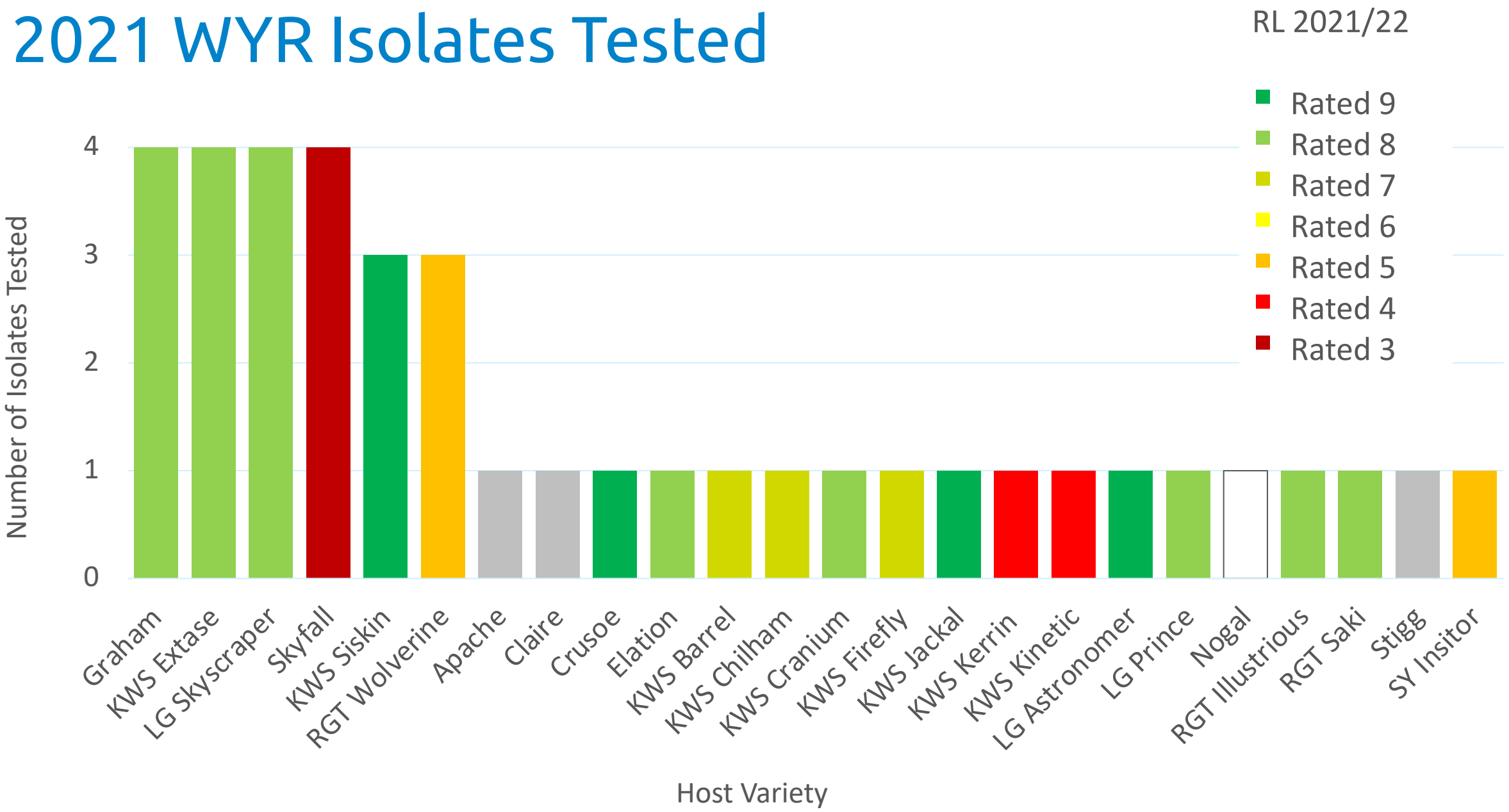
UK Climate


UK Mean Rainfall
Mean Rainfall mm
250
200
150
100
50
0
Oct
Nov
Dec
Jan
Feb
Mar
April
May
Jun
Jul
Month
2019/2020
2020/2021

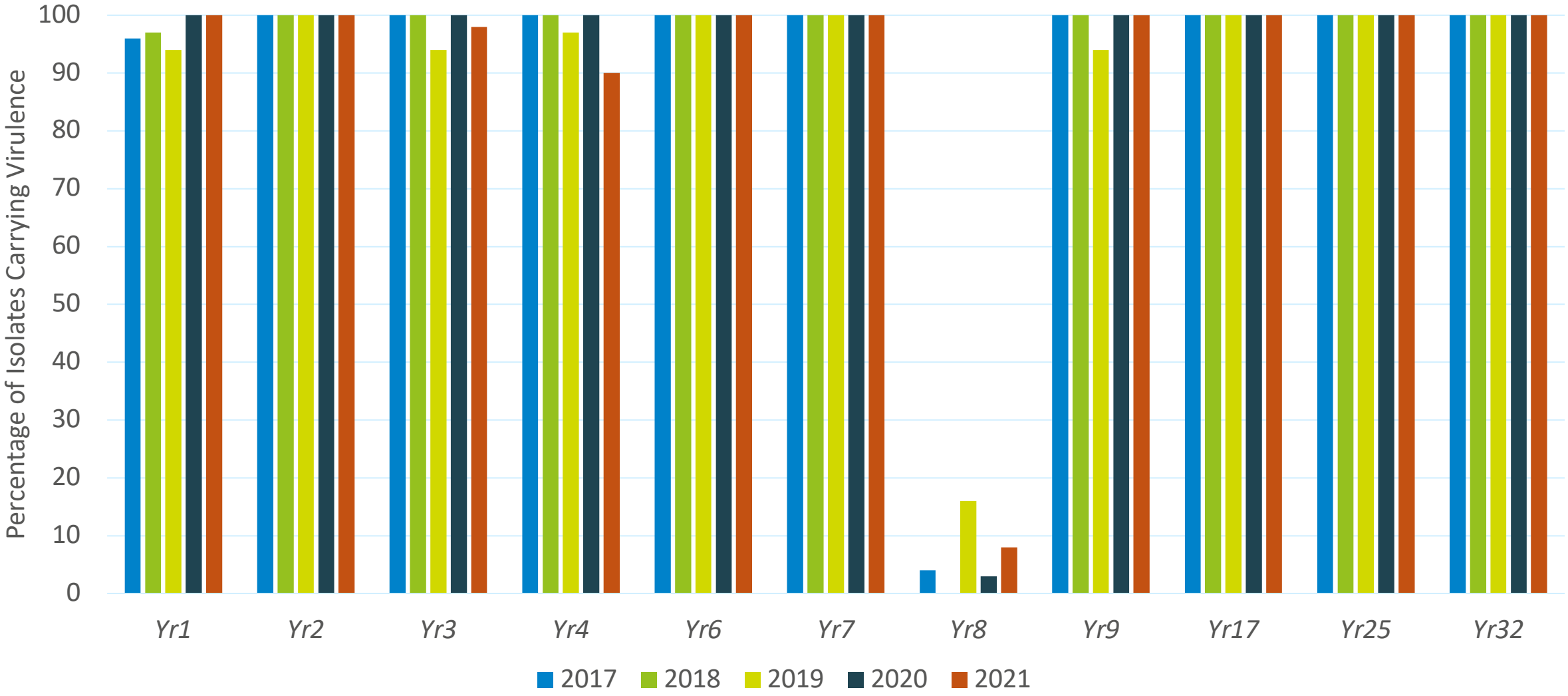
WYR Season Highlights

- 155 samples, majority from Lincolnshire
- Despite receiving fewer samples than recent years 54 varieties were represented in the samples we received
- Most sampled variety for wheat yellow rust – KWS Firefly [7]
- 4 samples from KWS Siskin [9] and none have re-infected KWS Siskin at seedling stage
- Unusual sightings/reports regarding one of the KWS Siskin samples and we had a report of yellow rust being particularly difficult to control on KWS Kinetic (samples from these were received and tested)
- 40 wheat yellow rust isolates tested due to low BR sample numbers

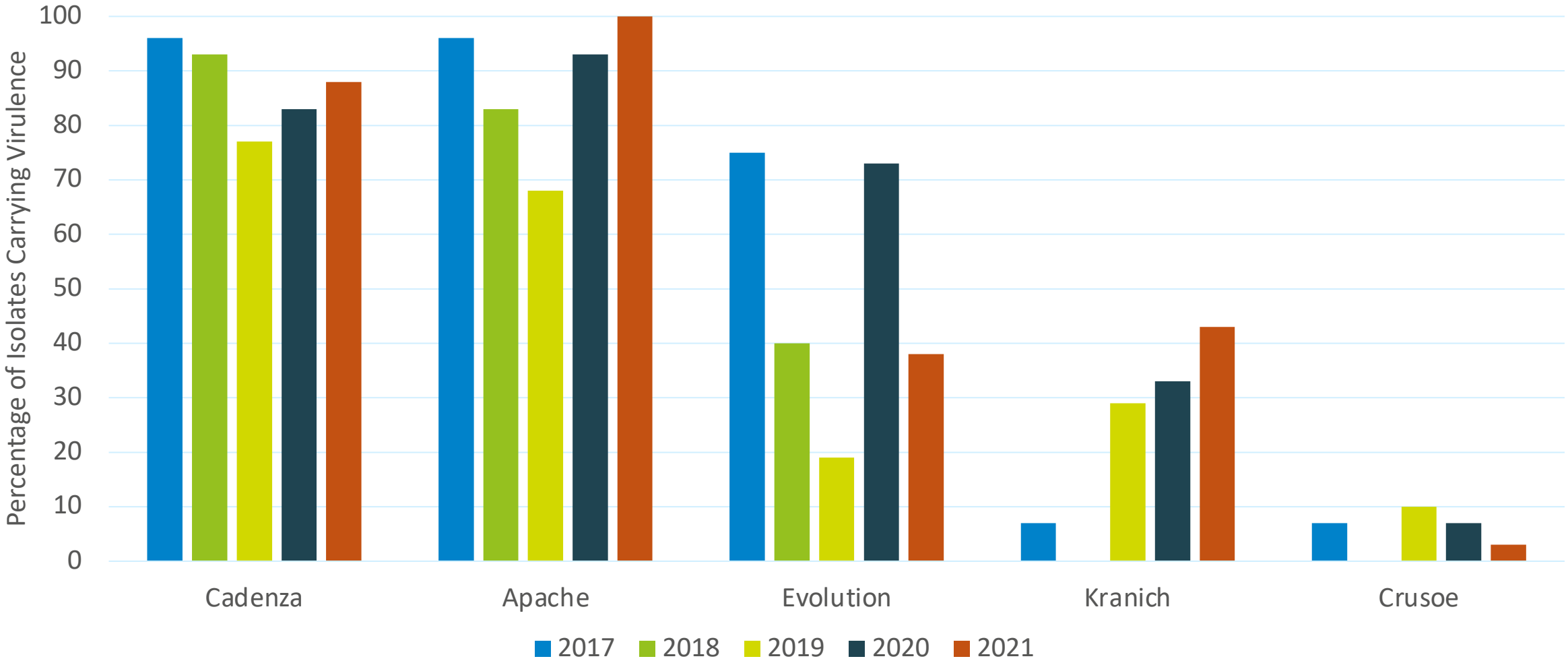
2021 WYR Isolates Tested



Wheat Yellow Rust Virulence Frequencies



Wheat Yellow Rust Virulence Frequencies



Common Pathotypes Found in 2021

“Race” name	Pathotype	% Frequency
Red 36	1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,St,Kr,Ap	12.5
Red 37	1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,St,Kr,Ap,Ev	12.5
Red 41	1,2,3,4,6,7,9,17,25,32,Sp,Ro,So,Wa,Ca,St,Ap	12.5

New Pathotypes Found in 2021

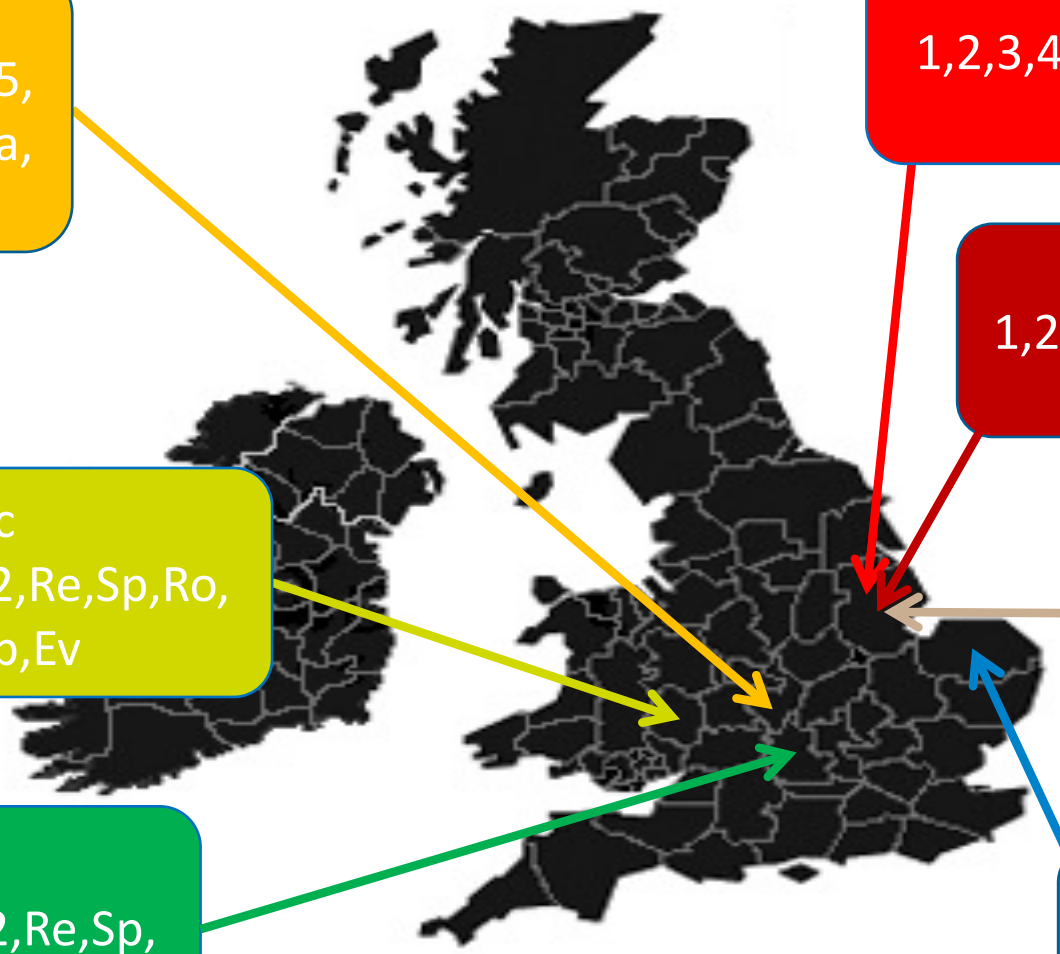
Pathotype	% Frequency
1,2,6,7,9,17,25,32,Sp,Ro,So,Ca,Ap	2.5
1,2,3,6,7,9,17,25,32,Re,Sp,Ro,So,Ca,Ap,Ev	2.5
1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,St,Kr,Ap,Ev	2.5
1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,St,Ap,Ev	2.5
1,2,3,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,St,Kr,Ap	2.5
1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,Kr,Ap,Ev	2.5
1,2,3,4,6,7,8,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,St,Kr,Ap,Cr,Ev	2.5

2021 Distribution of New Pathotypes

KWS Siskin
1,2,3,4,6,7,9,17,25,
32,Re,Sp,Ro,So,Wa,
St,Ap,Ev

KWS Jackal
1,2,3,4,6,7,8,9,17,25,32,Re,Sp,Ro,So,Wa,
Ca,St,Kr,Ap,Cr,Ev

RGT Illustrious
1,2,3,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,
St,Kr,Ap



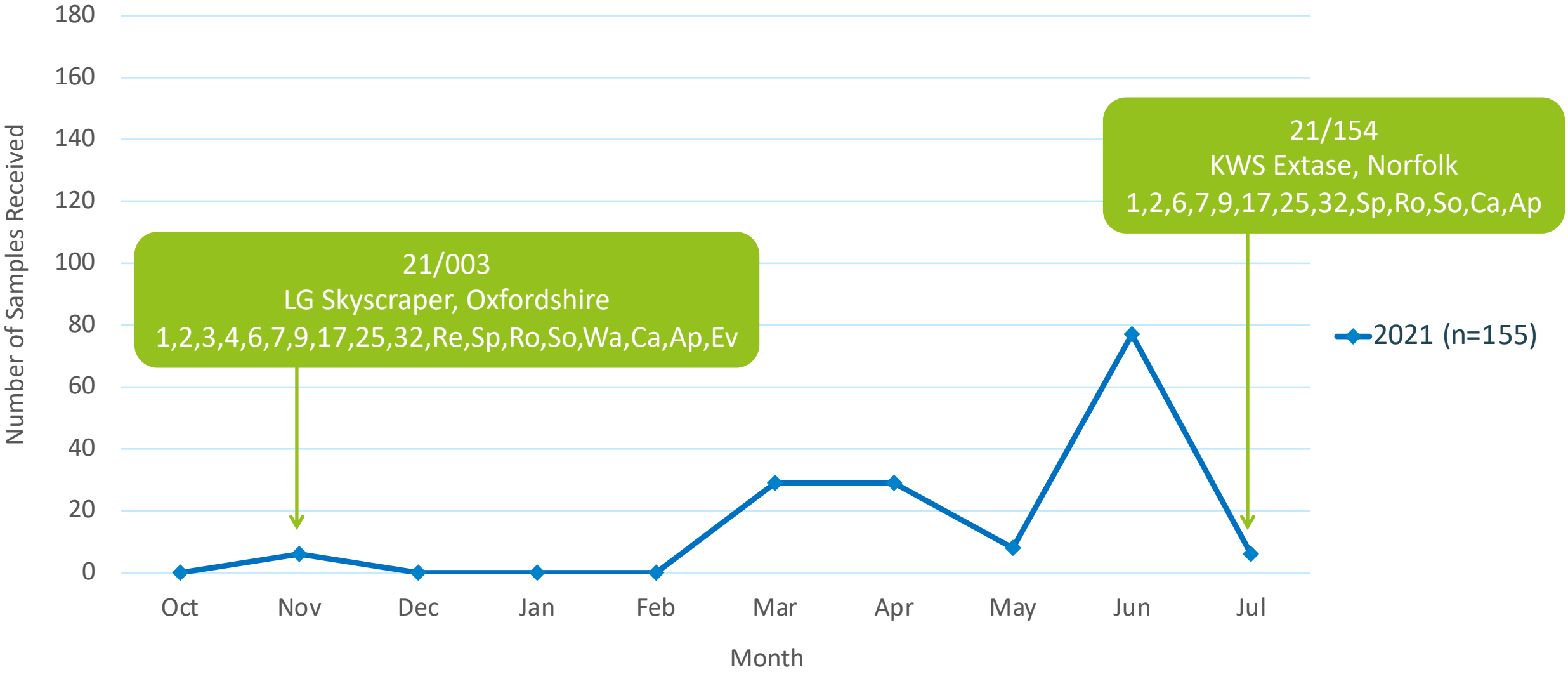
KWS Kinetic
1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,
So,Wa,Ca,Kr,Ap,Ev

KWS Barrel
1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,
St,Kr,Ap,Ev

Crusoe
1,2,3,6,7,9,17,25,32,Re,Sp,
Ro,So,Ca,Ap,Ev

KWS Extase
1,2,6,7,9,17,25,32,Sp,Ro,So,Ca,Ap

2021 WYR Samples Received

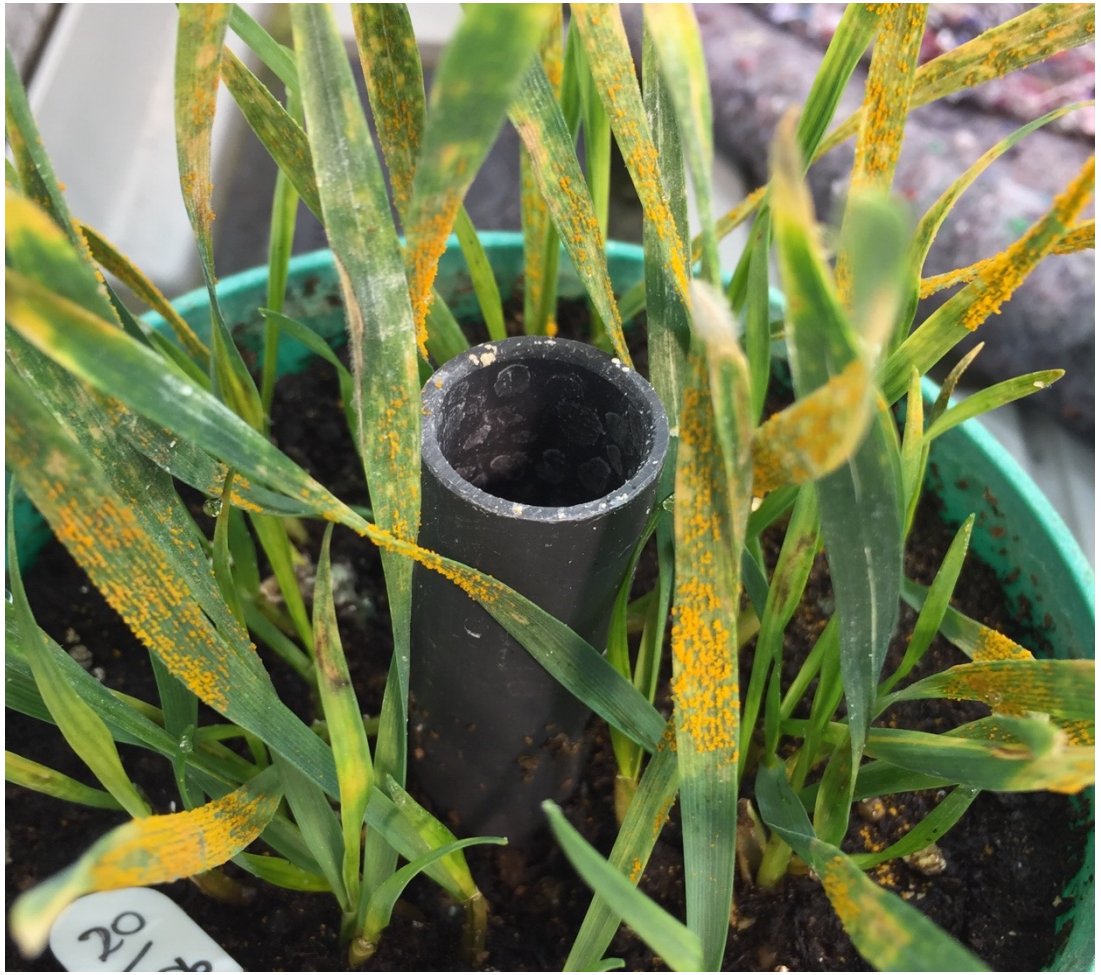


KWS Firefly Tests 2020

- Resistant in seedling virulence tests
- Mini tests conducted using 2020 KWS Firefly isolates
- Good AIT 3 infection levels in separate tests
- Environmentally sensitive?
- Further work needed

➢ Different lighting

➢ Different temperature regimes



KWS Firefly Tests 2021

Seedling tests conducted at a reduced temperature of 12/10 °C using two isolates from the 2021 survey

KWS Firefly Tests 2021

- Better sporulation seen on KWS Firefly with two 2021 isolates at a temperature regime of 12/10 °C
- More samples received from KWS Firefly in the cooler months March-April in 2020 and 2021

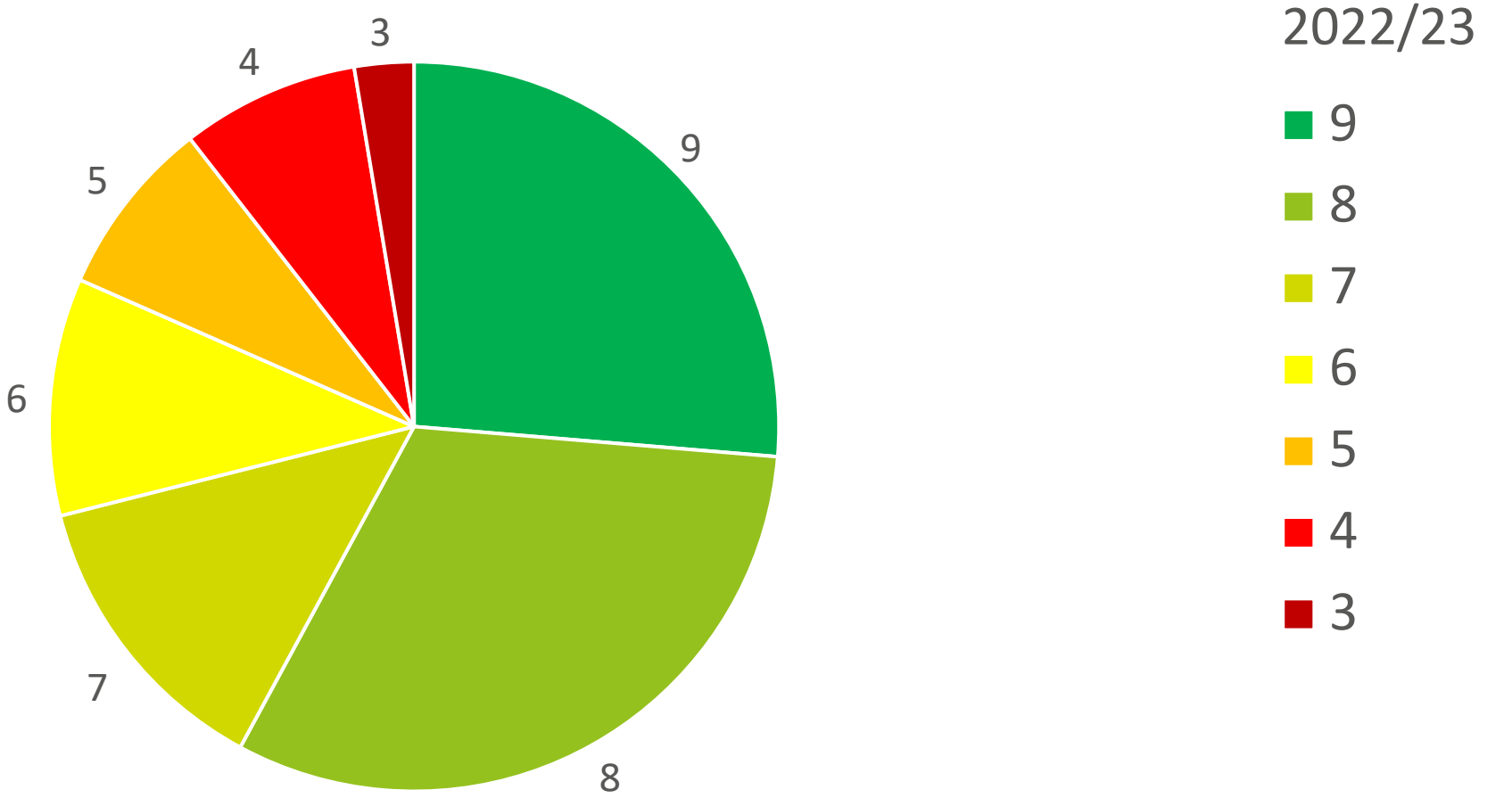
➢ Coincidence or could seedlings of KWS Firefly be more vulnerable to yellow rust at cooler temperatures?

2022 Season

2022 WYR Adult Plant Trials

Isolate	Host Variety	Pathotype
21/012	KWS Chilham	1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,St,Kr,Ap
21/014	LG Skyscraper	1,2,3,4,6,7,9,17,25,32,Sp,Ro,So,Wa,Ca,St,Ap
21/045	Skyfall	1,2,3,4,6,7,8,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,St,Kr,Ap
21/102	KWS Jackal	1,2,3,4,6,7,8,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,St,Kr,Ap,Cr,Ev
21/135	RGT Wolverine	1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Ca,St,Ap

RL 2022/23– Wheat Yellow Rust



Variety Rating Changes Over Time - WYR

Variety	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Gleam					7	6.9	6.7	5	5
KWS Barrel			8	8	8.2	8.5	8.5	6.9	6.2
KWS Firefly						8.7	8.6	6.6	6.1
KWS Kerrin				6.7	6.8	7	6.6	4.1	3.6
KWS Zyatt				7.0	7.2	7.5	7.3	5	4
LG Spotlight						8.2	8.1	5.6	4.6
RGT Gravity					8.3	8.4	8.2	6.5	5.8
Skyfall	6.2	5.9	6.2	6.1	5.7	5.4	5.2	3.2	3.2
SY Insitor							6.7	5.3	4.9

Wheat Yellow Rust Summary

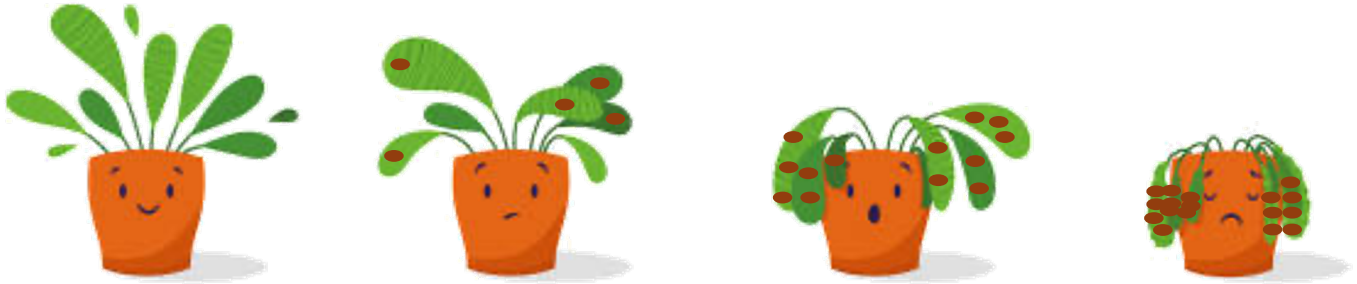
- 155 samples received in 2021
- 40 isolates seedling virulence tested
- 8% of isolates identified with virulence for *Yr8*
- 3% of isolates carried virulence for Crusoe
- Most common pathotypes seen in 2021 samples – Red 36, Red 37 and Red 41
- 7 new pathotypes, one with virulence for *Yr8* and Crusoe

Wheat Brown Rust

Sarah Wilderspin

Background

- Surveillance started later than other cereal diseases in 1973
- At the start of the survey there were limited options for resistant varieties to brown rust e.g. Clement
- In 2014 the *Puccinia triticina* population overcame the moderate resistance in Crusoe

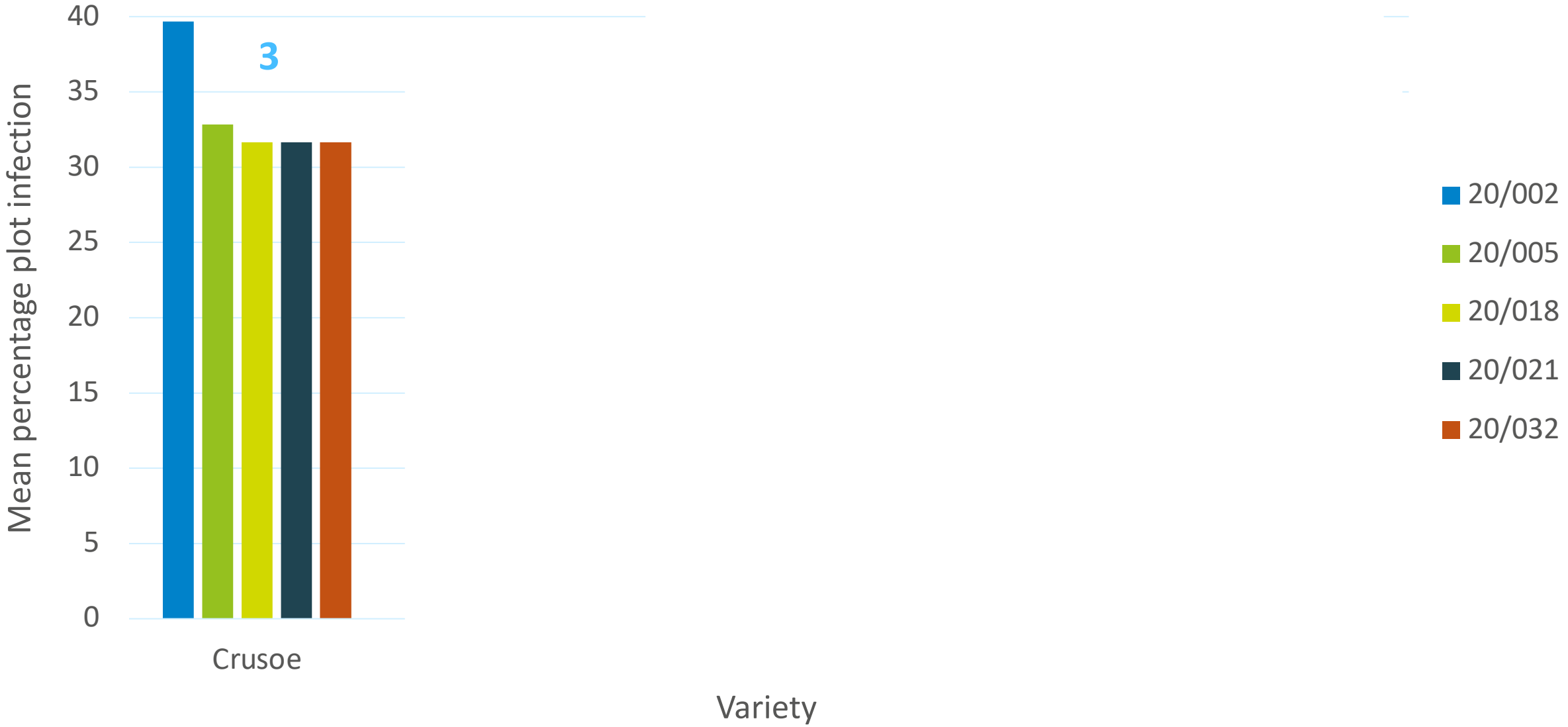


2020 samples

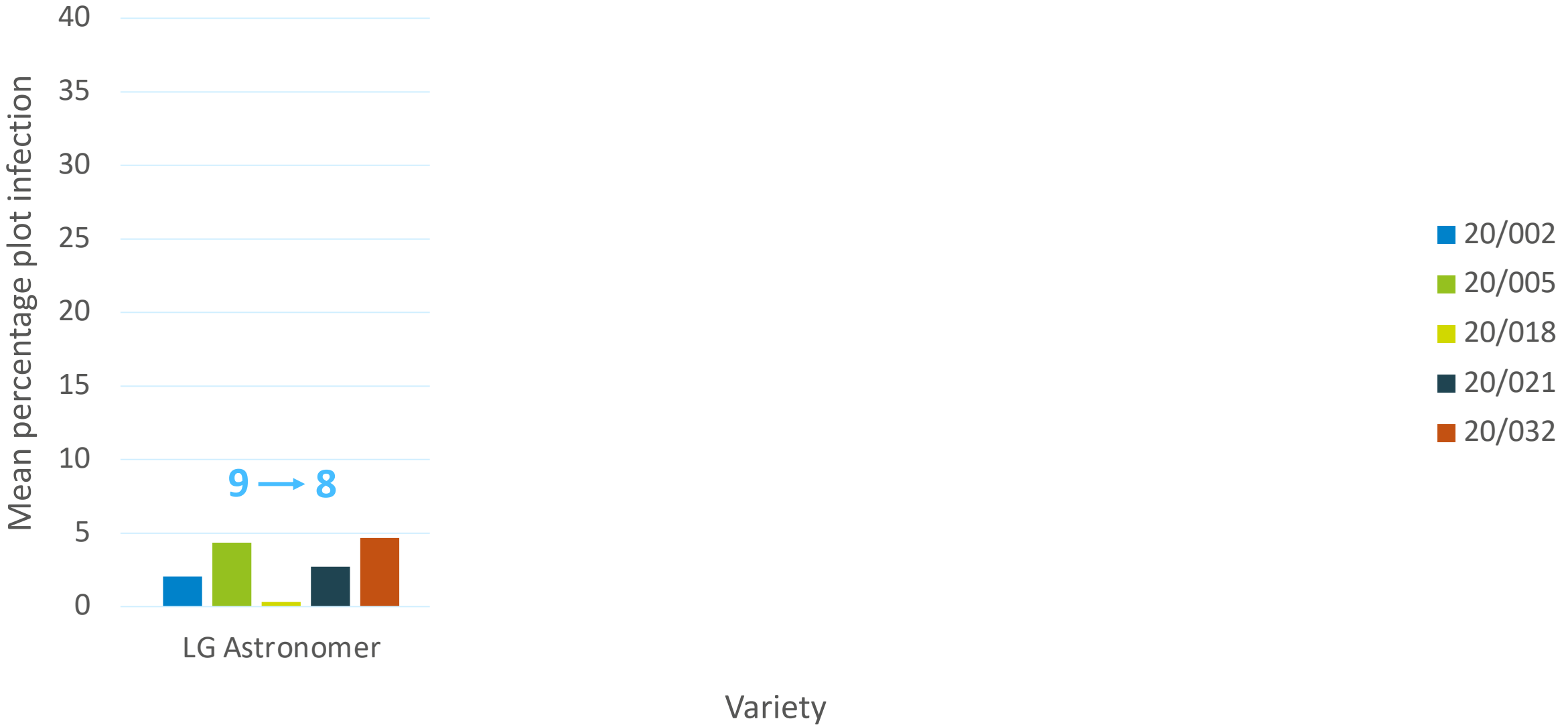
Adult Plant Trials

Isolate	Host Variety	Pathotype
20/002	KWS Colosseum	1,2c,3a,3bg,3ka,10,13,14a,15,16,17,23,26,37,Cr
20/005	KWS Firefly	1,3a,3bg,3ka,10,13,14a,15,16,17,23,26,28,37,Cr
20/018	Crusoe	1,2c,3a,3bg,3ka,10,13,14a,15,16,17,20,23,26,37,Cr
20/021	KWS Siskin	1,3a,3bg,3ka,10,13,14a,15,16,17,23,26,(28),37,Cr
20/032	KWS Extase	1,3a,3bg,3ka,10,13,14a,15,16,17,20,23,26,37,Cr

Adult Plant Trial Results



Adult Plant Trial Results



Variety Seedling Test Results

Seedling tests inoculated with same 5 isolates as those inoculated in the field

Variety	Current RL Rating	Seedling (Average Infection Type)					Adult Plant (% plot area infected)				
		20/002	20/005	20/018	20/021	20/032	20/002	20/005	20/018	20/021	20/032
Glasgow	-	3.0	3.0	*	3.0	3.0					
KWS Target	-	1.0	1.6	1.0	2.0	0.0					
Maris Halberd	-	2.0	2.0	2.0	2.0	3.0					
Robigus	-	1.0	1.0	1.0	2.0	0.5					
Theodore	7	0.0	0.0	0.0	0.0	0.0					
Stigg	-	0.9	0.6	1.2	0.6	0.3					
Skyfall	8	3.0	3.0	3.0	3.0	3.0					
Warrior	-	0.0	0.0	0.0	0.0	0.0					
Sterna	-	3.0	3.0	3.0	3.0	3.0					
LG Astronomer	9	1.0	0.0	1.0	2.0	0.0					
KWS Henum	Candidate	1.0	1.0	1.0	1.0	0.0					
LG Farrier	Candidate	2.0	3.0	3.0	2.0	2.0					
RGT Galactus	-	1.0	1.0	1.0	2.0	0.3					
LG Typhoon	Candidate	0.5	0.5	1.0	2.0	0.0					
Gamin	-	3.0	3.0	3.0	3.0	3.0					
Mayflower	Candidate	3.0	3.0	3.0	3.0	3.0					
Avalon	-	3.0	3.0	3.0	3.0	3.0					
LG Prince	8	1.0	1.0	1.0	2.0	0.1					
Astound	-	3.0	3.0	3.0	3.0	3.0					
KWS Kerrin	7	3.0	3.0	3.0	3.0	3.0					
RGT Wolverine	8	3.0	3.0	3.0	3.0	3.0					
LG Illuminate	8	1.0	0.0	*	1.0	*					
LG Quasar	8	1.0	0.0	1.0	2.0	0.2					
Champion	Candidate	1.0	1.0	1.0	2.0	2.0					
KWS Dawsum	Candidate	3.0	3.0	3.0	3.0	3.0					
LG Spotlight	6	3.0	3.0	3.0	3.0	3.0					
RGT Bairstow	2	1.0	0.2	1.0	3.0	0.0					
Merit	Candidate	1.0	1.0	1.0	2.0	0.0					
Sappo	-	2.0	2.0	3.0	2.0	3.0					

Variety	Current RL Rating	Seedling (Average Infection Type)					Adult Plant (% plot area infected)				
		20/002	20/005	20/018	20/021	20/032	20/002	20/005	20/018	20/021	20/032
RGT Saki	7	2.0	1.0	1.0	2.0	0.2	12.2	10.9	15.0	10.9	13.7
KWS Kinetic	6	3.0	3.0	3.0	3.0	3.0	0.0	0.0	12.2	6.3	13.8
RGT Rashid	Candidate	2.0	1.0	1.0	2.0	0.4	23.0	11.3	8.5	6.5	14.0
Banquo	-	3.0	3.0	3.0	3.0	3.0	21.4	17.8	14.5	21.3	14.3
RGT Flintoff	Candidate	3.0	3.0	3.0	3.0	3.0	9.5	11.7	0.0	6.2	14.4
Maris Ranger	-	0.0	*	1.0	*	*	0.0	5.0	0.0	2.5	14.4
Costello	5	3.0	3.0	3.0	3.0	3.0	16.2	19.3	14.5	17.3	14.8
RGT Silversurfer	-	2.0	1.0	1.0	2.0	0.0	11.2	14.9	15.7	8.4	14.8
Maris Fundin	-	3.0	3.0	3.0	3.0	3.0	4.2	5.0	11.7	15.7	15.3
SY Insitor	5	3.0	3.0	3.0	3.0	3.0	21.8	16.5	16.0	14.7	15.5
Swallow	6	1.0	1.0	1.0	2.0	0.1	16.3	20.9	12.7	16.2	15.5
Armada	-	3.0	3.0	3.0	3.0	3.0	13.5	11.7	11.7	12.4	15.7
KWS Sterling	-	3.0	3.0	3.0	3.0	3.0	19.3	14.5	14.7	19.3	15.7
KWS Palladium	Candidate	3.0	3.0	3.0	3.0	3.0	12.3	17.8	10.0	14.0	16.0
Elicit	6	3.0	3.0	3.0	3.0	3.0	15.8	11.4	13.5	16.2	16.3
KWS Jackal	5	3.0	3.0	3.0	3.0	3.0	21.7	16.8	19.0	16.2	16.5
RGT Gravity	6	3.0	3.0	3.0	3.0	3.0	9.3	13.2	15.5	14.8	16.8
KWS Extase	7	3.0	3.0	3.0	3.0	3.0	14.9	14.2	7.2	11.2	17.0
KWS Zyatt	6	3.0	3.0	3.0	3.0	3.0	0.0	14.3	0.0	0.6	17.2
Gleam	6	3.0	3.0	3.0	3.0	3.0	16.5	14.0	10.0	16.5	17.7
KWS Brium	Candidate	3.0	3.0	3.0	3.0	3.0	16.8	14.3	17.8	18.2	17.7
Tuxedo	-	3.0	3.0	3.0	3.0	3.0	15.6	19.3	15.9	15.0	17.7
Graham	5	3.0	3.0	3.0	3.0	3.0	26.0	18.0	19.3	19.8	18.2
LG Skyscraper	6	3.0	3.0	3.0	3.0	3.0	16.0	14.7	12.4	12.3	18.2
RGT Stokes	Candidate	3.0	3.0	3.0	3.0	3.0	16.4	11.7	9.5	12.2	18.2
KWS Cranium	5	3.0	3.0	3.0	3.0	3.0	14.0	15.7	18.2	21.0	18.3
KWS Siskin	5	3.0	3.0	3.0	3.0	3.0	16.8	18.7	17.2	12.4	18.3
RGT Illustrious	6	3.0	3.0	3.0	3.0	3.0	14.7	15.3	11.7	15.7	18.3
KWS Barrel	5	3.0	3.0	3.0	3.0	3.0	16.2	17.0	14.2	16.8	18.8
Soissons	-	3.0	3.0	3.0	3.0	3.0	13.0	15.5	18.5	17.3	19.3
KWS Firefly	5	1.0	1.0	1.0	2.0	0.0	18.2	18.0	6.2	9.7	19.5
Reaper	-	3.0	3.0	3.0	3.0	3.0	28.3	24.3	16.2	19.0	20.7

Variety Seedling Test Results

Seedling tests inoculated with same 5 isolates as those inoculated in the field

Resistant

- Champion
- KWS Firefly
- KWS Henum
- LG Astronomer
- LG Illuminate
- LG Prince
- LG Quasar
- LG Typhoon

Resistant

- Merit
- RGT Galactus
- RGT Rashid
- RGT Saki
- RGT Silversurfer
- Swallow
- Theodore

Susceptible

- All other RL varieties were susceptible to all 5 isolates, except for:
- LG Farrier
- RGT Bairstow

Variety Seedling vs Adult Plant Test Results

Table 13: Seedling and adult plant reactions to the five isolates selected for further characterisation. Seedling results are shown as average infection types on a scale of 0-4. Adult plant results are given as a percentage leaf area infected averaged over four assessments. Varieties are ordered in level of disease at adult plant stage. Control varieties are highlighted in green text.

Variety	Current RL	Seedling (Average Infection Type)	Adult Plant (% plot area infected)
Glasgow			
KWS Target			
Maris Halberd			
Robigus			
Theodore			
Stigg			
Skyfall			
Warrior			
Sterna			
LG Astronomer			
KWS Henum			
LG Farrier			
RGT Galactus			
LG Typhoon			
Gamin			
Mayflower			
Avalon			
LG Prince			
Astound			
KWS Kerrin			
RGT Wolverine			
LG Illuminate			
LG Quasar			
Champion			
KWS Dawsum			
LG Spotlight			
RGT Bairstow			
Merit			
Sappo			

Variety	Current RL Rating	Seedling (Average Infection Type)	Adult Plant (% plot area infected)
RGT Saki	7		
KWS Kinetic	6		
RGT Rashid	Candidate		
Banquo	-		
RGT Flintoff	Candidate		
Maris Ranger	-		
Costello	5		
RGT Silversurfer	-		
Maris Fundin	-		
SY Insitor	5		
Swallow	6		
Armada	-		
KWS Sterling	-		
KWS Palladium	Candidate		
Elicit	6		
KWS Jackal	5		
RGT Gravity	6		
KWS Extase	7		
KWS Zyatt	6		
Gleam	6		
KWS Brium	Candidate		
Tuxedo	-		
Graham	5		
LG Skyscraper	6		
RGT Stokes	Candidate		
KWS Cranium	5		
KWS Siskin	5		
RGT Illustrious	6		
KWS Barrel	5		
Soissons	-		
KWS Firefly	5		
Reaper	-		

Variety	Current RL Rating	Seedling (Average Infection Type)					Adult Plant (% plot area infected)				
		20/002	20/005	20/018	20/021	20/032	20/002	20/005	20/018	20/021	20/032
RGT Lantern	-	3.0	3.0	3.0	3.0	3.0	15.7	18.8	14.7	15.3	20.7
Mascot	-	3.0	3.0	3.0	3.0	3.0	16.7	22.0	10.5	15.3	22.2
Consort	-	3.0	3.0	3.0	3.0	3.0	26.5	20.8	8.8	19.8	22.8
Maris Huntsman	-	3.0	3.0	3.0	3.0	3.0	19.4	21.9	17.3	17.3	23.8
Elation	5	3.0	3.0	3.0	3.0	3.0	25.2	22.7	16.9	19.7	24.2
KWS Guium	Candidate	3.0	3.0	3.0	3.0	3.0	21.2	30.8	22.3	23.8	25.3
Buster	-	3.0	3.0	3.0	3.0	3.0	29.8	35.8	32.2	30.8	31.2
Crusoe	3	3.0	3.0	3.0	3.0	3.0	39.7	32.8	31.7	31.7	31.7
Thatcher Lr 1	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Thatcher Lr 2a	-	1.0	1.0	1.0	1.0	1.0	*	*	*	*	*
Thatcher Lr 2b	-	2.0	1.0	2.0	1.0	1.0	*	*	*	*	*
Thatcher Lr 2c	-	2.0	2.0	3.0	2.0	2.0	*	*	*	*	*
Thatcher Lr 3a	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Thatcher Lr 3bg	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Thatcher Lr 3ka	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Thatcher Lr 10	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Thatcher Lr 13	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Thatcher Lr 14a	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Thatcher Lr 15	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Thatcher Lr 16	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Thatcher Lr 17	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Thatcher Lr 20	-	2.0	2.0	2.0	2.0	3.0	*	*	*	*	*
Thatcher Lr 23	-	3.0	3.0	2.0	3.0	2.0	*	*	*	*	*
Thatcher Lr 24	-	0.6	1.5	1.2	0.6	1.2	*	*	*	*	*
Thatcher Lr 26	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Thatcher Lr 28	-	0.2	0.3	1.0	2.0	0.2	*	*	*	*	*
Thatcher Lr 37	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Clement	-	3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Mean	**-**	*	*	*	*	*	**12.6**	**12.8**	**10.9**	**11.7**	**13.7**

Variety Seedling vs Adult Plant Test Results

Variety	RL Rating 2021/22	Seedling (Average Infection Type)					Adult Plant (% plot area infected)				
		20/002	20/005	20/018	20/021	20/032	20/002	20/005	20/018	20/021	20/032
Theodore	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0
Glasgow	-	3.0	3.0	*	3.0	3.0	0.0	0.0	0.0	0.1	0.0
Skyfall	8	3.0	3.0	3.0	3.0	3.0	0.5	0.0	0.0	0.0	0.6
KWS Extase	7	3.0	3.0	3.0	3.0	3.0	14.9	14.2	7.2	11.2	17.0
RGT Gravity	6	3.0	3.0	3.0	3.0	3.0	9.3	13.2	15.5	14.8	16.8
Crusoe	3	3.0	3.0	3.0	3.0	3.0	39.7	32.8	31.7	31.7	31.7
KWS Guium	4	3.0	3.0	3.0	3.0	3.0	21.2	30.8	22.3	23.8	25.3

2020 Wheat Brown Rust Summary

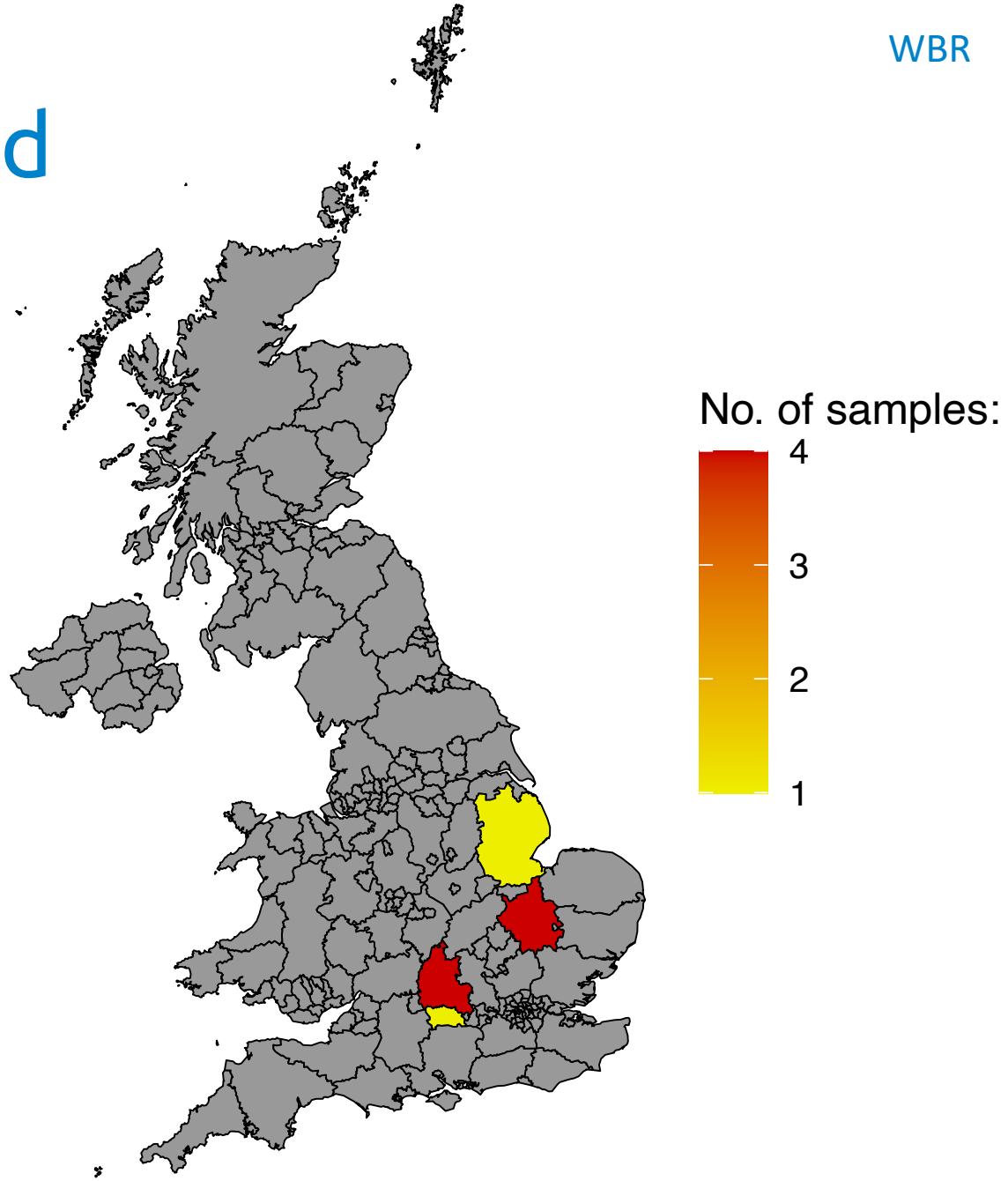
- Variety seedling tests
  - 15 RL varieties were resistant to all 5 isolates tested
  - All other RL varieties were susceptible to all 5 isolates with the exception of LG Farrier and RGT Bairstow

- Adult plant trials
  - Overall higher plot infection levels compared to last year
  - Results mostly reflected changes in RL ratings from 2021/22 to 2022/23
  - There were no major changes in varietal performance

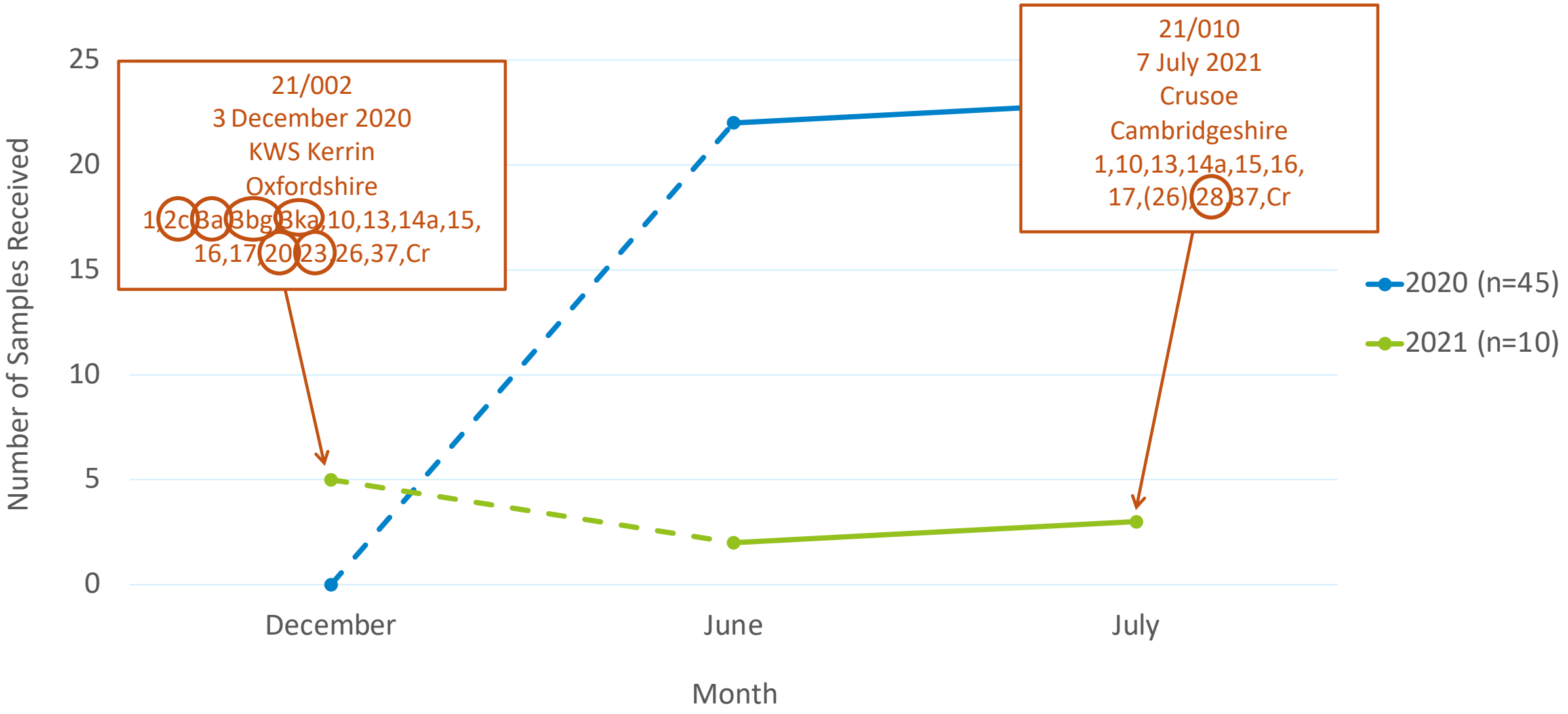
2021 samples

2021 WBR Samples Received

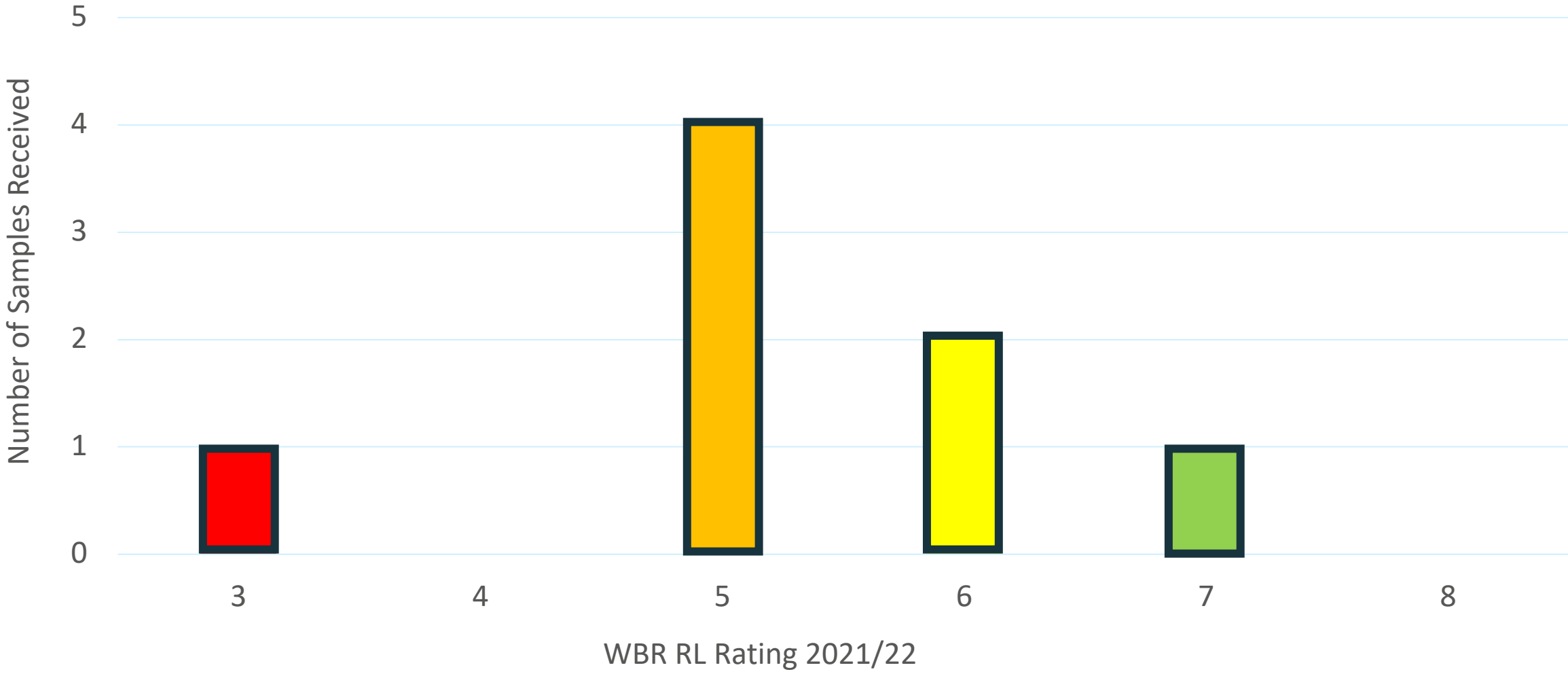
- 10 samples
- 4 counties
- 7 varieties
- 8 samples arrived on RL varieties and candidates



Timescale of Samples Received

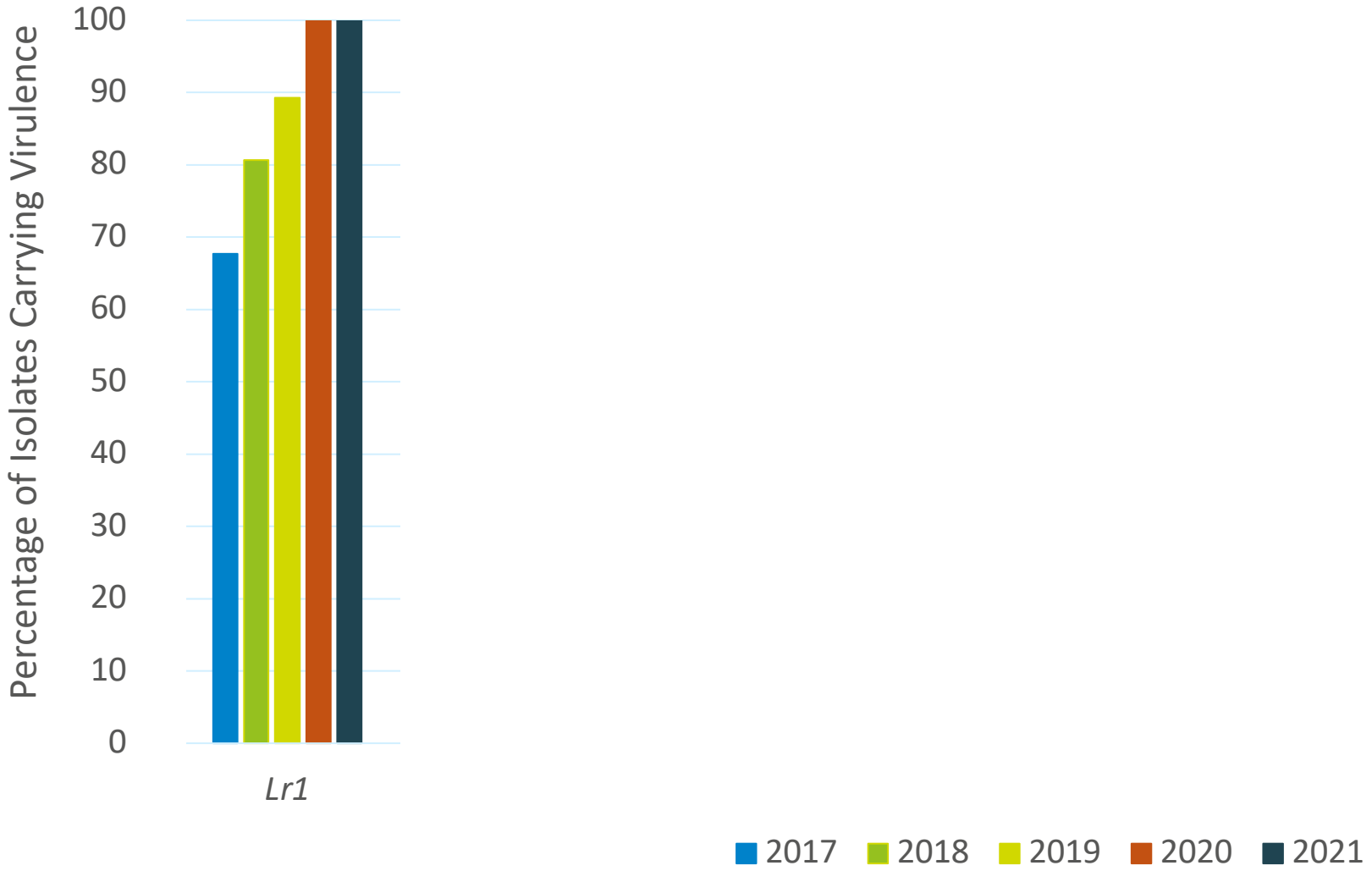


Samples Received RL Ratings

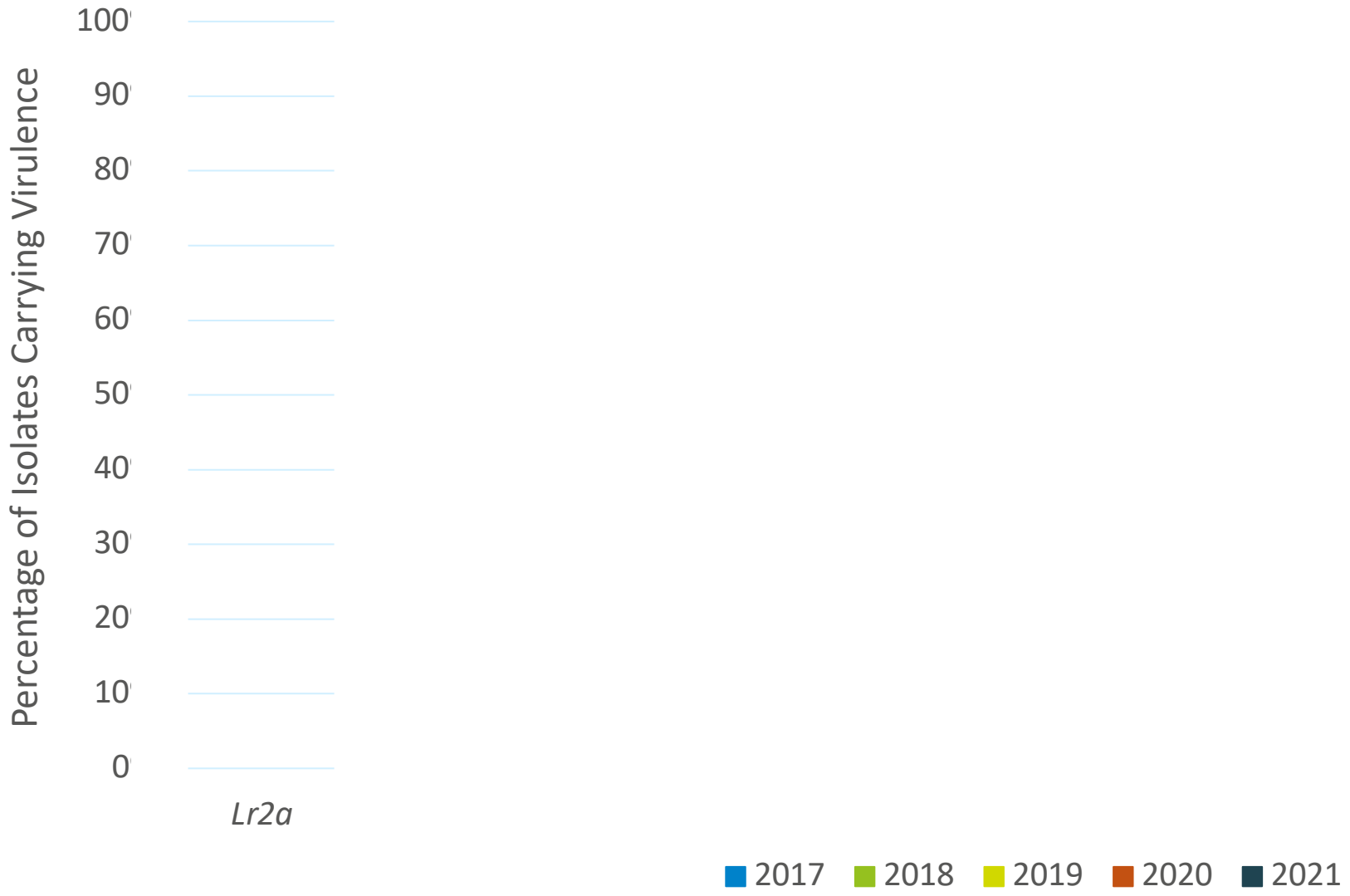


2 samples not on 2021/22 RL list

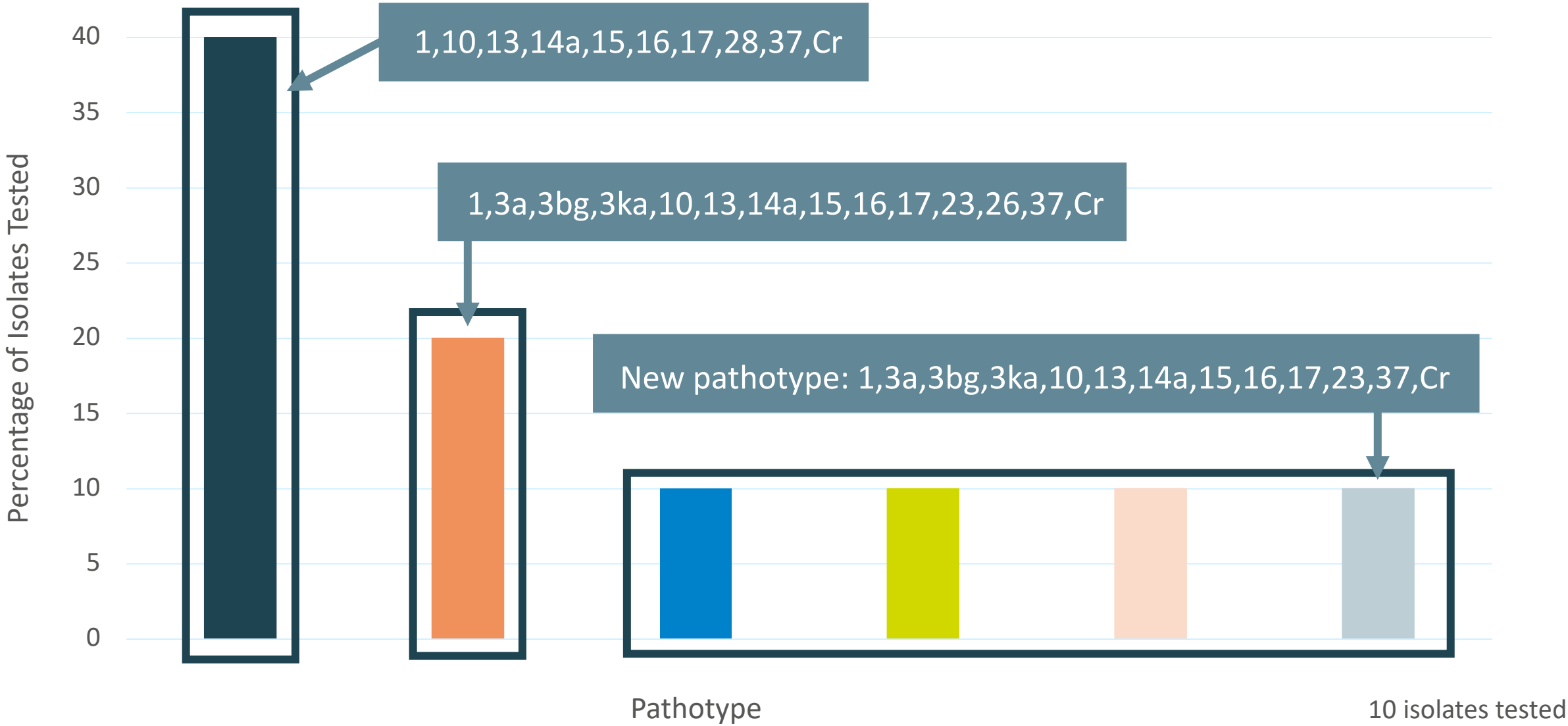
Virulence Frequencies: 5 Year Summary



Virulence Frequencies: 5 Year Summary



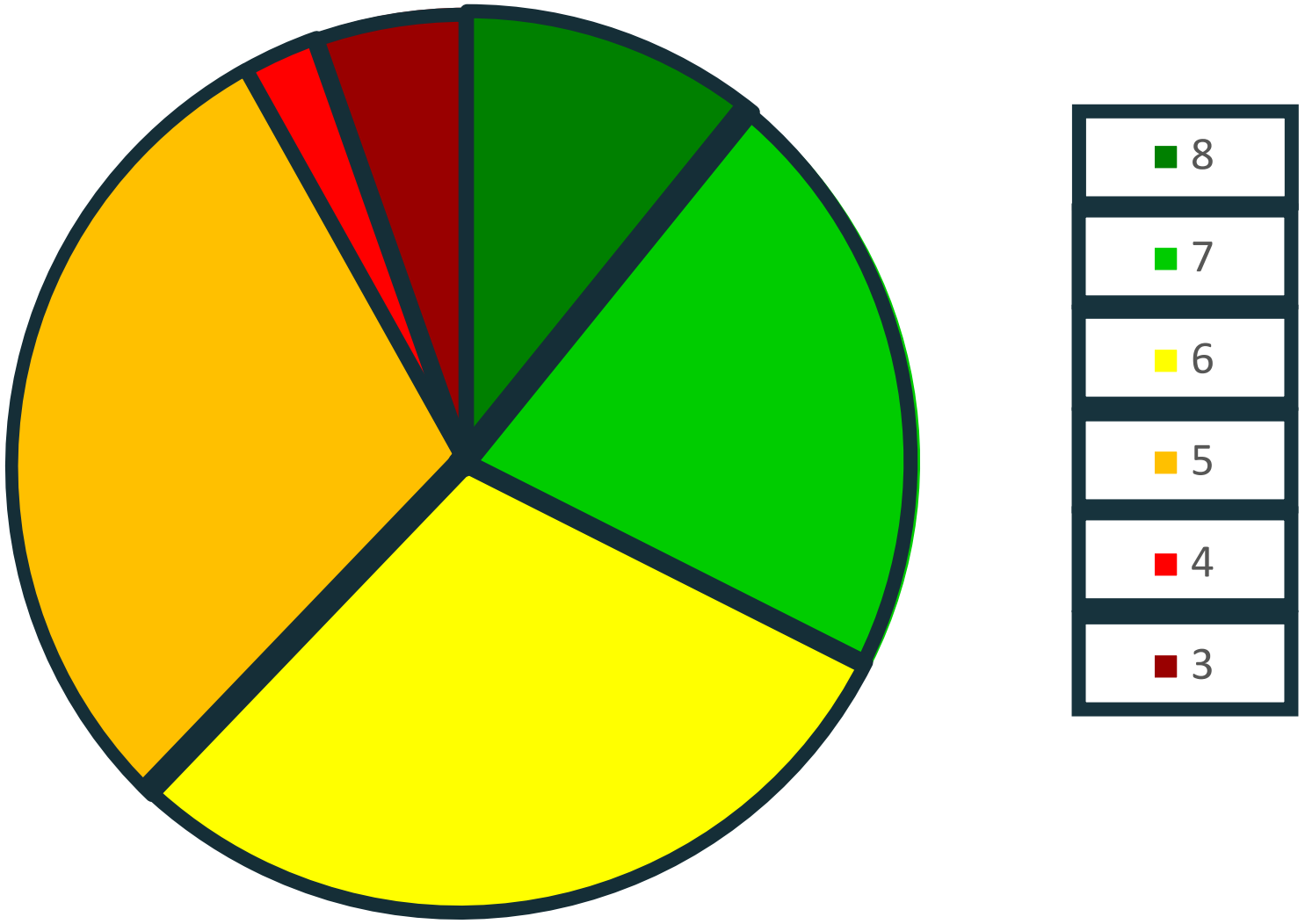
Pathotype Frequency 2021



Adult Plant Trials 2022

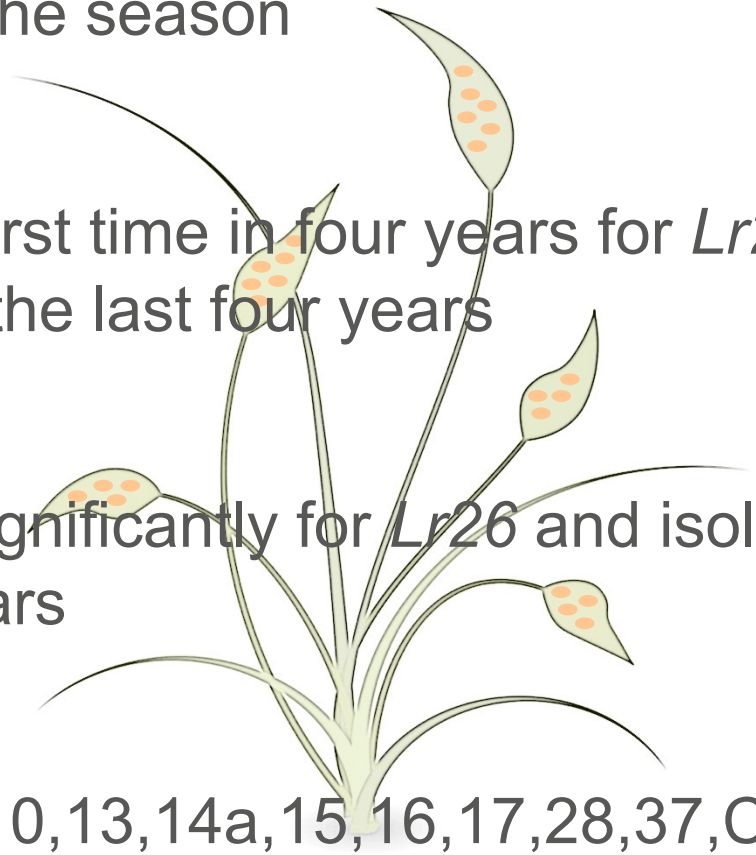
Isolate	Host Variety	Pathotype
21/002	KWS Kerrin	1,2c,3a,3bg,3ka,10,13,14a,15,16,17,20,23,26,37,Cr
21/003	LG Skyscraper	1,10,13,14a,15,16,17,28,37,Cr
21/004	KWS Basset	1,3a,3bg,3ka,10,13,14a,15,16,17,23,26,37,Cr
21/006	KWS Cranium	1,10,13,14a,15,16,17,(20),28,37,Cr
21/008	Relay	1,3a,3bg,3ka,10,13,14a,15,16,17,23,37,Cr

WBR RL Ratings 2022/23



2021 Wheat Brown Rust Summary

- Moderate to low disease pressure arriving late in the season
- Seedling virulence frequencies increased for the first time in four years for *Lr20 and Lr23* and continued to increase for *Lr28* over the last four years
- Seedling virulence frequencies have decreased significantly for *Lr26* and isolates tested remain avirulent to *Lr24* for the last four years
- A prevalent pathotype was detected for 2021 – 1,10,13,14a,15,16,17,28,37,Cr

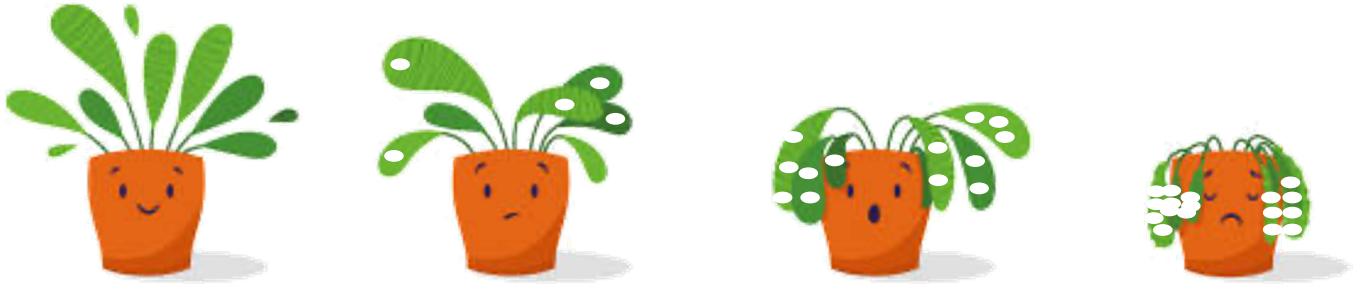


Wheat Powdery Mildew

Sarah Wilderspin

WPM Background

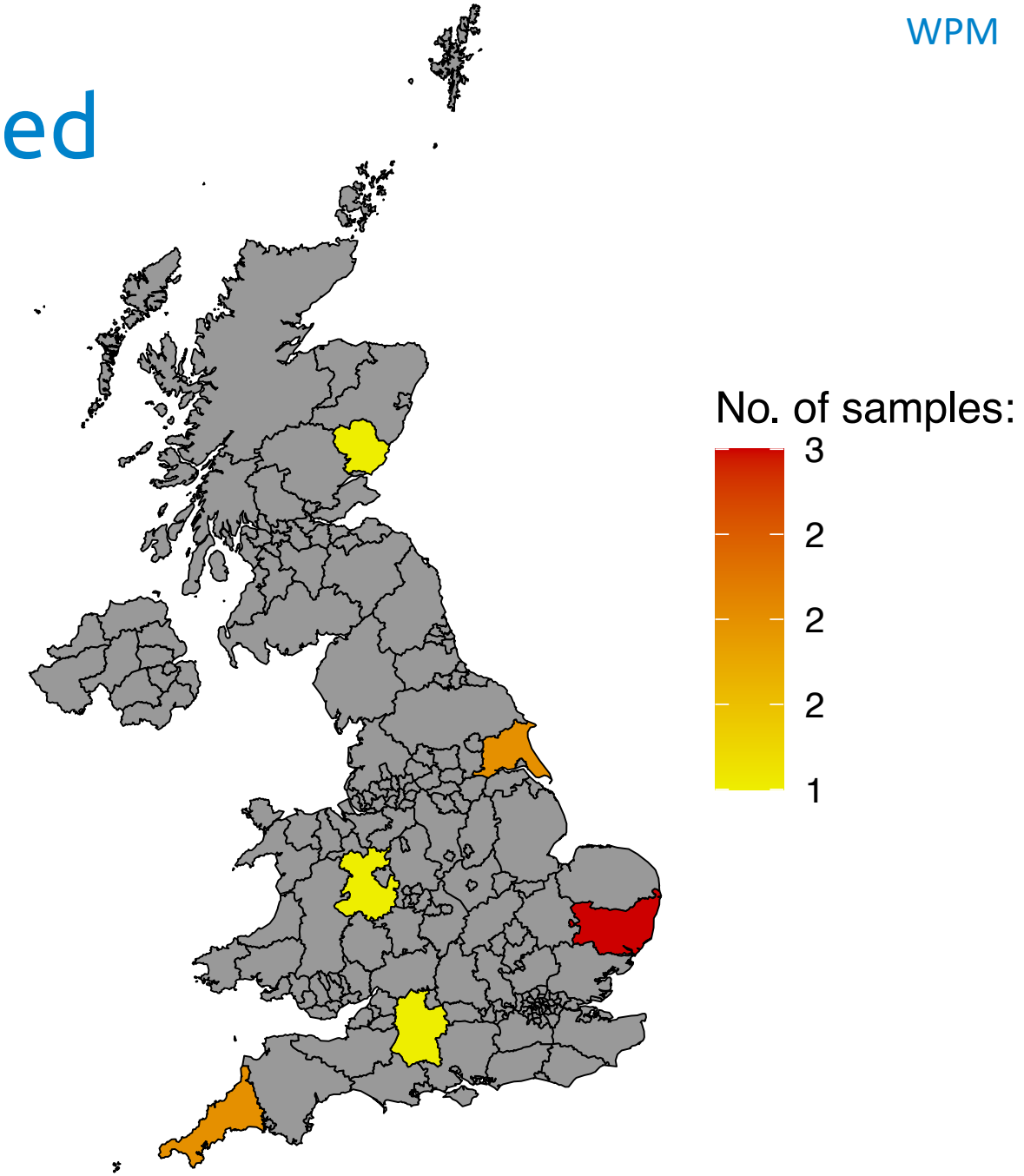
- Monitored since the beginning of the survey
- Resistance to mildew is based on *Pm* genes and other unnamed genes
- Historically there were issues with swift breakdowns in resistance as the *Pm* genes were overcome but now it's a more stable situation



2021 WPM Samples Received

- 10 samples
- 6 counties
- 3 varieties
  + 6 unknown varieties

- 8 single pustule isolates tested from 4 samples

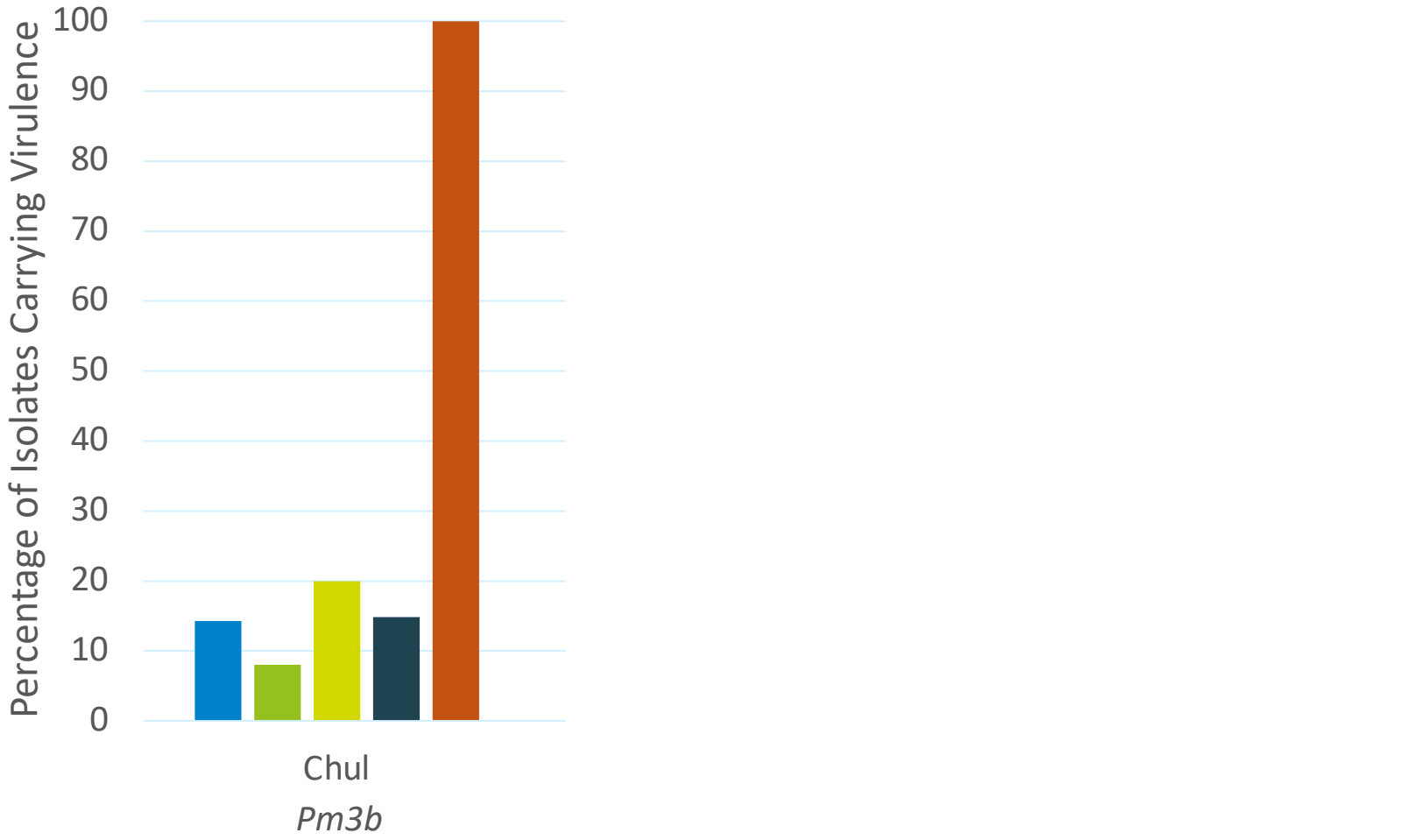


Current Differential Set

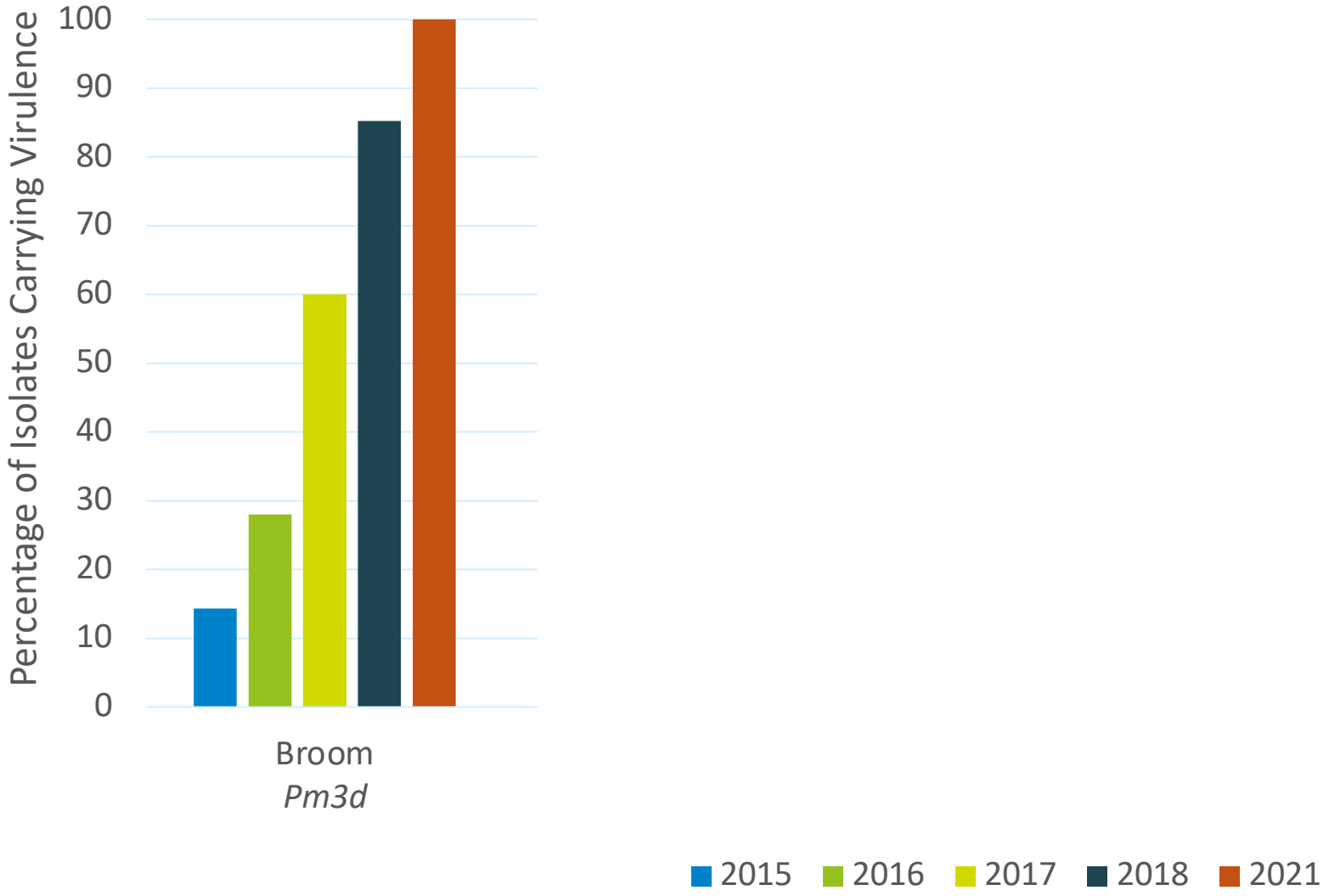
Differential	Resistance Gene
Cerco	
Galahad	*Pm2*
Chul	*Pm3b*
Armada	*Pm4b*
Flanders	*Pm5*
Brimstone	*Pm6*
Clement	*Mld*
Maris Dove	*Pm8*
Brock	*Pm2, MlTa2*
Mercia	*Pm5, MlTa2*
Tonic	*MlTo*

Differential	Resistance Gene
Broom	*Pm3d*
Sicco	*Pm5, MiSi2*
Wembley	*MlSo*
Axona	*MlAx*
Amigo	*Pm17*
Shamrock	*MlSh*
Robigus	*MlRo*
Warrior	
Stigg	
Crusoe	

Virulence Frequencies: 5 Year Summary



Virulence Frequencies: 5 Year Summary

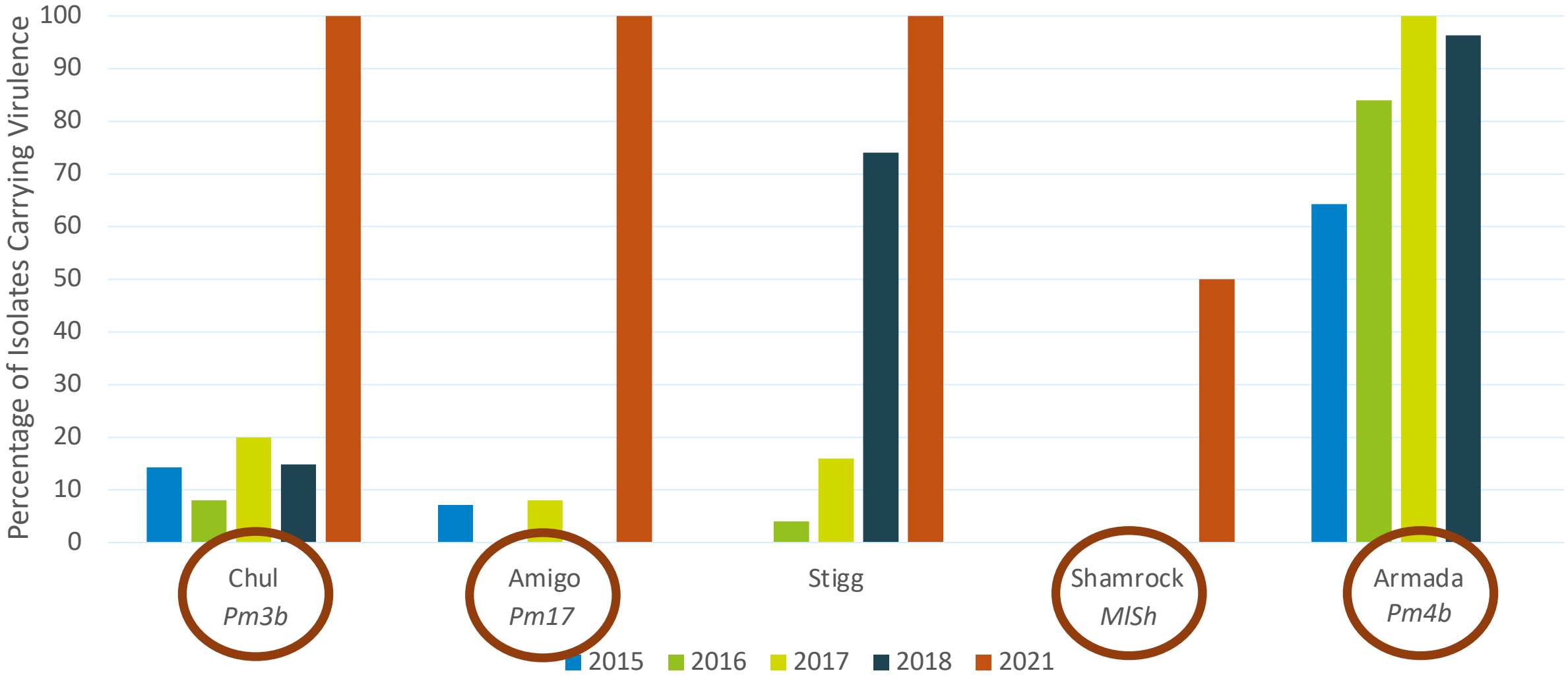


Pathotypes

- Not one single dominant pathotype: 8 pathotypes from 8 isolates tested

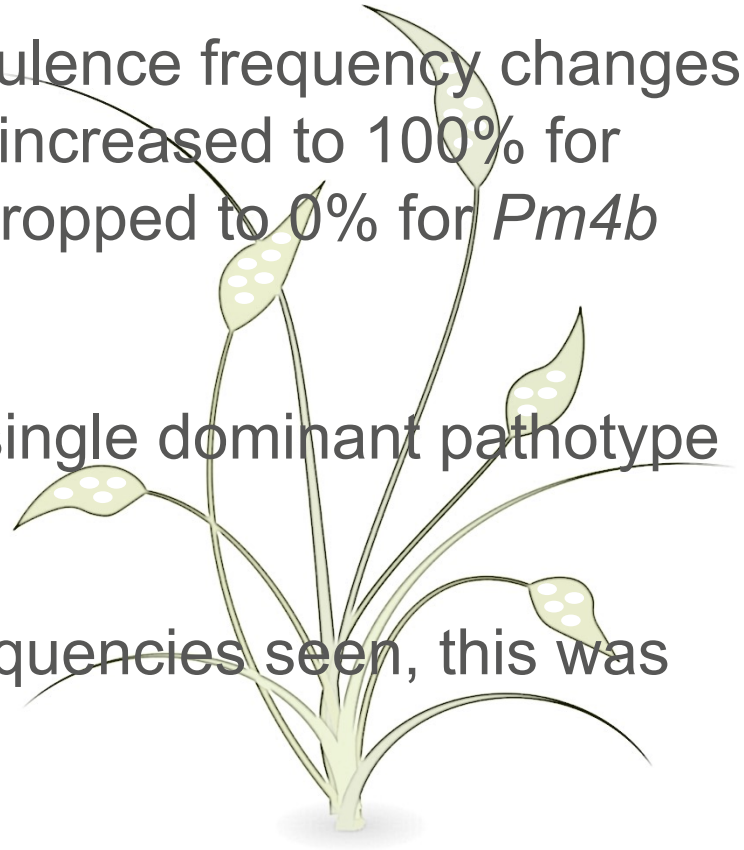
- All 8 pathotypes novel from 2021
  - Mainly due to increases in virulence for *Pm3b, Pm17* and *MlSh* and virulence dropping for *Pm4b*

Virulence Frequencies: 5 Year Summary



Wheat Powdery Mildew Summary

- Some resistance genes saw significant seedling virulence frequency changes compared to previous years; virulence frequencies increased to 100% for *Pm3b, Pm17* and Stigg and to 50% for *MlSh,* and dropped to 0% for *Pm4b*
- 8 new pathotypes were identified for 2021 with no single dominant pathotype
- Although there were some changes in virulence frequencies seen, this was not linked to any reports in the field



Barley Powdery Mildew

Amelia Hubbard

2021 BPM Samples Received

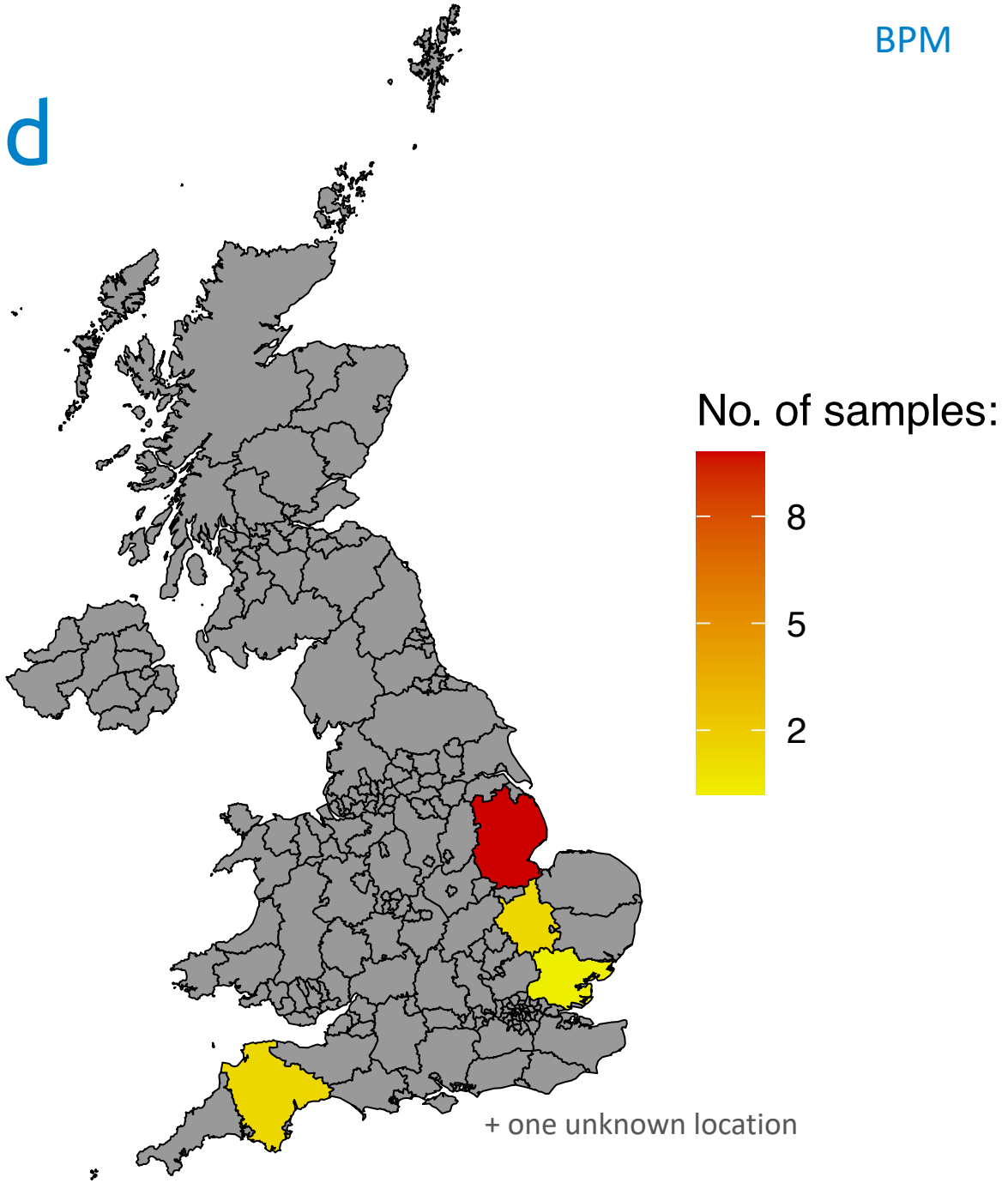
- 15 samples
- 4 counties

  + one unknown

- 9 varieties

  + 6 unknown

➢ 26 single pustule isolates tested from 15 samples

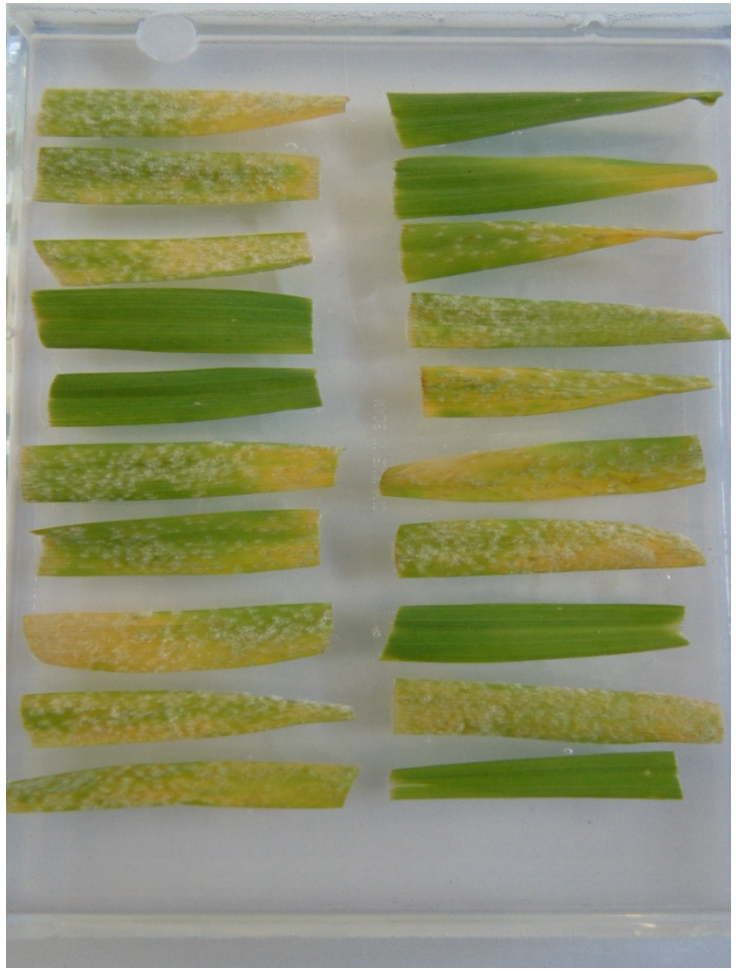


Current BPM Differential Set

Differential	Resistance Gene
Golden Promise	0
W.37/136	*Mlh*
W.41/145	*Mlra*
Goldfoil	*Mlg*
Zephyr	*Mlg,Ml(CP)*
Midas	*Mla6*
Lofa	*MlLa*
Hassan	*Mla12*
H.1063	*Mlk1*
Porter	*Mla7*
Lotta	*MlAb*
Triumph	*Mla7,MlAb*

Differential	Resistance Gene
Tyra	*Mla1*
Roland	*Mla9*
Apex	*mlo11*
Riviera	*mlo11*
Digger	*Mla13*
Ricardo	*Mla3*
Vanessa	
Optic	
Propino	
Funky	
Bazooka	

BPM Differential Tests

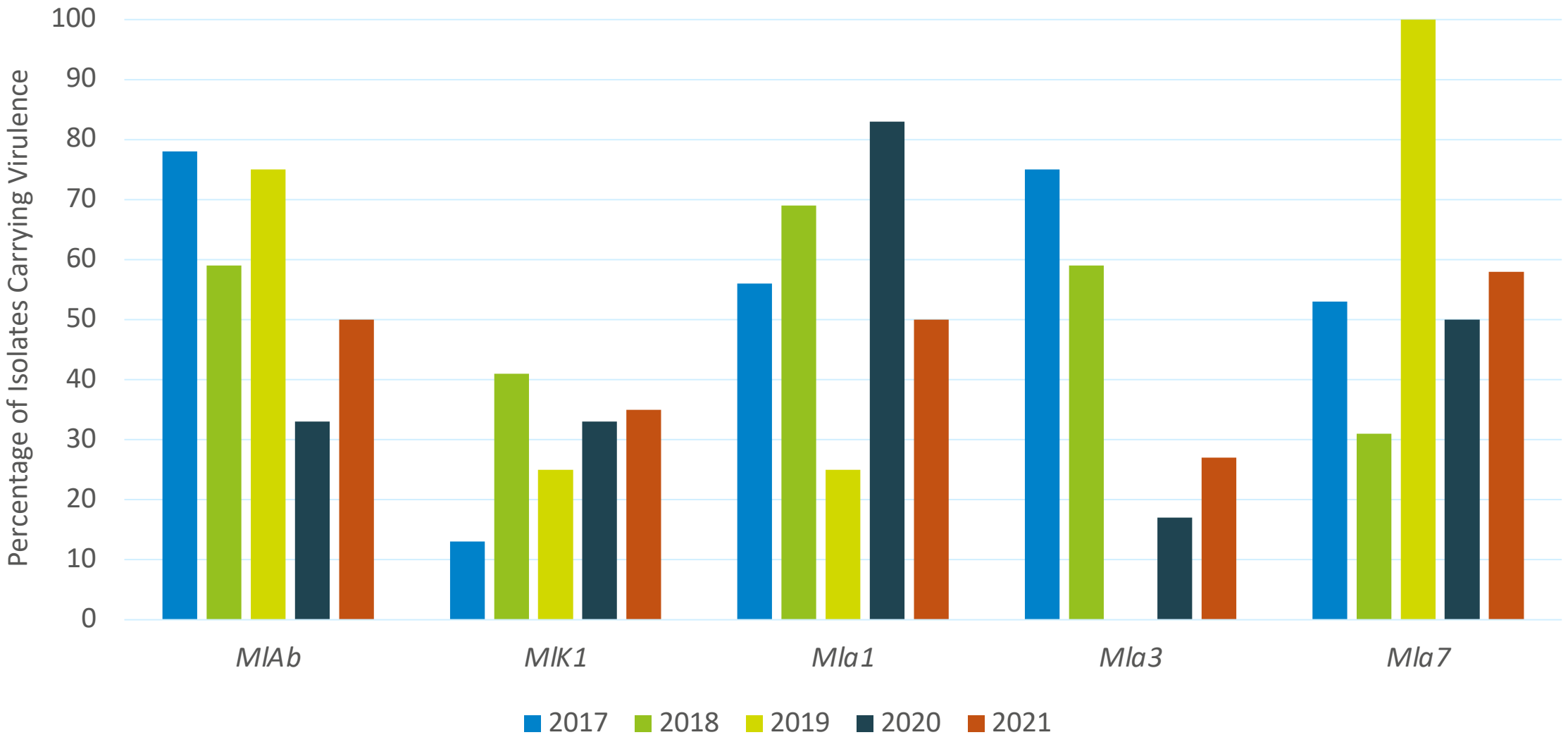


- Detached leaf segments inoculated with a single isolate
- 4 reps per test
- Scored on 0-4 scale

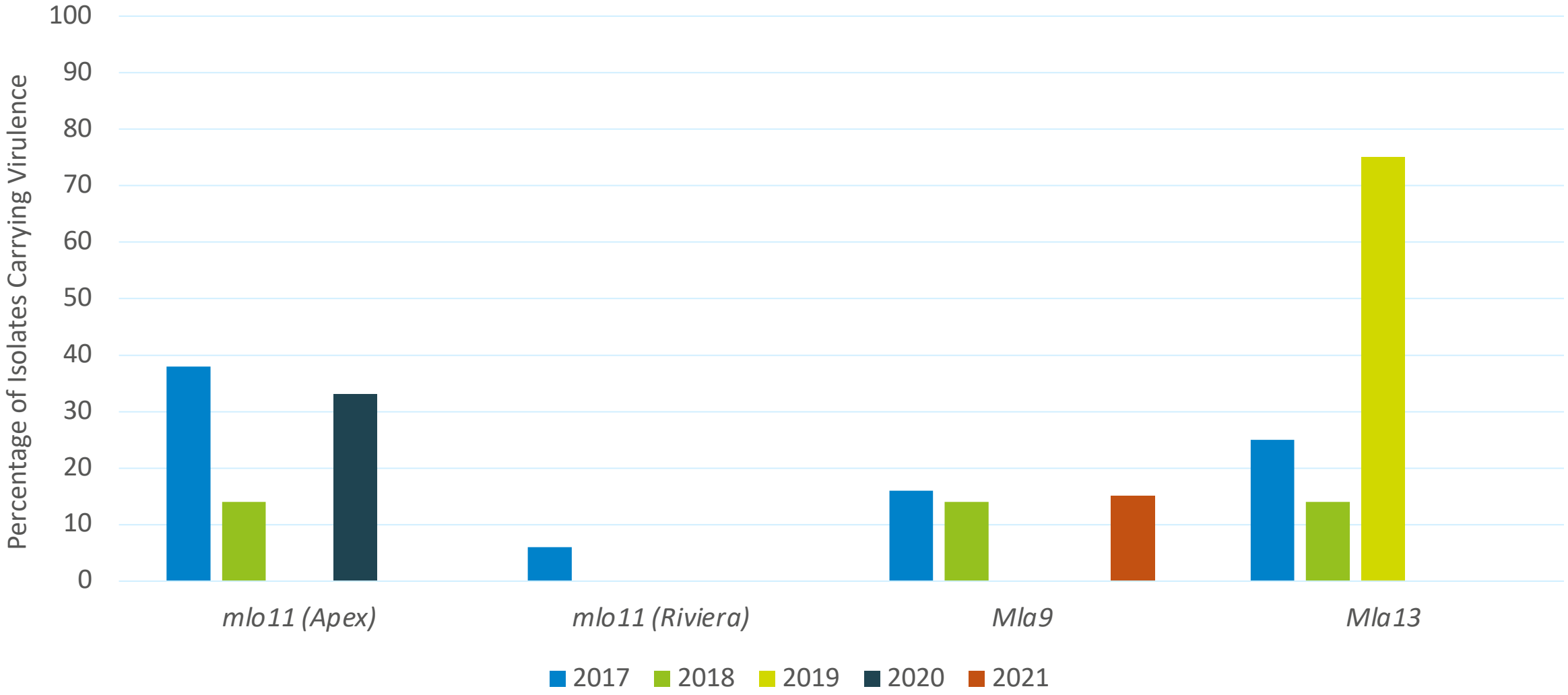
  0 = no sporulation, no mycelium

  4 = abundant sporulation, abundant mycelium
- 2.7 and over is classed as susceptible

BPM 5 Year Summary



BPM 5 Year Summary



2021 Barley Powdery Mildew Summary

- 26 single pustule isolates tested from 15 samples
- Virulence for *Mlh, Mlra, Mlg, MlCP, Mla6* and *Mla12* was found in >80% of isolates
- Virulence for *Mla9* rose from 0% in 2019 and 2020 to 15% in 2021 reaching a level similar to that seen in 2018
- No virulence was detected for *mlo11* (Apex), *mlo11* (Riviera) and *Mla13*

Genotyping

Charlotte Nellist

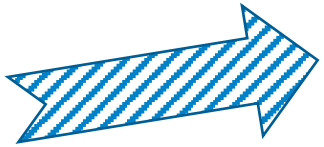
Genotyping of WYR

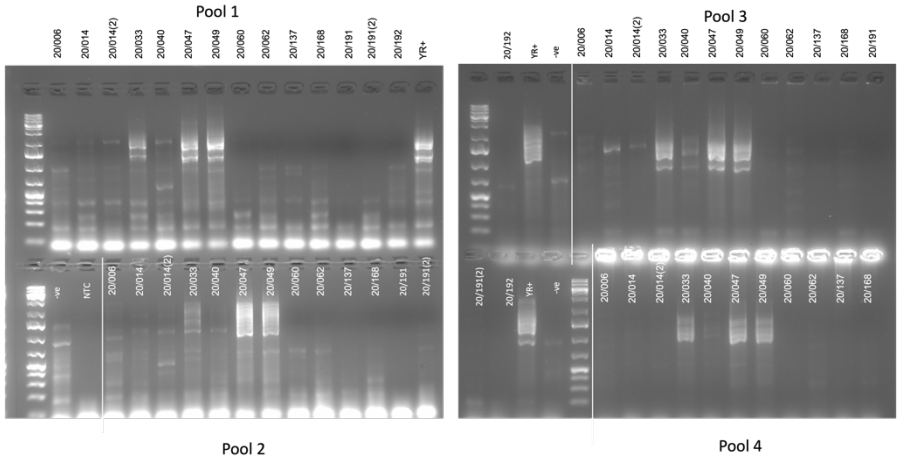
Aim: Develop routine genotyping of wheat yellow rust isolates using results from the Field Pathogenomics project to categorise isolates into the different genetic groups

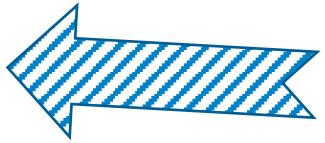
NIAB is optimising the WYR genotyping:

- 24 isolates selected from 2019
- 24 isolates selected from 2020
- 48 isolates selected from 2021

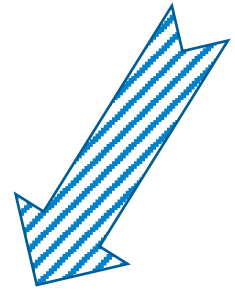
Genotyping progress





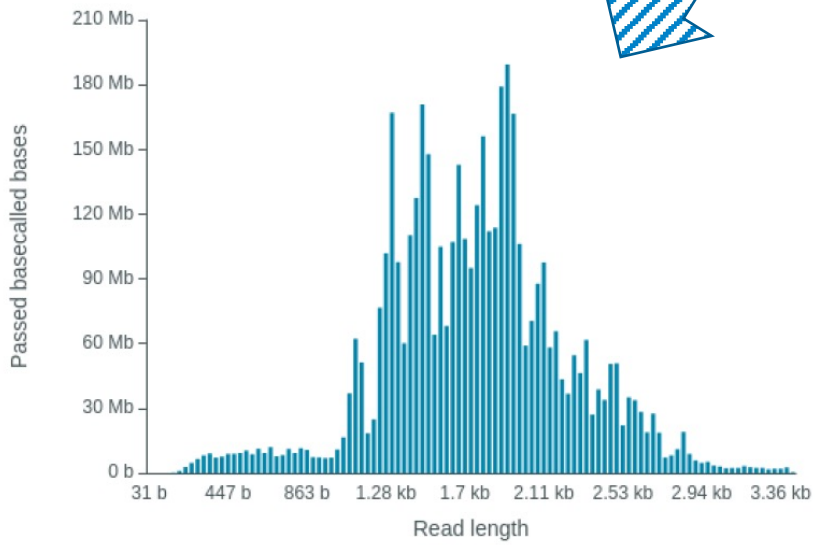


- ✓ 24 2019 isolates
- ✓ 24 2020 isolates
- ✓ 48 2021 isolates



Read Length Histogram Basecalled Bases

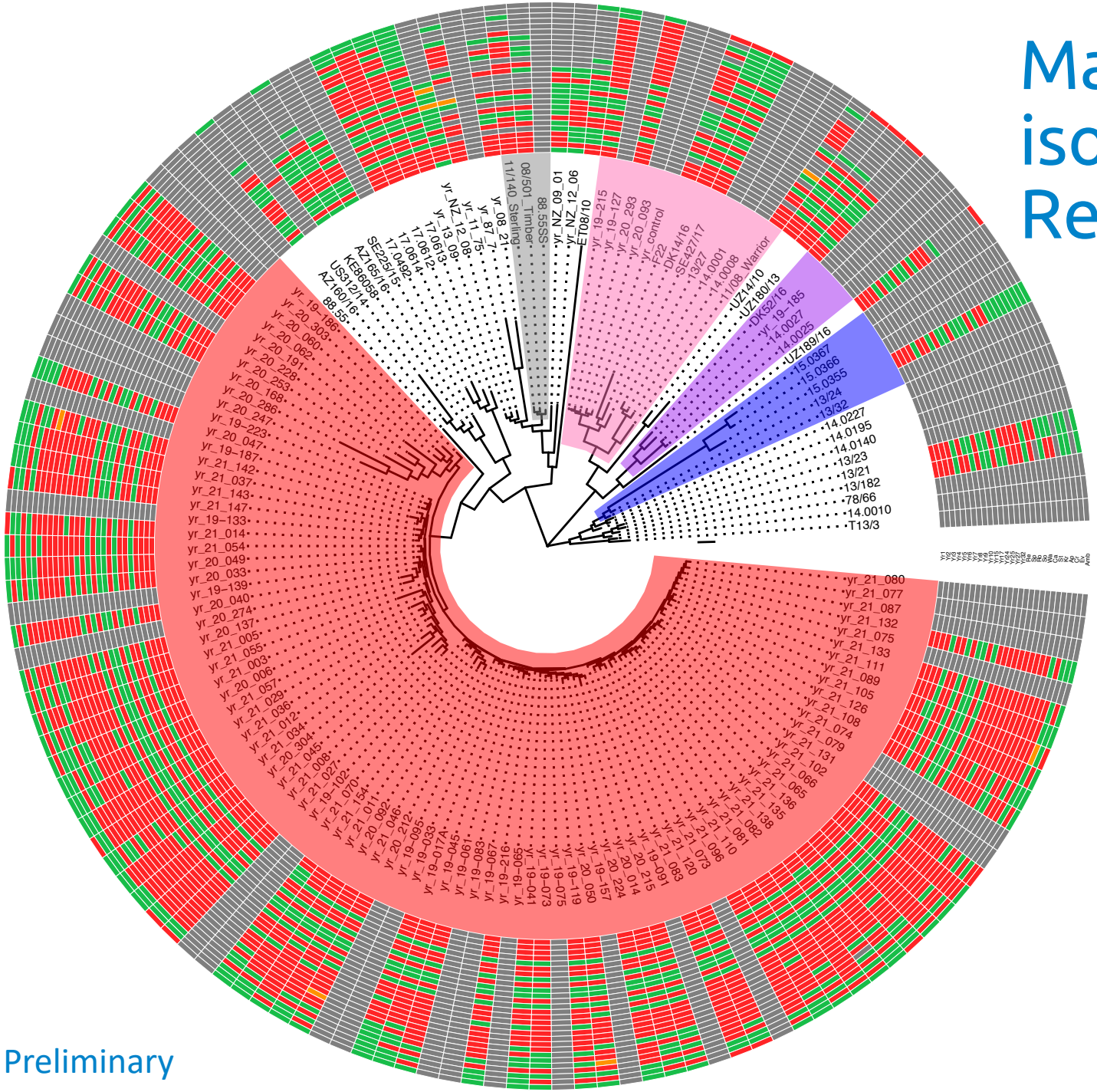
Estimated N50: 1.74 kb



Helen Bates and Anne Webb

Majority of UK genotyped isolates belong to the Red Group

WYR

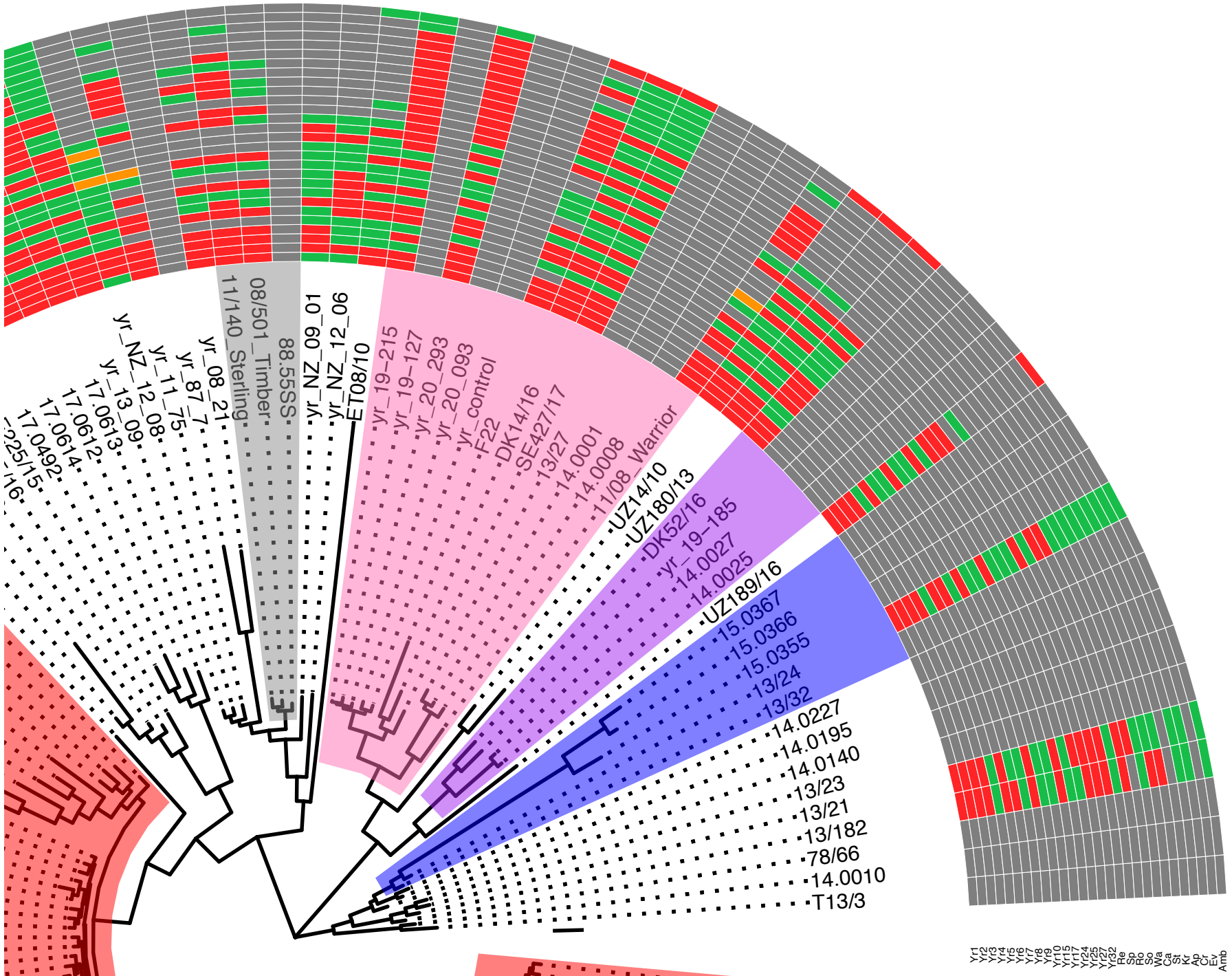


- MARPLE genotyping analysis separates isolates into genetic groups
- Red Group has dominated for the past 3 years
- 2021 – 155 isolates sent in, 48 tested, all Red Group
- Broad range of virulence profiles within the Red Group

Preliminary

Unusual isolates

- Helped ID unusual isolates
- Four isolates in Pink Group (2019 and 2020)
- One isolate in Purple Group (2019)

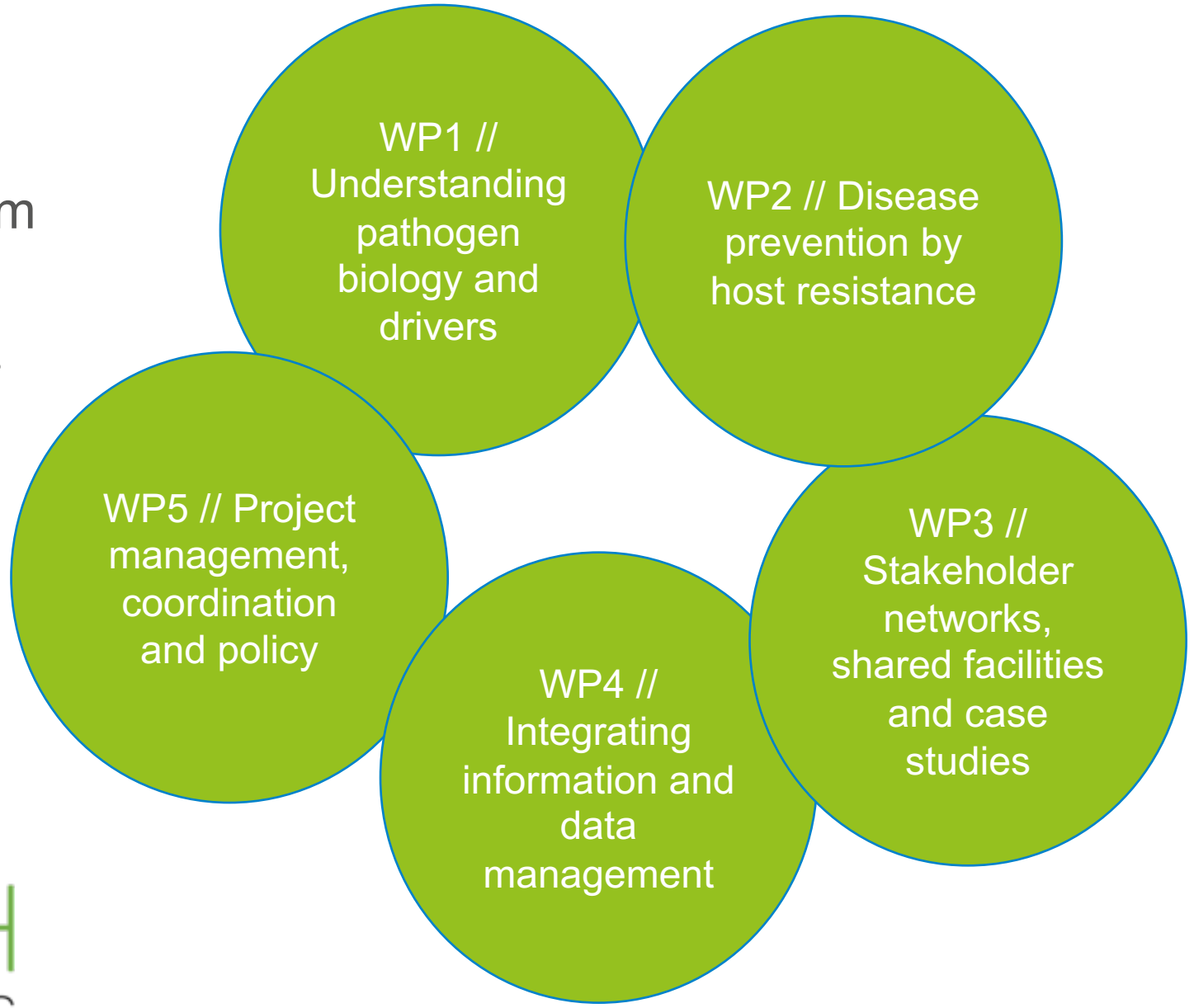


RustWatch

Charlotte Nellist

RustWatch

- A European early-warning system for wheat rust diseases
  - 12 Universities/Research Institutes
  - 5 Agricultural Advisory Services
  - 8 SMEs/Industries
- Studying a panel of over 200 European wheat and durum wheat varieties and their resistance to rust

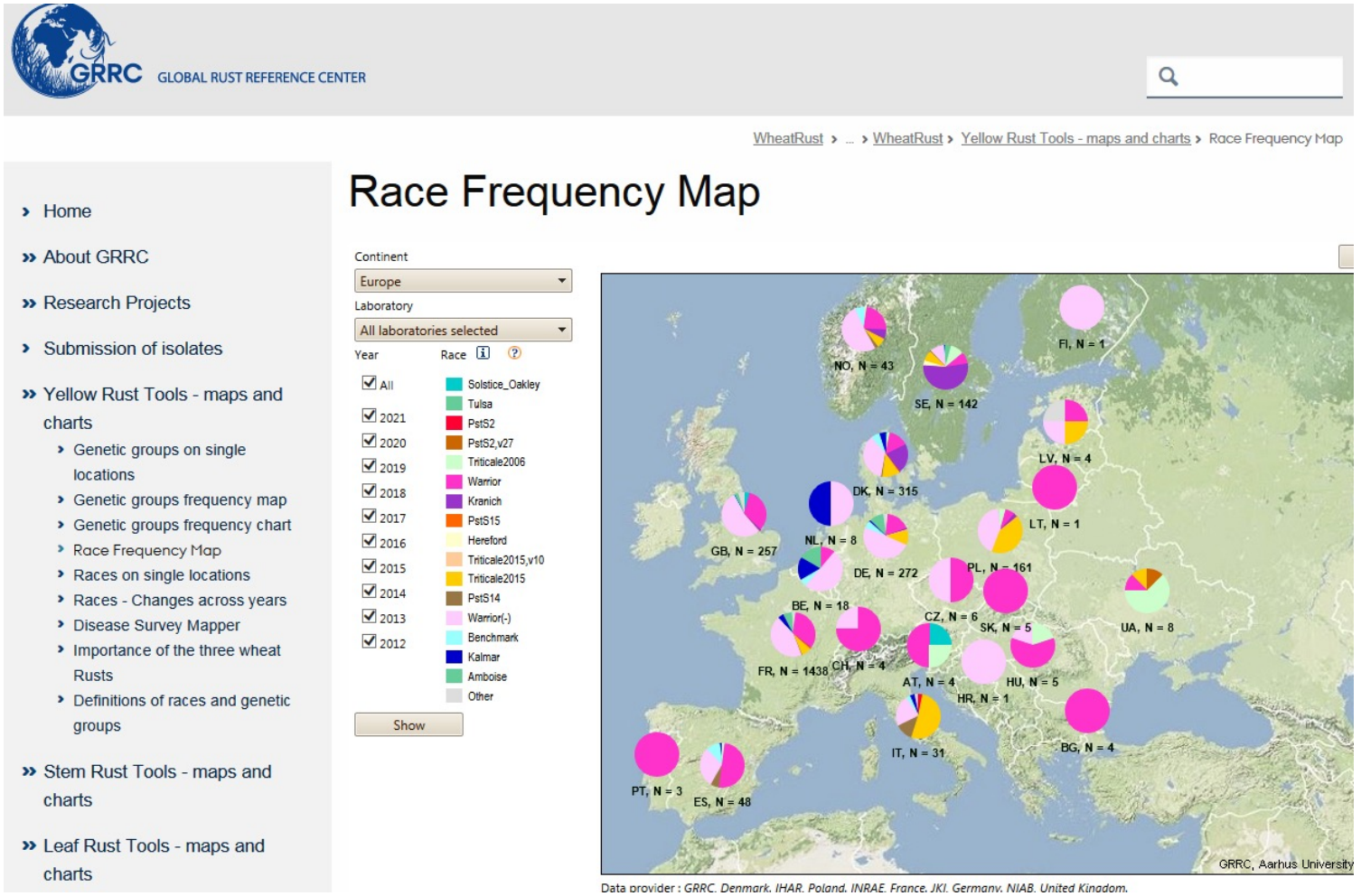


RUSTWATCH
WHEAT RUST EARLY WARNING

2018-2022

WP1 // Understanding pathogen biology & drivers

- Develop faster and more efficient diagnostic methods to track new rust races and genotypes
- Exchange and compilation of genotypic and phenotypic data, enabling population genetic analyses of European data in a global context

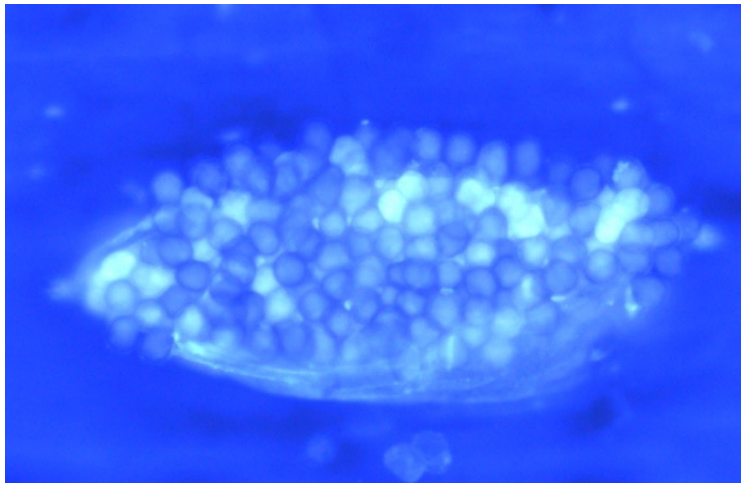


http://wheatrust.org/yellow-rust-tools-maps-and-charts/

WP2 // Disease prevention by host resistance

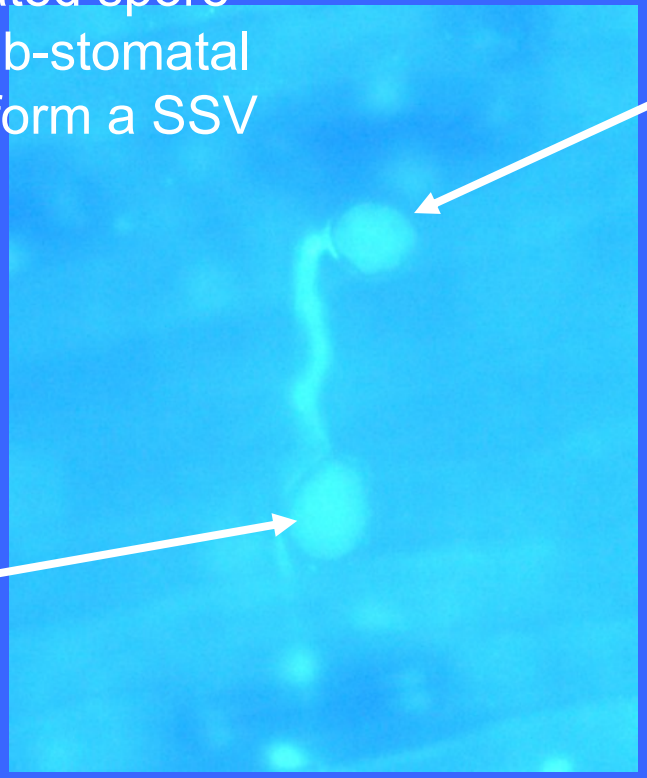
- **AIM:** To use the microphenotypes to distinguish between resistance mechanisms in approx. 240 wheat varieties

- Yellow rust growth stages:
  1. Germinated spore
  2. Germ tube enters stomata and forms a Sub-Stomatal Vesicle (SSV)
  3. Formation of Infection Hyphae and Haustorial Mother Cells (HMC)
  4. Formation of first Runner Hypha (RH)
  5. Runner Hyphae elongate and infect host cells
  6. Formation of pustule

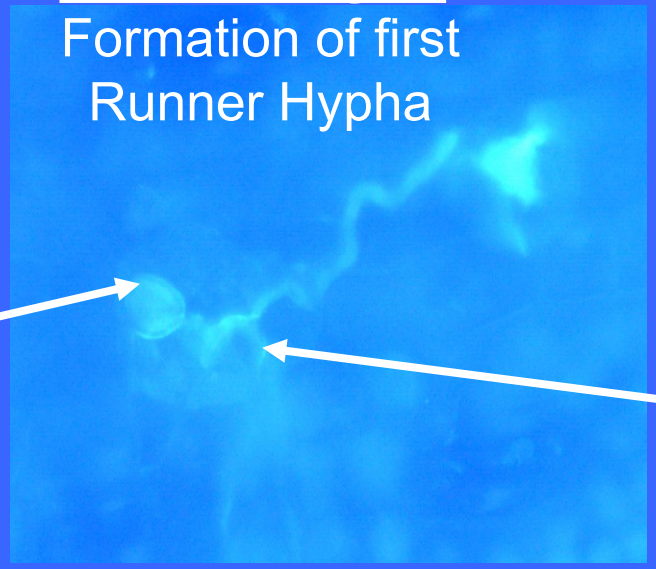


Microphenotyping

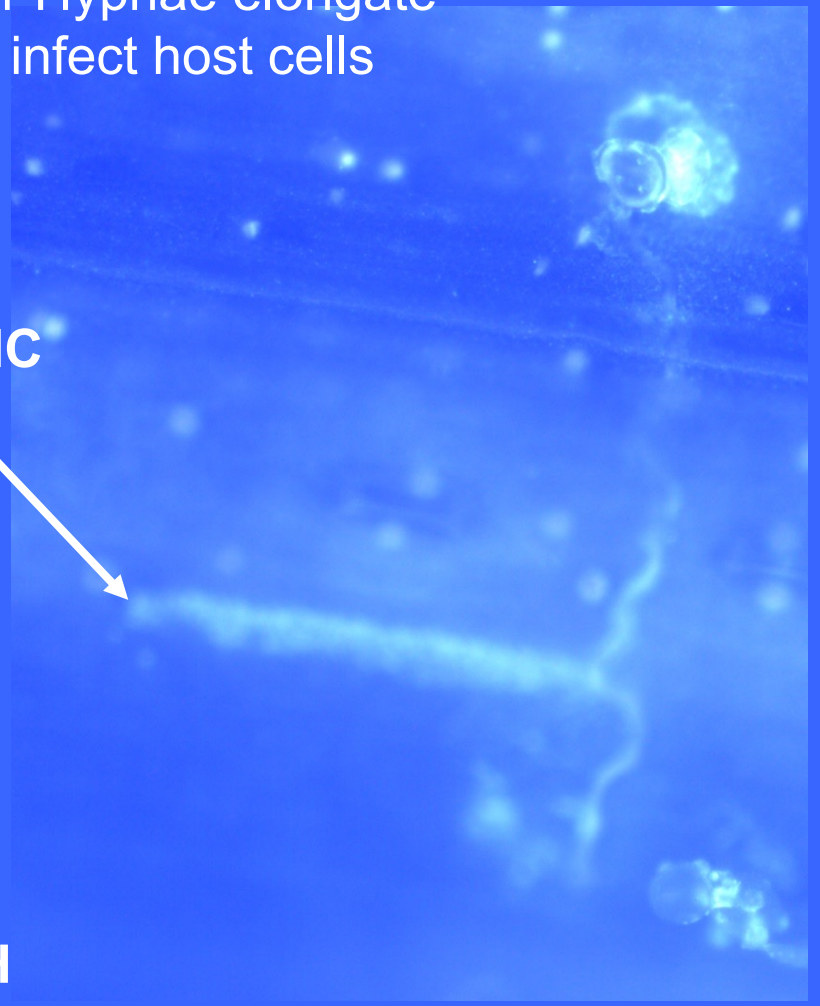
Growth stage 2:
Germinated spore enters sub-stomatal cavity to form a SSV



Growth stage 4:
Formation of first Runner Hypha



Growth stage 5:
Runner Hyphae elongate and infect host cells



Lesley Boyd, Eda Naska, Megan Burt and Robert Watts

Sampling 2022

Charlotte Nellist

2022 Samples

- Have we seen any rust?- Reports, samples?
  - Early season samples of yellow rust on KWS Zyatt and Skyfall from Kent
  - Early season samples of barley mildew

- The UKCPVS relies on the people that take the time to send us samples so please send in samples if you see any wheat YR, wheat BR or wheat or barley mildew

➢ Samples welcome from any RL or RL candidate variety

➢ From uninoculated and, preferably, untreated trials

UKCPVS Sampling Instructions

UKCPVS

Please complete this form and send with each sample for virulence analysis to FREEPOST UKCPVS

It is not compulsory to include contact information. However, it would be useful for NIAB to be able to contact you after a sample has been received in case we have any further questions. All personal data supplied will be kept confidential to the UKCPVS project, and will be deleted after two years of the sample submissions. Full details of the NIAB privacy policy can be found on www.niab.com.

Crop: _____ Disease: _____

Sample no FOR OFFICE USE ONLY	Variety	Date	Location (include county & postcode if known) (AHDB trials operators - include trial ID)	Severity of attack * (% leaf area infection)	Crop GS	Notes (e.g. fungicide treatment)

* If foci present, give assessment for foci and also plot (or field) as a whole.

Name: _____ Tel: _____

Address: _____ Mobile: _____

_____ Email: _____

Sampling and P&P

- Place leaf samples directly in a paper envelope, please do not use polythene bags – we are only surveying wheat yellow and brown rust and wheat and barley mildew

- Send sample along with a copy of the sampling sheet to…

FREEPOST UKCPVS

- If using a stamp please send first class or next day delivery to:

UKCPVS, NIAB Park Farm, Villa Road, Impington, Cambs, CB24 9NZ

Further Information

- Annual report

  https://ahdb.org.uk/ukcpvs

- Recommended Lists

  https://ahdb.org.uk

- Global Rust Reference Centre

  http://wheatrust.org/yellow-rust-tools-maps-and-charts/

- Field Pathogenomics

  http://yellowrust.com

- Rustwatch

  http://agro.au.dk/forskning/projekter/rustwatch/

CRPMC2022

16th International Cereal Rusts and Powdery Mildew

CONFERENCE 2022

- Wednesday 31st August – Friday 2nd September 2022
- Clare College, Cambridge

Acknowledgements

- AHDB
- APHA
- Trap Nursery providers
- Samplers
- Jane Thomas
- Judith Smith
- Helen Bates
- Anne Webb
- Field Trials Team
- Megan Burt
- Eda Naska
- Lucy James

AHDB
AGRICULTURE & HORTICULTURE DEVELOPMENT BOARD

Animal & Plant Health Agency

NIAB

UKCPVS

RUSTWATCH
WHEAT RUST EARLY WARNING

Any Questions?

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‘Inspiring our farmers, growers and industry to succeed in a rapidly changing world’