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# United Kingdom Cereal Pathogen Virulence Survey (UKCPVS) 2021 Annual Report

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# 1. Summary

The United Kingdom Cereal Pathogen Virulence Survey (UKCPVS) currently monitors the populations of the following major cereal pathogens:

- Puccinia striiformis f.sp. tritici (Pst), causing wheat yellow rust
- Puccinia triticina (Pt), causing wheat brown rust
- Blumeria graminis f.sp. tritici (Bgt), causing wheat powdery mildew
- Blumeria graminis f.sp. hordei (Bgh), causing barley powdery mildew

#### Wheat Yellow Rust

The UK *Pst* population continues to show high levels of diversity since the incursion of the Warrior population in 2011. The current population remains dominated by isolates from the Red group and within that group there are a broad range of virulence profiles which continue to change. Several new combinations of virulence were detected in 2020, with one novel isolate showing virulence for *Yr8*. Five isolates displaying novel and existing pathotypes were investigated in the adult plant trials. Genotyping has been established and improvements in methodology are ongoing.

#### Wheat Brown Rust

A differential set, used for the past five years, was used to analyse the *P. triticina* population. As seen in previous years, virulence was detected for many of the *Lr* genes tested and seedling variety tests highlighted that almost all varieties tested were susceptible to at least one of the races under evaluation. Some changes in seedling virulence frequencies were found, for example, virulence for *Lr1* and *Lr28* both increased, although no major changes in varietal performance were identified.

#### Wheat and Barley Powdery Mildew

Small changes in the *Bgh* population were detected, but this should be interpreted with caution due to the very limited number of isolates tested. As in previous years, no unusual outbreaks were reported so it is unlikely that these changes have translated into detrimental effects on variety performance.

# 2. Introduction

# 2.1. General Introduction to the United Kingdom Cereal Pathogen Virulence Survey (UKCPVS)

#### 2.1.1. Establishment of the survey

Wheat production in the UK is threatened annually by a number of pests and diseases. In our cool maritime climate, the foliar diseases Septoria leaf blotch and yellow (stripe) rust are easily found. Warmer summers have also led to the sighting of brown (leaf) rust at the end of the season which can be serious if left unchecked on susceptible varieties. Current methods of control are based principally on fungicidal inputs: however, for the latter two diseases host resistance plays an important role due to the high levels offered in some UK wheat varieties. Host resistance to the rust fungi is however subject to change and should be monitored as part of a virulence survey due to the ability of the pathogen to mutate and overcome some kinds of resistance. For this reason, the UK Cereal Pathogen Virulence Survey was established in 1967 following an unexpected outbreak of yellow rust on the previously resistant variety Rothwell Perdix.

# 2.1.2. Targets of the survey and pipeline for pathotyping

# 2.1.2.1. Targets

Known originally as the Physiologic Race Survey of Cereal Pathogens, the survey was conducted by a group of organisations including NIAB. The list of target diseases was longer and included wheat yellow rust, wheat and barley mildew, barley brown rust, barley leaf scald (*Rhynchosporium*), barley net blotch, oat crown rust, oat leaf spot and oat mildew. Over time, the list of target species has reduced but the principals remain the same and in its 54<sup>th</sup> year the survey continues to provide information to growers, breeders and other interested parties on the population of these important pathogens. The survey currently limits its activities to monitoring the pathogens causing the diseases wheat yellow and brown rust and wheat and barley powdery mildew. Both yellow and brown rust of barley are not part of the UKCPVS, but occasional samples are received and kept as ampules for potential future reference.

#### 2.1.2.2. Timescale of characterisation

Once a sample is received by the survey, the causal agent is multiplied and stored for further testing. At the end of July when all the samples have been received, the list is scrutinised and at least 25 samples are selected per disease for further characterisation using a differential test. The differential tests follow a worldwide standard procedure where the different isolates of rust or mildew are inoculated onto a set of different varieties ("differentials") whose

underlying resistance gene(s) are known (designated Yr, Lr, Pm, Ml or similar for yellow rust, brown rust, wheat mildew and barley mildew, respectively). Other varieties carrying uncharacterised sources of resistance are also included in these tests. By assessing whether the isolate can cause disease on the individual varieties (termed as virulent) or not (termed avirulent) allows the isolate to be characterised and compared with isolates previously identified within the UKCPVS and also with colleagues elsewhere in the world. A new race is declared when virulence for a particular resistance gene, gene combination or variety is detected which has not been seen before in the UKC.

#### 2.1.3. Key virulence changes over the years: Wheat Yellow Rust

In 2011, a new race of yellow rust, the Warrior race, was identified that appeared to be similar to previous races, but with additional virulence for the resistance gene *Yr7* and the variety Spaldings Prolific. It is important to note that virulence for the resistance gene *Yr7* had been seen before, but not in combination with virulence to the resistance genes *Yr6*, *Yr9*, *Yr17* and *Yr32*. There were, however, other pieces of evidence to suggest that the Warrior race was different to previous races, with abundant production of the sexual stage spores (teliospores) and multiple sightings of the new race across Europe in the same year. Further molecular genotyping of the Warrior race has shown that this new race was a foreign incursion and not a mutation of the existing population (Hovmøller et al. 2016; Hubbard et al. 2015). The Warrior race was also characterised by its high population diversity, indicating that it was likely to be derived via sexual recombination, and not the asexual mutation that previously characterised the UK population (Ali et al. 2014; Hovmøller et al. 2002). The population diversity identified in the Warrior race highlighted that the incursion was of multiple isolates, in effect a population, rather than a single isolate or race.

Since the arrival of the Warrior group of isolates in 2011, existing European populations have been replaced so that the population is now dominated by isolates classified as members of the Warrior group (Hovmøller et al. 2016; Hubbard et al. 2015). In 2015, the UKCPVS confirmed that an additional race had arrived in the UK, the Kranich race (since renamed Purple 3) and later that year the Blue 7 group of isolates were detected (Hubbard, Pritchard, and Holdgate 2016). An epidemic year followed the arrival of these two groups of isolates, although it was later found that another group, Red 24, first detected in 2016, was the most likely culprit for substantial changes to AHDB Recommended List (RL) ratings that year (Hubbard et al. 2017). An unusual outbreak on KWS Zyatt and Dunston in some parts of the country was identified during 2019. After close examination of UKCPVS adult plant trials carried out in 2019, a Red 27 isolate was identified as the likely cause of the outbreak. In 2020, only one isolate was found to carry virulence for *Yr8* and two isolates carried virulence for

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Crusoe. The most common pathotypes identified from the seedling differential test data were Red 28 and Red 37. The pathotype for Red 27 continued to be detected.

#### 2.1.3.1. Changes in naming of races

With the recent race changes affecting the UK and across Europe, the UKCPVS has sought to redefine the naming system for new races. A meeting between virulence surveys from across Europe in 2016 failed to reach a consensus of how to deal with such a diverse pathogen population. In the UK, a system has now been proposed to take into consideration the genetic data produced by the John Innes Centre as well as the pathotype data generated by the UKCPVS. The races are now assigned a colour to divide the races into their genetic groups using the genotype data and then a number to divide the isolates according to the pathotype data. The colour group is based on that produced in the STRUCTURE programme used to analyse the data and the number is assigned sequentially. So, for example, the race Blue 1 will have been discovered in advance of Blue 2. Using this system, it will be possible to separate races that may otherwise look similar. During this renaming process, colleagues at the Global Rust Reference Centre also developed a new naming system which groups races into PstS groups (Ali et al. 2017). This system takes a broader approach to naming races so that individual races are not named, rather they are included into the broad groups and important races within the group are highlighted. Translation between the two systems is ongoing.

#### 2.1.4. Key virulence changes over the years: Wheat Brown Rust

Surveillance of the *Puccinia triticina* (formerly *P. recondita*) population in the UK began a little later than surveys for the other cereal diseases, starting in 1973 with samples collected from 1972. Colleagues at the Welsh Plant Breeding Station (now Institute of Biological, Environmental and Rural Sciences at the University of Aberystwyth) managed the survey of this pathogen until 2006 when the survey was transferred to NIAB. In the early stages of this programme, there was very little known or developed in the way of differential sets, and the initial screening of isolates was conducted using a selection of winter and spring wheat varieties from the RL of that year along with some research lines from a Septoria leaf blotch resistance screen. From here, nine varieties were selected that were able to differentiate between the isolates and included current differentials Maris Halberd and Sappo. Like today, wheat brown rust is less important than wheat yellow rust, and at the start of the survey, there were only limited options for resistant varieties, for example, Clement, which carried the gene Lr26 (also referred to as WBR1). Official ratings of resistance to wheat brown rust were not introduced onto the RL until 1977. Dominant races of *P. triticina* tend to match commonly

deployed host resistance genes. For example, use of the resistance gene Lr1 in the variety Glasgow led to the emergence of the Glasgow race in 2005 which carried virulence for this resistance gene (Table 1). Once the acreage of varieties carrying these resistance genes reduces, the frequency of finding these isolates reduces. A recent example is virulence for Lr24. The two varieties carrying this resistance gene (Warrior and Stigg) are no longer widely grown and the population has, therefore, mirrored this, and the frequency of detection continues to decline. In 2014, a change to the population overcame the moderate resistance in the variety Crusoe; however, it is still unclear what resistance gene has broken down. Over recent years, pathogen populations have remained relatively stable; however, an unusual outbreak on KWS Firefly in some parts of the country was identified during 2019. In 2020, the most notable change was increasing virulence for Lr28 but this was not accompanied by reports of varietal breakdowns.

Year	Variety	Key Resistance Gene Combination
1973*	Sappo	<i>Lr20</i> (WBR3)
1973*	Maris Halberd	<i>Lr20</i> (WBR4)
1974*	Maris Fundin	Lr17b (WBR2)
1976	Maris Huntsman	WBR5 (APR)
1977	Clement	<i>Lr26</i> (WBR1)
1977	Sterna	<i>Lr3a</i> (WBR7)
1978	Maris Ranger	WBR8
1980	Avalon	WBR9
1982	Gamin	WBR6
1991	Slejpner	<i>Lr</i> 26 + APR
1993	Spark	Not specified
1994	Flame	Not specified
1995	Chablis	Lr3a + ?
1999	Rialto	<i>Lr17b, Lr26</i> + APR
2005	Glasgow	Lr1
2005	Claire	<i>Lr3a, Lr17b, Lr20, Lr26,</i> APR
2006	Robigus	Lr28
2006	Multiple <i>Lr</i> 37 varieties	Lr1,Lr3a,Lr17b,Lr26,Lr37
2011	Stigg	Lr24
2014	Crusoe	Unknown
2019	KWS Firefly	Lr28?

**Table 1**: Key wheat brown rust changes in the UK since the start of the survey.

\* Tested for the first time, virulence may have been present in previous years. APR = Adult plant resistance

### 2.2. Aims and Objectives

The principal aim of the project is to detect new races of economically important pathogens for UK growers to provide an early warning system that will aid effective disease management. To achieve this, the UKCPVS currently monitors the populations of the fungi causing wheat yellow rust and brown rust and wheat and barley powdery mildew. A subset of the isolates collected will be characterised to identify any new races. The reactions of the current RL varieties and candidates will be assessed using some of the newest isolates at both the seedling and adult plant stages to establish future risks of disease outbreaks.

# 3. Materials and methods

## 3.1. Wheat Yellow Rust and Wheat Brown Rust

### 3.1.1. Collection of samples and preparation of isolates

Infected wheat leaves were received from growers, agronomists and operators of RL trials. Spores from the infected samples were transferred on to plants of the universally susceptible variety Victo or Vuka (wheat yellow rust) or Armada (wheat brown rust). Plants were grown under controlled environment conditions on Burkard isolation benches until fresh sporulation was evident. Spores were collected and used to re-infect further pots of the susceptible varieties until enough spores were available to inoculate a differential test.

### 3.1.2. Characterisation of isolates using differential tests

Seedlings of the differential set were inoculated with spores from the new isolates, using a complete set of differential varieties for each isolate under test (Hubbard et al. 2015). The differentials used and the resistance genes they carry are listed in Table 2 (for wheat yellow rust) and Table 10 (for wheat brown rust). Approximately 14 days post inoculation, the tests were scored using a 0-4 scale which was then converted into an average infection type score (A.I.T.). A score of 0-2.3 indicates an incompatible (avirulent) reaction, a score of 2.4-2.6 represents a borderline reaction and should be treated with caution as it is difficult to be certain whether the reaction is one of virulence or avirulence, and scores of 2.7 – 4.0 indicate a compatible reaction and the isolate is virulent on that differential.

## 3.1.3. Characterisation of isolates using adult plant trials

Varieties from the current RL, RL candidate varieties and selected control varieties were hand sown in tussock plots for evaluation under field conditions to selected isolates. Each of the three isolates were tested in separate trials and each trial consisted of two replicates. As an alternative to foliar fungicide applications to eliminate natural infection, as used in previous years, plots were directly inoculated every 7-14 days from approx. GS 13 onwards, with the aim of increasing disease pressure of the target isolate and preventing natural influx which can confound experimental results in high disease pressure seasons. The wheat yellow rust trials were inoculated ten times and the wheat brown rust trials were inoculated nine times. Assessments were made from inflorescence onwards until senescence.

To check for natural contamination, spores were re-isolated from each inoculated trial and inoculated onto the seedling differential set, as described in **3.1.2**.

#### 3.1.4. Characterisation of isolates using variety seedlings

The isolates under evaluation in the field trials were also used in parallel experiments under controlled environment conditions to assess the seedling reaction of the varieties used in the adult plant tests. These tests were inoculated in the same way as previously described for differential tests (**3.1.2**), and assessment was carried out using the same average infection type scoring system.

#### 3.1.5. Off-season adult plant trials

Plants were grown for 10 days in an environmentally controlled growth room then placed in the vernalisation chamber at 4 °C for 8 weeks, after which time they were moved to the growth rooms. Plants were inoculated at approximately GS39. The time from sowing to scoring was approximately five months.

#### 3.2. Wheat and Barley Powdery Mildew

#### 3.2.1. Collection of samples and preparation of isolates

Infected leaves were received from growers, agronomists and trials operators for the RL trials. Individual pustules taken from the infected samples were mounted on agar and when sporulation was seen the pustules were transferred onto fresh detached leaf sections using the universally susceptible varieties Cerco (wheat mildew) and Golden Promise (barley mildew). Subsequent transfers onto new detached leaves were conducted to maintain the isolate.

#### 3.2.2. Characterisation of isolates using differential tests

Seedlings of the differential set were inoculated with spores from the new isolates. The differentials used and the resistance genes they carry are listed in Table 17 (for wheat powdery mildew) and Table 19 (for barley powdery mildew). Each differential was represented by four detached leaf sections, giving four replicates. This was to ensure the maximum amount of information was obtained using the small amount of spores available. Approximately 14 days post inoculation, the detached leaves were scored using a 0-4 scale. The score for each of the four detached leaf sections was then averaged to give the final score for each differential. A score of 0-2.5 indicates an incompatible (avirulent reaction) and a score of 2.75-4 indicates a compatible reaction and the isolate was virulent on that differential.

### 3.2.3. Characterisation of isolates using adult plant field trials

No adult plant field trials were carried out as part of the UKCPVS mildew survey.

### 3.3. Wheat Yellow Rust Genotyping

#### 3.3.1. Sample preparation

Each single lesion leaf section used for bulking the isolates was transferred to a humidity chamber for approximately 48 hours to encourage respondation. The leaf sections were then transferred to a 10mL vial and flooded with 3mL of the nucleic acid stabilisation solution RNAlater® (Thermo Fisher Scientific, UK). Samples were stored at 4 °C.

### 3.3.2. DNA extraction and amplification of genes

Genomic DNA (gDNA) was extracted from 24 samples from 2020 using the Qiagen DNeasy Plant Pro kit (Qiagen), following the manufacturer's protocol. The quantity and purity of the gDNA were determined using the NanoDrop (Thermo Fisher Scientific) spectrophotometer and the Qubit 2 Fluorometer (Thermo Fisher Scientific). A total of 242 variable *Pst* genes were amplified from the gDNA samples via multiplex PCR, followed from the MARPLE pipeline described by Radhakrishnan et al. (2019). Five pools containing different concentrations of optimised primers were amplified with Q5® Hot Start High-Fidelity 2X Master Mix (New England Biolabs, USA), modified from Radhakrishnan et al. (2019). PCR conditions used were 98 °C for 30 s, 40 cycles of 98 °C for 10 s, 63 °C for 30 s and 72 °C for 2 min 30 s, and a final extension of 72 °C for 2 min.

#### 3.3.3. Library preparation and sequencing

Following PCR amplification of the *Pst* genes, an equal mass of purified PCR products from each of the five primer pools were combined prior to library preparation. The amplicon libraries were prepared using Ligation Sequencing Kit (LSK108) with native barcoding (Oxford Nanopore Technologies, UK). Twelve libraries were pooled and were sequenced on the GridION platform on a R9.4.1 flow cell (Oxford Nanopore Technologies, UK) overnight, following the manufacturer's instructions. The flow cell was washed and the other 12 pooled 2020 libraries were sequenced on the flow cell, overnight.

## 3.3.4. Phylogenetic analysis

A maximum-likelihood approach with RAxML was used for phylogenetic analysis, following Radhakrishnan et al. (2019). The phylogenetic tree was visualised with Dendrogram.

# 4. Results and Discussion

# 4.1. Wheat Yellow Rust

# 4.1.1. Samples received

In 2020, the UKCPVS received 306 samples of wheat yellow rust from 25 different counties across the UK (Figure 1).



**Figure 1**: Map of the UK with the number of samples of wheat yellow rust received in 2020 from the different counties.

Disease pressure was higher compared to that experienced in 2019. The UKCPVS did receive some reports of unusual sightings such as yellow rust in the resistant cultivars KWS Siskin and Costello, and a flurry of late season samples came in from the cultivar KWS Extase. In total, samples were received from 88 different varieties consisting of current and past RL varieties, spreader plots and other breeding lines. For a second year running, the most sampled variety was KWS Firefly. The full sample register is provided in Appendix I. It is important to note that the host varieties in the sample register have not all been confirmed, and it is entirely possible that a sample listed as coming from a resistant variety may turn out to be from another more susceptible variety. For this reason, the sample register is included as an indicator of what was received but should not be used to infer any breakdowns in resistance or changes in rating at this stage.

#### 4.1.2. Pathotyping of isolates

#### 4.1.2.1. Virulence for individual resistance genes and varieties

Thirty isolates were selected for further pathotyping (Table 2). The isolates were selected based on their county of origin and the resistance rating of the host. Isolates were assessed for their reactions on a differential set and their reactions, expressed as an average infection type (A.I.T.), were recorded. Isolates were classified as virulent if the A.I.T. score was 2.7 or above. Scores between 2.4 and 2.7 were considered borderline. Using these scores, it was possible to combine the scores for reactions to different resistance genes to infer a pathotype for each of the isolates (Table 3). No new virulences to individual resistance genes were detected in the isolates collected in 2020 using the differentials tested at the seedling stage. Changes in frequency of virulence for known individual resistance genes remained relatively minor in comparison to previous years (Table 4). One isolate showed virulence for Yr8, which was a decrease in the percentage of isolates carrying virulence from the previous year. In addition, the variety Kranich also saw a slight increase in the percentage of isolates carrying virulence which continues this trend from its initial rise in 2019. Virulence for Rendezvous increased and returned to its 2016 level. Virulence for the other additional cultivars KWS Sterling, Apache and Evolution also increased with Evolution seeing the biggest rise from 19% of isolates in 2019 to 73% of isolates tested in 2020. Virulence detected for the variety Warrior declined. It is unclear at this stage whether these recent changes are significant, but it is possible that this could indicate further changes in the pathogen population.

#### 4.1.2.2. Virulence frequencies for pathotype groups

Previously, some isolates have been assigned to different genetic groups using tools developed in the Field Pathogenomics project (Diane Saunders, *pers. comm.*, Table 3). In the cases where this information was unavailable at the time of writing, the isolates were classed according to the pathotype data only based on results from previous years. Considering the population by genetic group, the frequencies of isolates found in each group were similar to that found in 2019 (Table 5). The Red group almost entirely dominated the surveyed isolates. There were also a number of isolates which could not be classified into a genetic group due to the expression of seemingly novel pathotypes. These isolates are under further investigation and will remain in the 'Other' category until such a time, that they can be assigned to a genetic group.

		1	٢	2	3a, 4a	3b,4b	4,Su	5	9	2,6	2,6,25	7	7,22,23	6,7	7,17	8	8,19	6	2,9,25	10	15	17	17	17	24	2,25	25,Sd	32	25,32	Sp	Sp	Ro	So	Wa	St		Am					
Isolate code	Host	Avocet Yr1	Chinese 166	Kalyansona	Vilmorin 23	Hybrid 46	Suwon Omar	Avocet Yr5	Avocet Yr6	Heines Kolben	Heines Peko	Avocet Yr7	Lee	Cadenza	Apache	Avocet Yr8	Compair	Avocet Yr9	Clement	Moro	Avocet Yr15	VPM 1	Rendezvous	Avocet Yr17	Avocet Yr24	Heines VII	<b>Strubes Dickkopf</b>	Avocet Yr32	Carstens V	Avocet Sp	<b>Spaldings Prolific</b>	Robigus	Solstice	Warrior	<b>KWS Sterling</b>	Claire	Ambition	Crusoe	Avocet S	Vuka	Kranich	Evolution
20/001	Graham	3.0	3.0	3.0	3.0	0.5	3.0	0.0	3.0	3.0	3.0	3.0	3.0	1.6	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	1.3	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	<mark>4.0</mark>	0.5	0.1	3.0	0.0	0.0	3.0	3.0	0.0	0.0
20/006	KWS Firefly	3.0	3.0	3.0	3.0	3.0	4.0	0.0	3.0	3.0	3.0	4.0	3.0	1.8	0.1	0.2	0.0	3.0	3.0	0.0	0.0	3.0	3.0	3.5	0.0	3.0	3.0	3.5	2.1	3.0	3.0	3.2	3.0	0.3	3.0	3.0	0.2	0.0	3.0	3.0	0.1	<mark>3.0</mark>
20/014	KWS Firefly	3.0	3.0	3.0	3.0	3.0	4.0	0.0	3.5	3.0	3.0	3.5	3.0	3.0	2.7	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	4.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	<mark>3.0</mark>	0.2	2.0	4.0	0.7	0.0	3.0	3.0	0.9	<mark>3.0</mark>
20/033	LG Skyscraper	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	2.7	2.8	0.0	0.0	3.0	3.0	0.0	0.0	3.0	0.6	3.2	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.7	2.0	4.0	0.6	0.0	3.0	3.0	0.2	3.0
20/040	Costello	3.1	3.1	3.2	3.1	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	4.0	3.5	0.0	0.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.2	3.1	3.0	2.8	4.0	3.0	0.0	3.0	3.3	2.7	<mark>3.0</mark>
20/044	KWS Jackal	3.0	3.0	3.1	3.0	3.0	4.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.5	3.0	0.0	0.0	3.1	3.0	3.0	0.0	3.0	3.2	3.0	3.1	3.1	3.0	3.1	3.3	3.0	3.0	4.0	2.7	0.0	3.0	3.0	3.0	<mark>3.0</mark>
20/047	LG Skyscraper	3.0	3.0	3.0	3.0	2.1	3.0	0.0	3.1	3.0	3.0	3.0	3.0	3.0	1.7	0.0	0.0	3.0	3.0	0.0	0.0	3.0	0.3	3.0	0.0	3.0	2.1	3.0	3.0	3.0	3.0	3.2	3.1	3.0	3.0	3.0	2.0	0.0	3.0	3.0	0.1	0.0
20/049	Costello	3.0	3.3	3.5	3.7	3.0	3.0	0.0	4.0	3.0	3.0	3.0	3.0	3.0	2.7	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	3.0	0.0	3.0	3.0	3.1	3.0	3.0	3.0	3.0	3.0	2.9	0.0	3.0	3.0	0.0	3.0	<mark>3.2</mark>	2.2	0.4
20/050	KWS Siskin	3.0	3.0	3.0	3.0	3.0	3.5	0.0	3.0	3.0	3.0	3.2	3.0	3.0	3.0	0.0	0.0	4.0	3.0	0.0	0.0	3.2	3.0	<mark>3.3</mark>	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	1.8	3.0	3.0	2.3	0.0	3.0	3.0	2.5	<mark>3.0</mark>
20/060	KWS Siskin	3.0	3.0	3.2	3.0	3.0	3.3	0.0	3.2	3.0	3.0	3.0	3.0	2.9	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	2.8	3.0	0.0	3.0	3.0	4.0	3.0	3.2	3.0	3.2	3.0	3.0	3.0	3.0	1.6	0.1	4.0	3.0	0.4	<mark>3.0</mark>
20/062	KWS Siskin	3.0	3.0	3.0	3.0	3.0	3.5	0.0	3.3	3.0	3.0	4.0	3.1	3.0	3.0	0.0	0.0	4.0	3.0	0.0	0.0	3.0	2.7	4.0	0.0	3.0	3.0	3.0	3.0	3.1	3.0	3.1	3.2	3.0	2.2	4.0	2.2	0.0	3.0	3.0	0.4	<mark>3.0</mark>
20/065	KWS Zyatt	3.0	3.0	3.0	3.5	2.9	3.0	0.0	4.0	3.0	2.8	3.0	3.0	3.0	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	2.9	4.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.2	3.0	2.8	3.0	3.0	2.7	0.0	3.0	3.0	3.0	2.7
20/092	LG Astronomer	4.0	3.0	3.3	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.1	2.8	3.0	2.7	0.0	0.0	4.0	3.0	0.0	0.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.1	3.0	3.0	3.0	3.0	3.0	0.0	2.8	2.0	3.0	3.0	3.0	<mark>3.0</mark>
20/104	KWS Basset	3.0	3.0	3.0	3.0	3.0	3.5	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	3.1	0.0	3.0	3.0	3.0	3.1	3.0	3.0	3.2	3.0	3.0	3.0	4.0	3.0	0.3	3.0	3.0	3.0	<mark>3.0</mark>
20/134	RGT Silversurfer	3.1	3.0	3.1	3.0	3.0	4.0	0.0	3.3	3.0	3.0	3.2	3.1	2.7	3.0	0.0	0.0	3.1	2.9	0.0	0.0	3.1	2.9	4.0	0.0	3.0	3.0	3.0	3.0	3.1	3.1	3.1	3.2	1.2	2.8	3.0	2.2	0.0	3.0	3.0	1.7	<mark>3.0</mark>
20/137	KWS Siskin	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	1.8	2.8	0.0	0.0	4.0	3.0	0.0	0.0	3.2	3.0	3.4	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.9	0.0	3.0	4.0	3.0	<mark>3.0</mark>
20/138	KWS Cranium	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	4.0	3.0	0.0	0.0	4.0	3.0	3.5	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.1	2.0	2.0	3.0	0.0	0.0	3.0	3.0	1.6	2.2
20/168	RGT Saki	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	4.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.7	3.5	0.0	0.0	3.0	3.0	0.5	<mark>2.9</mark>
20/189	RGT Gravity	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.5	3.0	0.0	0.0	2.9	2.7	4.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.5	3.0	2.1	2.1	3.0	0.2	0.0	3.0	3.0	2.0	2.7

**Table 2**: Average infection type (A.I.T.) scores for the selected isolates against the UKCPVS differential set. Yellow shading indicates a compatible reaction; orange shading indicates a borderline reaction. Compatible interactions classify the isolate as virulent against a particular resistance gene or variety. Numbers next to the differential variety names indicate the known resistance genes carried by the variety. \* = missing data.

		٦	1	2	3a, 4a	3b,4b	4,Su	5	9	2,6	2,6,25	7	7,22,23	6,7	7,17	8	8,19	6	2,9,25	10	15	17	17	17	24	2,25	25,Sd	32	25,32	Sp	Sp	Ro	So	Wa	St		Am					
lsolate Code	Host	Avocet Yr1	Chinese 166	Kalyansona	Vilmorin 23	Hybrid 46	Suwon Omar	Avocet Yr5	Avocet Yr6	Heines Kolben	Heines Peko	Avocet Yr7	Lee	Cadenza	Apache	Avocet Yr8	Compair	Avocet Yr9	Clement	Moro	Avocet Yr15	VPM 1	Rendezvous	Avocet Yr17	Avocet Yr24	Heines VII	Strubes Dickkopf	Avocet Yr32	Carstens V	Avocet Sp	<b>Spaldings Prolific</b>	Robigus	Solstice	Warrior	KWS Sterling	Claire	Ambition	Crusoe	Avocet S	Vuka	Kranich	Evolution
20/191	KWS Siskin	<mark>3.0</mark>	3.0	3.0	3.0	2.1	3.0	0.0	3.0	3.0	3.0	3.0	3.0	0.6	2.9	3.0	1.4	3.2	3.0	0.0	0.0	3.0	2.3	3.0	0.0	3.0	0.6	3.0	3.0	3.0	3.0	3.0	3.0	1.6	2.7	3.0	1.8	0.0	3.0	3.0	2.7	<mark>3.0</mark>
20/197	Gleam	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.1	3.0	3.0	3.0	3.0	2.7	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	4.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.2	3.0	2.1	0.0	3.0	3.0	0.0	3.0	3.0	2.0	2.1
20/203	Elation	<mark>3.0</mark>	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.5	3.0	2.3	2.2	3.0	2.0	0.0	3.0	3.0	1.4	3.0
20/207	RGT Illustrious	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.5	3.0	0.0	0.0	3.2	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.7	3.0	3.0	1.2	0.0	3.0	3.0	1.8	3.0
20/212	RGT Saki	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	2.7	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	4.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.6	3.0	3.1	1.4	0.0	3.1	3.0	2.0	3.0
20/215	KWS Barrel	3.0	3.0	3.0	3.0	2.7	2.7	0.0	3.0	3.0	3.0	4.0	3.0	1.8	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	4.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	1.9	2.8	3.0	2.0	0.0	3.0	3.0	1.8	3.0
20/224	KWS Zyatt	3.0	3.0	3.2	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.5	3.0	0.0	0.0	3.5	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.3	3.0	3.0	1.1	0.0	3.0	3.0	2.7	0.0
20/253	KWS Firefly	3.0	3.0	3.2	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	2.7	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.7	3.0	1.0	0.0	3.0	3.0	2.3	3.0
20/269	KWS Zyatt	<mark>3.2</mark>	3.0	3.5	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.3	3.0	0.0	0.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.5	3.0	2.0	2.7	4.0	1.0	0.0	3.0	3.0	0.2	2.0
20/293	KWS Extase	3.0	3.1	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	2.9	3.0	0.0	3.0	3.0	3.0	3.0	3.1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20/304	KWS Extase	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	3.1	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.8	3.0	3.0	3.0	3.0	3.0	3.0	1.0

Isolate	Heat	Race														Viru	lence	e Prof	ile <sup>2</sup>									
code	HOSI	Number <sup>1</sup>	1	2	3	4	5	6	7	8	9	10	15	17	24	25	32	Re	Sp	Ro	So	Wa	Са	St	Kr	Ар	Cr	Ev
20/001	Graham	Red 4	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So					Ар		
20/006	KWS Firefly	New	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So			St				Ev
20/014	KWS Firefly	Red 27	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca			Ар		Ev
20/033	LG Skyscraper	Red 31	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So	Wa	Ca			Ар		Ev
20/040	Costello	Red 37	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ар		Ev
20/044	KWS Jackal	Red 37	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ар		Ev
20/047	LG Skyscraper	Red 52	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So	Wa	Ca	St				
20/049	Costello	Red 23	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca			Ар		
20/050	KWS Siskin	Red 28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St	(Kr)	Ар		Ev
20/060	KWS Siskin	Red 24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ар		Ev
20/062	KWS Siskin	Red 34	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca			Ар		Ev
20/065	KWS Zyatt	Red 37	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ар		Ev
20/092	LG Astronomer	Red 37	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ар		Ev
20/104	KWS Basset	Red 37	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ар		Ev
20/134	RGT Silversurfer	Red 28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ар		Ev
20/137	KWS Siskin	New	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa		St	Kr	Ар		Ev
20/138	KWS Cranium	Red 5	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca			Ар		
20/168	RGT Saki	Red 28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ар		Ev
20/189	RGT Gravity	Red 27	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca			Ар		Ev
20/191	KWS Siskin	New	1	2	3	4		6	7	8	9			17		25	32		Sp	Ro	So			St	Kr	Ар		Ev
20/197	Gleam	Red 5	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca			Ар		
20/203	Elation	Red 27	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca			Ар		Ev
20/207	RGT Illustrious	Red 24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ар		Ev
20/212	RGT Saki	Red 28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	(Wa)	Ca	St		Ар		Ev
20/215	KWS Barrel	New	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So			St		Ар		Ev
20/224	KWS Zyatt	New	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St	Kr	Ар		
20/253	KWS Firefly	Red 28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ар		Ev
20/269	KWS Zyatt	Red 11	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ар		
20/293	KWS Extase	Pink 16	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ар	Cr	Ev
20/304	KWS Extase	Red 29 or Pink	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ар	Cr	

**Table 3**: Pathotypes of the 2020 wheat yellow rust isolates based on the differential test results in Table 2. Yellow shading indicates virulence of an isolate for a particular resistance gene or variety; orange shading with parentheses indicates a borderline reaction.

<sup>1</sup> Race number assigned by the UKCPVS using pathotype data in Table 2. <sup>2</sup> Numbers refer to previously designated Yr genes, Re = Rendezvous, Sp = Spaldings Prolific, Ro = Robigus, So = Solstice, Wa = Warrior, Ca = Cadenza, St = KWS Sterling, Kr = Kranich, Ap = Apache, Cr = Crusoe, Ev = Evolution. \* = Missing data.

Virulence For Resistance	Percent	age of Isol for (	ates Identi Gene or Va	fied with V riety	ïrulence
Gene or variety	2016	2017	2018	2019	2020
Yr1	100	96	97	94	100
Yr2	100	100	100	100	100
Yr3	100	100	100	94	100
Yr4	100	100	100	97	100
Yr5	0	0	0	0	0
Yr6	100	100	100	100	100
Yr7	89	100	100	100	100
Yr8	3	4	0	16	3
Yr9	100	100	100	94	100
Yr10	0	0	0	0	0
Yr15	0	0	0	0	0
Yr17	100	100	100	100	100
Yr24	0	0	0	0	0
Yr25	97	100	100	100	100
Yr32	100	100	100	100	100
Rendezvous	87	96	67	48	87
Spaldings Prolific	82	96	100	81	100
Robigus	100	100	100	100	100
Solstice	100	100	100	100	100
Warrior	37	46	20	61	47
Cadenza	76	96	93	77	83
KWS Sterling	32	89	17	55	70
Kranich	8	7	0	29	33
Apache	55	96	83	68	93
Crusoe	5	7	0	10	7
Evolution	16	75	40	19	73
Total Number of Isolates	38	28	30	31	30

**Table 4**: Frequency of detection of isolates carrying virulence to the different yellow rust resistance genes and varieties over the past five years. \* = missing data.

**Table 5**: Pathotype group frequencies from the past five years.

Pathotype Group*	Freq	uency o	f Isolate	es Foun	d (%)
Fathotype Group	2016	2017	2018	2019*	2020*
Pink	8	0	0	6	3
Blue	29	3	0	0	0
Red	63	93	93	65	80
Purple	0	0	3	0	0
Other	0	4	4	29	17
Number of Isolates	46	28	30	31	30

\* Genetic groups have been assigned using phenotyping data until pathogenomics data has been fully interrogated, 2019 data is still to be sequenced. Novel isolates are currently classified as 'Other' until a genetic group can be assigned. Figures are correct at the time of publication and may be updated in future reports.

#### 4.1.2.3. Commonly detected isolates

In 2020, there were 18 different pathotypes detected (Table 3), five of which were unique to this year. This contrasts with the 2019 results where 24 pathotypes were identified and ten isolates were found to be unique. Similar to 2019, the isolates fell predominantly into the Red group (Table 3).

The two most common groups of isolates in 2020, equally represented by 17% isolates, were Red 37 which has the pathotype *Yr1,2,3,4,6,7,9,17,25,32*,Re,Sp,Ro,So,Wa,Ca,St,Kr,Ap,Ev and Red 28 pathotype *Yr1,2,3,4,6,7,9,17,25,32*,Re,Sp,Ro,So,Ca,St,Ap,Ev. Red 37 had previously been seen in the field pathogenomics work and Red 28 was detected for the first time in 2017. The isolates of these groups were collected from the varieties Costello, KWS Jackal, KWS Siskin, KWS Zyatt, KWS Basset, KWS Firefly, LG Astronomer, RGT Silversurfer and RGT Saki, and were collected from across the country: East and South Yorkshire, Derbyshire, West Sussex, Bridgend, Hertfordshire, Norfolk and East Lothian. No correlation between pathotype and location was found when the data was examined.

No isolates from the purple or blue pathotype groups were found in 2020, but an isolate from the Pink group was identified, carrying virulence for *Yr1,2,3,4,6,7,9,17,25,32*,Re,Sp,Ro,So, Wa,Ca,St,Kr,Ap,Cr,Ev. This pathotype, Pink 16, is relatively rare and was previously detected in 2017 at a low frequency. A similar isolate was also identified; however, its pathotype places it in the Red group.

#### 4.1.3. Variety testing of isolates from 2020

Five isolates from the thirty isolates tested were selected for further testing on the wider set of RL varieties and candidates (Table 6). Each year's isolates are selected to best represent the results of the tested isolates, choosing isolates with the most complex or novel virulence profiles, where possible. In 2020, the isolates 20/050, 20/092, 20/191, 20/293 and 20/304 were selected due to their novel and common pathotypes.

**Table 6**: Virulence profile of the isolates chosen for further characterisation in seedling and adult plant tests. Re = Rendezvous, Sp = Spaldings Prolific, Ro = Robigus, So = Solstice, Wa = Warrior, Ca = Cadenza, St = KWS Sterling, Kr = Kranich, Ap = Apache, Cr = Crusoe, Ev = Evolution. Yellow shading = compatible reaction (virulence), blank = avirulence, \* = missing data.

Isolato															,	Virul	ence	Profi	le <sup>2</sup>									
code	Host	Race Number <sup>1</sup>	1	2	3	4	5	6	7	8	9	10	15	17	24	25	32	Re	Sp	Ro	So	Wa	Са	St	Kr	Ар	Cr	Ev
20/050	KWS Siskin	Red 28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St	(Kr)	Ар		Ev
20/092	LG Astronomer	Red 37	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ар		Ev
20/191	KWS Siskin	New	1	2	3	4		6	7	8	9			17		25	32		Sp	Ro	So			St	Kr	Ар		Ev
20/293	KWS Extase	Pink 16	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ар	Cr	Ev
20/304	KWS Extase	Red 29 or Pink	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ар	Cr	

#### 4.1.3.1. Seedling tests

The five selected isolates were tested in seedling tests containing RL and candidate varieties in the controlled environment rooms at NIAB in the spring of 2021. Results are combined with the adult plant test results (Table 7) and are sorted by the reaction on the adult plant trials (see **4.1.3.2**). In general, there was good agreement between the control differentials included in this test and the original differential test results (Table **8**). Some variation was seen in the "supplementary" differentials, these are differentials that are included as they carry currently uncharacterised resistance genes. The reasons for these discrepancies are unclear, although it is possible that despite our best efforts and following subsequent rounds of multiplication, one or more of the isolates are more heavily selected for, hence the differences. As in previous years, the two RL varieties Costello and KWS Siskin were resistant to all isolates tested, along with RGT Saki and Theodore. Many of the newly recommended varieties and RL candidate varieties were also resistant to all five isolates at seedling stage. KWS Firefly remains resistant in seedling tests, although investigative work is ongoing. KWS Firefly was moderately susceptible at adult plant stage to all five isolates.

RL varieties that are only occasionally susceptible at the seedling stage included Crusoe and KWS Extase. Virulence for Crusoe was first detected in 2013 and continues to be detected in occasional isolates, such as 19/038 and 19/215 in 2019 and 20/293 and 20/304 in 2020. Isolate 20/304 was also found to be virulent on Crusoe at the adult plant stage. Isolates 20/293 and 20/304 were found to be virulent on KWS Extase at both seedling stage and adult plant stage.

Table 8 also shows the seedling data from re-isolates sampled directly from the inoculated trials. Natural infection contamination was detected late in the season, but this did not adversely affect the trial results.

#### 4.1.3.2. Adult plant tests

Alongside the seedling tests, the five isolates were also evaluated in the UKCPVS adult plant trials at NIAB in the summer of 2021 which contained RL and candidate varieties. Plots were directly inoculated early in the season to help keep natural infection at bay and inoculated every 7-14 days until the flag leaf had fully emerged. The first inoculation was carried out on the 23<sup>rd</sup> March 2021 and the first assessment was made on 10<sup>th</sup> June when the plants were at GS59. The percentage of plot area infected was assessed and the mean was calculated from three assessments (Table 7). Disease levels were moderate to high in the trials. In 2021, the adverse weather conditions experienced by the UK throughout the disease season may

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have impacted on disease development, but infection levels were considered good. In combination with results from the control varieties included in the trials, the adult plant results suggested that the trials were generally infected with the correct races. As expected, the susceptible controls Reflection and Robigus produced the highest levels of disease with up to 60.4% as an average of the percentage plot area infected assessments. Out of the 48 RL varieties and candidates under evaluation, 25 were classed as resistant to all isolates tested with mean percentage plot areas infected of 2% or less. The control variety Rendezvous was also resistant to all isolates.

During the 2021 field season, the most reported variety in the first half of the season was KWS Firefly. In these adult plant trials, KWS Firefly was susceptible to all isolates, which deviates from its current Recommended List score of 7 but is in line with its position in the AHDB yellow rust watch list.

### 4.1.3.3. Off-season adult plant tests

Off-season adult plant tests were conducted in the growth room in the spring-summer of 2021 using isolate 20/191. The results for yellow rust were unusual, in that, the RL varieties showed very low infection levels when compared to some of the susceptible differentials (Table 9). The current data is not informative for predicting the field adult plant reaction. Further optimisation of environmental conditions within the growth room are required.

During the same period, an off-season glasshouse trial was performed for the EU project RustWatch, following a similar protocol. This trial investigated some current, but mostly old RL varieties for their resistance/susceptibility to isolate 19/501. The results from this trial were more informative for predicting field adult plant reaction, indicating the environment in the glasshouse better replicates field conditions than the current conditions used in the growth room. These trials were more expensive than the growth room trials, which is prohibitive for regular screening but may be an option if an incursion occurs and off-season data is required.

 Table 7: 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.

Variaty	Current		Seedling (A	verage Infe	ction Type)			Adult Plant	t (% plot are	a infected)	
variety	RL Rating	20/050	20/092	20/191	20/293	20/304	20/050	20/092	20/191	20/293	20/304
KWS GUIUM	Candidate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LG FARRIER	Candidate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
THEODORE	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KWS PALLADIUM	Candidate	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 TYPHOON	Candidate	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
COSTELLO	9	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
KWS BRIUM	Candidate	2.1	1.3	0.2	3.0	2.5	0.0	0.0	0.0	0.1	0.1
KWS CRANIUM	8	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1
KWS DAWSUM	Candidate	0.0	0.0	0.0	0.0	0.0	0.2	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
RGT RASHID	Candidate	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
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
GRAHAM	8	3.0	3.0	3.0	3.0	3.0	0.1	0.1	0.0	0.1	0.3
CHAMPION	Candidate	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.5	0.0
MERIT	8	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.1	0.1	0.0
LG PRINCE	8	0.0	0.0	0.0	0.1	0.0	0.9	0.1	0.0	0.1	0.1
RENDEZVOUS		3.0	3.0	2.8	3.0	3.0	0.9	0.2	0.2	0.1	0.3
ASTOUND		3.0	3.0	0.0	0.1	0.3	1.0	0.4	0.3	0.1	0.0
RGT SAKI	8	0.0	0.0	0.0	0.0	0.0	0.2	1.3	0.1	0.1	0.1
RGT SILVERSURFER		0.2	0.0	0.2	0.0	0.7	0.6	0.6	0.0	0.2	0.5
KWS HENUM	Candidate	3.0	3.0	3.0	3.0	1.8	1.3	0.3	0.1	0.2	0.9
LG ILLUMINATE	7	0.0	0.1	0.0	0.0	0.0	2.0	1.0	0.2	0.1	0.1
MAYFLOWER	Candidate	0.0	0.3	0.0	0.3	0.0	1.5	0.2	1.1	0.3	0.6
RGT ILLUSTRIOUS	8	2.8	2.4	1.3	2.0	1.5	2.8	1.1	0.3	0.2	0.3
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
RGT BAIRSTOW	Candidate	0.0	0.0	0.3	0.0	0.0	3.8	2.2	0.1	5.5	0.9
LG QUASAR	6	0.1	0.0	0.0	0.1	0.0	5.9	3.2	0.6	3.1	0.9
Variety			Seedling (A	Average Infe	ction Type)		Adult Plan	nt (% plot area	a infected)		

	Current RL Rating	20/050	20/092	20/191	20/293	20/304	20/050	20/092	20/191	20/293	20/304
KWS EXTASE	8	0.5	0.9	0.4	2.2	3.0	0.2	0.1	0.0	6.2	8.0
RGT STOKES	Candidate	0.0	0.0	0.0	0.0	0.0	3.7	1.8	0.6	6.0	4.0
STRATOSPHERE		2.6	3.0	3.0	3.0	4.0	1.2	2.3	6.7	1.8	7.7
GLEAM	5	3.0	3.0	3.0	3.0	2.0	7.5	2.7	5.4	3.2	3.7
SY INSITOR	5	3.0	3.0	3.0	3.0	3.0	2.8	0.6	0.8	12.0	7.0
COUGAR		0.3	0.0	0.0	1.4	1.2	10.2	1.7	2.2	2.8	7.0
WARRIOR		2.4	3.0	1.0	3.0	3.0	0.2	0.1	0.1	11.2	13.7
RGT LANTERN		3.0	3.1	3.0	3.0	3.0	10.5	7.5	4.3	0.7	4.8
KWS BARREL	7	3.0	3.0	3.0	3.0	2.0	10.7	2.8	3.8	3.5	7.3
KRANICH		2.0	3.0	2.2	3.0	3.0	0.9	0.2	0.1	16.5	13.7
SWALLOW	6	0.0	0.0	0.0	0.0	0.0	6.0	4.7	6.0	4.0	13.5
RGT GALACTUS		0.0	0.0	0.0	0.0	0.0	14.2	6.0	6.7	9.0	2.0
LGW110		0.0	0.6	0.0	3.0	3.1	0.1	0.1	0.1	18.7	19.8
RGT GRAVITY	7	3.0	3.0	2.2	0.6	0.1	15.5	15.3	6.2	0.9	12.5
BANQUO		4.0	3.0	3.0	3.0	2.7	16.2	16.5	6.2	12.3	5.2
KWS GATOR		3.0	3.0	3.0	2.2	3.0	15.5	13.5	8.3	6.6	13.9
KWS STERLING		3.0	3.0	2.8	3.0	3.0	11.2	12.2	6.2	13.7	18.8
KWS FIREFLY	7	0.0	0.0	0.0	0.0	0.0	14.0	7.4	11.2	16.2	13.7
CADENZA		3.0	3.2	3.0	3.0	3.0	9.0	13.5	12.8	13.5	14.8
APACHE		3.0	3.0	2.3	3.0	3.0	13.7	13.7	11.8	12.5	15.7
RGT WOLVERINE	5	3.0	3.0	3.0	3.0	3.0	15.3	14.2	12.5	11.2	15.2
RGT FLINTOFF	Candidate	3.0	3.0	2.2	2.2	0.2	22.3	20.8	16.2	16.2	12.8
CORDIALE		1.3	3.0	2.6	3.0	3.0	16.2	14.2	14.3	19.2	27.5
DELPHI		4.0	3.5	3.0	3.0	3.0	18.8	24.7	19.7	13.2	16.3
LG SPOTLIGHT	6	3.0	4.0	3.0	3.0	3.1	20.7	14.8	15.0	24.2	20.8
AMBITION		0.8	1.8	2.0	3.0	3.3	1.5	8.4	0.1	33.3	61.7
HOBBIT		3.0	3.0	3.0	3.0	3.0	20.8	12.0	16.5	2.7	40.0
SKYFALL	3	3.0	3.0	3.0	3.0	3.0	20.8	24.3	14.7	26.3	26.2
KWS KERRIN	4	0.0	0.0	0.0	0.0	0.0	44.2	35.0	17.3	11.0	17.3
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
BRITANNIA		3.0	3.0	3.0	3.0	3.0	39.2	37.8	40.8	34.2	33.5
Variety			Seedling (A	verage Infe	ction Type)			Adult Plan	t (% plot are	a infected)	

	Current RL Rating	20/050	20/092	20/191	20/293	20/304	20/050	20/092	20/191	20/293	20/304
CLAIRE		3.0	3.0	3.0	3.0	3.0	43.3	40.8	39.2	40.0	35.8
REFLECTION		4.0	3.0	4.0	4.0	3.1	51.7	40.0	47.5	42.5	34.2
ROBIGUS		3.0	3.0	3.0	3.0	3.0	52.5	50.4	54.2	50.0	60.4
Avocet Yr1		3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Chinese 166		3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Kalyansona		3.0	3.5	3.0	3.1	3.0	*	*	*	*	*
Vilmorin 23		3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Hybrid 46		2.0	2.0	0.0	3.0	3.0	*	*	*	*	*
Suwon Omar		3.0	2.2	0.5	4.0	3.0	*	*	*	*	*
Avocet Yr5		0.0	0.0	0.0	0.0	0.0	*	*	*	*	*
Avocet Yr6		3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Heines Kolben		3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Heines Peko		3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Avocet Yr7		3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Lee		3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Avocet Yr8		0.0	0.0	3.0	0.0	0.4	*	*	*	*	*
Compair		0.0	0.0	2.0	0.0	0.2	*	*	*	*	*
Avocet Yr9		3.0	3.5	3.0	3.0	3.0	*	*	*	*	*
Clement		3.0	3.5	3.0	3.0	3.0	*	*	*	*	*
Moro		0.0	0.0	0.0	0.0	0.0	*	*	*	*	*
Avocet Yr15		0.0	0.0	0.0	0.0	0.0	*	*	*	*	*
VPM1		3.0	3.1	3.0	3.0	4.0	*	*	*	*	*
Avocet Yr17		4.0	3.0	3.0	3.0	3.3	*	*	*	*	*
Avocet Yr24		0.0	0.0	0.0	0.0	0.0	*	*	*	*	*
Heines VII		3.0	3.0	3.0	3.0	3.1	*	*	*	*	*
Strubes Dickkopf		3.0	3.0	3.0	3.0	3.9	*	*	*	*	*
Avocet Yr32		3.0	3.0	3.0	3.0	3.1	*	*	*	*	*
Carstens V		3.0	3.0	3.0	3.0	3.1	*	*	*	*	*
Avocet Sp		3.0	3.0	4.0	3.0	3.0	*	*	*	*	*
Spaldings Prolific		3.0	3.0	3.0	3.0	3.0	*	*	*	*	*
Avocet S		3.0	3.5	3.0	3.0	3.0	*	*	*	*	*
Vuka		3.0	3.5	3.0	4.0	3.0	*	*	*	*	*
Evolution		3.0	3.0	2.7	3.0	0.0	*	*	*	*	*
Mean		*	*	*	*	*	9.6	8.3	7.2	9.9	11.5

20/050 20/092 20/191 20/293 20/304 Differential Diff<sup>1</sup> Var<sup>2</sup> Re-Isol<sup>3</sup> Avocet Yr1 3.0 3.0 3.0 4.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.1 3.0 3.0 Chinese 166 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.3 3.5 3.0 3.0 3.0 3.0 3.0 3.1 3.0 3.0 3.0 3.0 3.0 Kalyansona Vilmorin 23 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 Hybrid 46 3.0 2.0 3.0 2.0 2.2 2.1 0.0 2.1 3.0 3.0 3.0 3.0 3.0 2.0 2.0 Suwon Omar 3.0 3.0 2.2 3.0 3.0 0.5 3.0 3.0 3.0 3.0 3.5 3.0 3.0 4.0 3.0 0.0 0.0 Avocet Yr5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 3.0 Avocet Yr6 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 Heines Kolben 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 Heines Peko 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.2 3.0 3.0 3.0 3.0 3.0 3.0 Avocet Yr7 3.0 3.1 3.0 3.0 3.0 3.0 3.0 3.0 2.8 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 Lee 3.0 0.0 Avocet Yr8 0.0 0.0 0.0 0.0 3.0 0.0 0.0 0.0 0.0 0.4 0.0 0.0 0.0 Compair 0.0 0.0 0.0 0.0 1.4 2.0 0.0 0.0 0.0 0.0 0.2 0.0 0.0 0.0 0.0 Avocet Yr9 4.0 3.0 4.0 3.5 3.0 3.2 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.5 3.0 Clement 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 0.0 0.0 Moro 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.3 0.0 0.0 0.0 Avocet Yr15 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 VPM 1 3.0 3.1 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.2 3.0 3.0 3.0 3.0 4.0 3.3 3.0 3.0 3.0 3.1 3.0 4.0 3.0 3.0 3.3 Avocet Yr17 3.0 3.0 3.0 3.0 3.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 Avocet Yr24 0.0 0.0 0.0 0.0 0.0 0.0 0.0 Heines VII 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.1 3.0 3.0 3.0 0.6 3.0 3.0 3.0 3.0 3.9 3.0 Strubes Dickkopf 3.0 3.0 3.0 3.0 3.0 Avocet Yr32 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.1 Carstens V 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.1 3.0 3.0 3.0 3.0 3.0 3.0 2.3 2.8 2.9 2.8 0.4 Rendezvous 3.0 3.0 0.0 3.0 3.0 3.0 3.0 3.0 3.0 3.1 3.0 3.0 4.0 3.0 3.1 3.0 3.0 3.0 3.0 Avocet Sp 3.0 3.0 Differential 20/050 20/092 20/191 20/293 20/304

**Table 8**: Comparison between initial differential test results, variety seedling test results and re-isolations from samples taken from variety adult plant trials for the isolates used in the 2020 variety tests and trials. <sup>1</sup> Diff = Differential test result, <sup>2</sup> Var = Variety seedling test result, <sup>3</sup> Re-Isol = Re-isolation results from adult plant trials, \* = missing data.

	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>
Spaldings Prolific	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Robigus	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Solstice	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Warrior	1.8	2.4	3.0	3.0	3.0	2.8	1.6	1.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Cadenza	3.0	3.0	1.9	3.0	3.2	2.7	0.6	3.0	2.8	3.0	3.0	1.8	3.0	3.0	2.0
KWS Sterling	3.0	3.0	3.0	3.0	3.0	3.0	2.7	2.8	0.0	3.0	3.0	3.0	2.8	3.0	0.0
Kranich	2.5	2.0	3.0	3.0	3.0	3.0	2.7	2.2	0.2	3.0	3.0	3.0	3.0	3.0	0.0
Apache	3.0	3.0	2.3	2.7	3.0	3.0	2.9	2.3	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Crusoe	0.0	0.0	0.0	2.0	0.0	0.1	0.0	0.3	0.0	3.0	0.0	3.0	3.0	0.0	0.0
Evolution	3.0	3.0	2.8	3.0	3.0	0.0	3.0	2.7	0.0	3.0	3.0	0.1	1.0	0.0	0.0

**Table 9:** Off-season adult plant tests inoculated with 20/191. \* = missing data, - = senescence.

	Avera	ge % lea	f area inf	fected
VARIETY	Leaf 1	Leaf 2	Leaf 3	Leaf 4
ASTOUND	0.3	0.0	0.0	0.0
BANQUO	0.0	0.0	0.0	0.0
CHAMPION	0.7	0.1	0.0	0.0
COSTELLO	0.0	0.0	0.0	0.0
CRUSOE	0.0	0.0	0.0	0.0
ELATION	0.0	0.0	0.0	0.0
ELICIT	0.0	0.0	0.3	0.0
GLEAM	0.0	0.0	0.0	2.9
GRAHAM	0.0	0.0	0.0	0.0
KWS BARREL	0.0	0.0	0.0	0.0
KWS BRIUM	0.0	0.0	0.0	0.0
KWS CRANIUM	0.0	0.0	0.0	0.0
KWS DAWSUM	0.0	0.0	0.0	0.0
KWS EXTASE	0.0	0.0	0.0	0.0
KWS FIREFLY	0.0	0.0	0.0	1.5
KWS GUIUM	0.0	0.0	0.0	0.0

KWS HENUM	0.0	0.0	0.0	0.8
KWS JACKAL	0.0	0.0	0.0	0.0
KWS KERRIN	0.3	0.0	0.3	0.2
KWS KINETIC	0.4	0.3	2.1	3.3
KWS PALLADIUM	0.0	0.0	0.0	0.0
KWS SISKIN	0.0	0.0	0.0	0.0
KWS ZYATT	1.2	1.6	4.4	0.0
LG ASTRONOMER	0.0	0.0	0.0	0.0
LG FARRIER	0.0	0.0	0.0	0.0
LG ILLUMINATE	0.0	0.0	0.0	0.0
LG PRINCE	0.0	0.0	0.0	0.0
LG QUASAR	0.0	0.0	0.0	0.0
LG SKYSCRAPER	0.0	0.0	0.0	0.0
LG SPOTLIGHT	0.0	0.0	4.8	0.0
LG TYPHOON	0.0	0.0	0.0	0.0
MAYFLOWER	0.0	0.0	0.0	0.3
MERIT	0.0	0.0	0.0	0.0
RGT BAIRSTOW	0.0	0.0	0.0	0.3
RGT FLINTOFF	0.0	0.0	1.1	0.3
RGT GALACTUS	0.0	0.0	0.0	0.0
RGT GRAVITY	0.0	0.0	0.0	0.0
RGT ILLUSTRIOUS	0.0	0.0	0.0	0.0
RGT LANTERN	0.0	0.0	0.0	0.8
RGT RASHID	0.0	0.0	0.0	0.0
RGT SAKI	0.0	0.0	0.0	0.0
RGT SILVERSURFER	0.0	0.0	0.0	0.7
RGT STOKES	0.0	0.0	0.0	0.0
RGT WOLVERINE	0.0	0.0	0.0	0.0
SKYFALL	0.1	0.0	0.0	0.0
SWALLOW	0.0	0.0	0.0	0.0
SY INSITOR	0.0	0.0	0.0	0.0
THEODORE	0.0	0.0	0.0	0.0
BRITTANIA	3.4	2.2	3.7	0.8

CORDIALE	2.6	3.4	5.5	1.4
COUGAR	0.0	0.0	0.6	0.0
DELPHI	0.3	0.0	0.3	0.0
HOBBIT	0.0	0.3	2.0	1.3
KWS GATOR	0.0	0.0	0.0	3.2
LGW110	0.0	0.0	0.1	0.8
REFLECTION	1.3	2.1	22.1	21.3
STRATOSPHERE	0.4	1.2	1.3	0.0
TORCH	*	*	*	*
Avocet 1	7.9	17.5	24.6	28.3
Chinese 166	0.0	1.9	18.8	-
Kalyansona	5.5	3.7	6.4	0.3
Vilmorin 23	0.0	1.0	0.0	0.0
Hybrid 46	0.0	1.7	0.0	0.0
Suwon Omar	15.7	40.8	55.8	-
Avocet 5	0.0	0.0	0.0	0.0
Avocet 6	22.1	55.8	57.5	-
Heines Kolben	0.0	58.3	75.0	-
Heines Peko	0.0	27.1	36.3	-
Avocet 7	22.8	59.2	57.9	81.3
Lee	12.4	22.9	65.0	-
Cadenza	16.8	29.2	16.3	-
Apache	0.0	0.0	0.6	0.0
Avocet 8	0.0	0.1	0.7	1.7
Compair	0.0	0.0	0.0	0.0
Avocet 9	21.7	44.6	60.8	-
Clement	0.0	0.0	0.8	0.0
Moro	0.0	0.0	0.0	0.0
Av x Yr15	0.0	0.0	0.0	0.0
VPM1	8.8	21.7	31.7	45.0
Rendezvous	0.0	0.0	0.0	0.0
Avocet 17	0.0	0.0	0.0	0.0
Avocet 24	0.0	0.0	0.0	0.0

Heines VII	0.0	0.0	0.0	0.0
Strubes Dickopff	0.0	0.0	0.0	0.0
Opata	0.0	0.0	0.0	0.0
Avocet 27	0.1	3.2	1.7	0.0
Avocet 32	0.0	16.2	17.1	4.2
Carstens V	0.0	0.0	1.3	6.7
Avocet Sp	9.9	23.3	33.3	52.1
Spaldings Pro	0.0	0.5	0.0	0.0
Robigus	1.5	3.3	14.6	0.0
Solstice	0.0	0.4	1.1	1.3
Warrior	0.0	0.0	0.0	0.0
KWS Sterling	0.0	0.2	0.4	0.8
Claire	0.0	0.0	0.7	7.9
Ambition	0.0	0.0	0.0	0.0
Avocet S	26.7	67.9	70.4	-
Vuka	32.5	57.5	58.3	-
Kranich	0.0	0.0	0.0	0.0
Evolution	0.0	0.0	0.0	0.0

#### 4.1.4. Genotyping

Twenty-four samples from 2020 were selected for genotyping based on their location and host cultivar (detailed in Appendix I). A phylogenetic tree based on 242 *Pst* genes following the MARPLE pipeline (Radhakrishnan et al., 2019) was constructed of the 24 isolates from 2020 (Figure 2). The tree also includes 48 isolates selected from the 2021 survey (Figure 2); pathotyping experiments of these are underway and will be reported fully in next year's report, along with 24 samples from 2019. The analysis grouped together many pathotyped Red group isolates and it also pulled out isolates that behaved different, yr\_20\_293a (20/293), from the Pink group and yr 20 304 (20/304) which has a pathotype similar to Pink (Figure 2).



**Figure 2**: Phylogenetic analysis of 242 *Pst* genes from selected samples from the UKCPVS programme from the 2020 and 2021 survey. Blue asterisk indicates isolates taken forward for adult trial plant trials.

Implementation of the MARPLE genotyping pipeline (Radhakrishnan et al., 2019) at NIAB is under development, with our current data, we are unable to distinguish pathotypes. There were issues with the quality of DNA extracted from older samples stored in RNAlater, and as a result. some genes were not amplified and therefore, not sequenced. Method development over the summer has included removing the use of RNAlater and collecting fresh samples of the isolates from the bulked-up material and transferring straight to the -80 °C freezer. This dramatically improved the quality of the DNA and the quality of data from the sequencer and will be used for all sample preparation going forward. Further optimisation included separating the primers in Pool 4 into two pools due to unmigrated DNA on the agarose gel. This appears to be related to the DNA extracted from RNAlater samples, a further reason why we adapted this part of the protocol. Moreover, Dr Diane Saunders and team at the John Innes Centre have improved the MARPLE pipeline and have included additional genes, which we will incorporate next year.

The MARPLE genotyping analysis supported that the five isolates selected for adult plant trials in 2021 represent diverse isolates (highlighted by blue asterisks; Figure 2). These isolates were also selected for whole genome sequencing, through our on-going collaboration with Dr Saunders. In this global analysis, isolates 20/293 and 20/304 were placed on separate parts on the tree, grouping 20/293 with Pink group isolates and 20/304 with Red group isolates (Figure 3). Though the MARPLE system has not yet been able to predict pathotype based on position in a phylogenetic tree, it succeeded in flagging an unusual isolate and thus, has achieved one of the important objectives for the technology. In future, the use of MARPLE, combined with information on variety of origin, will inform selection of isolates for testing.



**Figure 3**: Whole genome sequencing places 20/304 closer to Red group (Genetic group 4) isolates. Figure provided by Dr D. Saunders.

# 4.2. Wheat Brown Rust

### 4.2.1. Samples received

In 2020, the UKCPVS received 45 samples of wheat brown rust from 9 different counties across the UK (Figure 4).



**Figure 4**: Map of the UK with the number of samples of wheat brown rust received in 2020 from the different counties.

The full sample register is provided in Appendix I. Samples were received from 24 different varieties with the most sampled variety being Crusoe. There were no unexpected outbreaks of brown rust on established varieties. The host varieties in the sample register have not all been confirmed, and it is entirely possible that a sample listed as coming from a resistant variety may turn out to be another more susceptible variety. For this reason, the sample register is included as an indicator of what was received but should not be used to infer any breakdowns in resistance or changes in rating at this stage.

#### 4.2.2. Pathotyping of isolates

#### 4.2.2.1. Virulence for individual resistance genes and varieties

Twenty-five isolates were selected for further pathotyping (Table 10). The isolates were selected based on their county of origin and the resistance rating of the host. Isolates from known susceptible varieties were also selected to investigate whether the same or similar isolates are found on different varieties across the resistance spectrum. Isolates were assessed for their reactions on a differential set, their reactions are expressed as an average infection type (A.I.T.). As before, isolates were classified as virulent if the A.I.T. score was 2.7 or above. Scores between 2.4 and 2.7 were considered borderline. Using these scores, along with data from other differentials not listed here, it was possible to combine the scores for reactions to different resistance genes to infer a pathotype for each of the isolates (Table 11). This was the fifth year that the UKCPVS employed the use of the updated differential set which, for the past 5 years has aligned the UKCPVS with other virulence surveys across the world (for example Kolmer et al. 2013). The frequency of detection of virulence for the Lr genes monitored is shown in Table 12. Virulence for Lr13, Lr14a, Lr15, Lr16, Lr17, Lr17b and Lr37 was detected in all isolates which follows the trend of 2019. Interestingly, virulence for Lr1 increased and was also found in 100% of isolates tested. Virulence for Lr28 increased and in 2019 the UKCPVS concluded that KWS Firefly appears to carry the same resistance as Lr28. Virulence for Lr20 continued to decline in the pathogen population. No virulence was detected for Lr2a, Lr2b and Lr24. There appeared to be no major effect on RL varietal performance relating to these changes.

#### 4.2.2.2. Commonly detected races

In 2020, there were 15 different pathotypes detected in the 25 isolates tested, most of which were pre-existing pathotypes. The most common pathotype identified was *Lr1,3a,3bg,3ka,10, 13,14a,15,16,17,26,37*,Cr, this pathotype was first seen in 2018 and has been detected every year since.

Although it is likely that there will be more than one race present in some of the samples based on the experience of colleagues in France (H. Goyeau, *pers. comm.*), every effort is now made to culture single pustule isolates to solve any issues with mixed isolates.

#### 4.2.3. Variety testing of isolates from 2020

Five isolates from the 25 tested isolates were selected for further testing on the wider set of RL varieties and candidates (Table 13) and were selected to best represent the diversity of the isolates tested.

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**Table 10:** Average infection type (A.I.T.) scores for the selected isolates against the UKCPVS differential set. Yellow shading indicates a compatible reaction; orange shading indicates a borderline reaction. Compatible interactions classify the isolate as virulent against a particular resistance gene or variety.

lsolate	Host Variety	Thatcher Lr1	Thatcher Lr2a	Thatcher Lr2b	Thatcher Lr2c	Thatcher Lr3a	Thatcher <i>Lr3bg</i>	Thatcher <i>Lr3k</i> a	Thatcher Lr10	Thatcher Lr13	Thatcher <i>Lr14</i> a	Thatcher Lr15	Thatcher Lr16	Thatcher Lr17	Thatcher Lr20	Thatcher Lr23	Thatcher Lr24	Thatcher Lr26	Thatcher Lr28	Thatcher Lr37	Armada	Crusoe	Maris Fundin ( <i>Lr17b</i> )	Robigus ( <i>Lr28</i> )
20/001	Graham	3.0	0.0	1.0	1.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.9	3.0	2.0	3.0	3.0	3.0	3.0	0.0
20/002	KWS Colosseum	3.0	0.0	1.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	0.5	3.0	0.8	3.0	3.0	3.0	3.0	0.8
20/003	Crusoe	3.0	0.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	0.8	3.0	0.4	3.0	3.0	3.0	3.0	0.0
20/004	KWS Extase	3.0	0.0	1.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	0.8	3.0	0.0	3.0	3.0	3.0	3.0	0.0
20/005	KWS Firefly	3.0	0.0	0.1	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	0.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20/006	Elicit	3.0	0.0	1.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.6	3.0	0.0	3.0	3.0	3.0	3.0	0.0
20/015	LG Spotlight	3.0	0.0	0.2	1.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20/017	RGT Gravity	3.0	0.0	0.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20/018	Crusoe	3.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.9	3.0	2.0	3.0	3.0	3.0	3.0	2.0
20/019	Crusoe	3.0	0.0	0.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	1.2	2.0	3.0	3.0	3.0	3.0	3.0	3.0
20/021	KWS Siskin	3.0	0.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	0.9	3.0	3.0	3.0	3.0	3.0	3.0	2.0
20/024	RGT Saki	3.0	0.0	0.0	1.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.9	3.0	0.4	3.0	3.0	3.0	3.0	2.0
20/026	KWS Firefly	3.0	0.0	0.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.3	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20/027	LG Prince	3.0	0.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	1.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20/028	KWS Lili	3.0	0.0	0.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.3	3.0	2.0	3.0	3.0	3.0	3.0	2.0
20/032	KWS Extase	3.0	0.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	1.8	3.0	2.0	3.0	3.0	3.0	3.0	2.0
20/033	KWS Firefly	3.0	0.0	1.0	2.0	1.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.6	2.0	3.0	3.0	3.0	3.0	3.0	3.0
20/034	RGT Saki	3.0	0.0	1.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20/036	Crusoe	3.0	0.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.3	3.0	0.8	3.0	3.0	3.0	3.0	0.8

Isolate	Host Variety	Thatcher Lr1	Thatcher Lr2a	Thatcher Lr2b	Thatcher Lr2c	Thatcher Lr3a	Thatcher Lr3bg	Thatcher <i>Lr3ka</i>	Thatcher Lr10	Thatcher Lr13	Thatcher Lr14a	Thatcher Lr15	Thatcher Lr16	Thatcher Lr17	Thatcher Lr20	Thatcher Lr23	Thatcher Lr24	Thatcher Lr26	Thatcher Lr28	Thatcher Lr37	Armada	Crusoe	Maris Fundin ( <i>Lr17b</i> )	Robigus ( <i>Lr28</i> )
20/038	KWS Extase	3.0	0.0	0.0	1.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	1.2	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20/039	Crusoe	3.0	0.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.3	3.0	2.0	3.0	3.0	3.0	3.0	2.0
20/041	KWS Cranium	3.0	0.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	1.2	3.0	2.0	3.0	3.0	3.0	3.0	2.0
20/042	RGT Illustrious	3.0	0.0	1.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.3	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20/043	Crusoe	3.0	0.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	1.5	3.0	2.0	3.0	3.0	3.0	3.0	2.0
20/044	KWS Extase	3.0	0.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	1.8	3.0	2.0	3.0	3.0	3.0	3.0	2.0

**Table 11:** Pathotypes of the 2020 *Puccinia triticina* isolates based on the differential test results in Table 10. Numbers refer to specific Lr resistance genes, Cr = Crusoe, Ro = Robigus.

Isolate	lle et veriet.										Vir	ruler	ice P	rofile	e								
Number	Host variety	1	2a	2b	2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23	24	26	28	37	17b	Ro	Cr
20/001	Graham	1						3ka	10	13	14a	15	16	17	20	23		26		37	17b		Cr
20/002	KWS Colosseum	1			2c	3a	3bg	3ka	10	13	14a	15	16	17		23		26		37	17b		Cr
20/003	Crusoe	1				3a	3bg	3ka	10	13	14a	15	16	17		23		26		37	17b		Cr
20/004	KWS Extase	1			2c	3a	3bg	3ka	10	13	14a	15	16	17		23		26		37	17b		Cr
20/005	KWS Firefly	1				3a	3bg	3ka	10	13	14a	15	16	17		23		26	28	37	17b	Ro	Cr
20/006	Elicit	1						3ka	10	13	14a	15	16	17				26		37	17b		Cr
20/015	LG Spotlight	1								13	14a	15	16	17				26	28	37	17b	Ro	Cr
20/017	RGT Gravity	1						3ka	10	13	14a	15	16	17				26	28	37	17b	Ro	Cr
20/018	Crusoe	1			2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23		26		37	17b		Cr
20/019	Crusoe	1						3ka	10	13	14a	15	16	17					28	37	17b	Ro	Cr
20/021	KWS Siskin	1				3a	3bg	3ka	10	13	14a	15	16	17		23		26	(28)	37	17b		Cr
20/024	RGT Saki	1							10	13	14a	15	16	17				26		37	17b		Cr
20/026	KWS Firefly	1							10	13	14a	15	16	17				26	28	37	17b	Ro	Cr
20/027	LG Prince	1				3a	3bg	3ka	10	13	14a	15	16	17				26	28	37	17b	Ro	Cr
20/028	KWS Lili	1				3a	3bg	3ka	10	13	14a	15	16	17				26		37	17b		Cr
20/032	KWS Extase	1				3a	3bg	3ka	10	13	14a	15	16	17	20	23		26		37	17b		Cr
20/033	KWS Firefly	1							10	13	14a	15	16	17					28	37	17b	Ro	Cr
20/034	RGT Saki	1							10	13	14a	15	16	17				26	28	37	17b	Ro	Cr
20/036	Crusoe	1				3a	3bg	3ka	10	13	14a	15	16	17	(20)			26		37	17b		Cr
20/038	KWS Extase	1						3ka	10	13	14a	15	16	17				26	28	37	17b	Ro	Cr
20/039	Crusoe	1				3a	3bg	3ka	10	13	14a	15	16	17				26		37	17b		Cr
20/041	KWS Cranium	1				3a	3bg	3ka	10	13	14a	15	16	17				26		37	17b		Cr
20/042	RGT Illustrious	1						3ka	10	13	14a	15	16	17				26	28	37	17b	Ro	Cr
20/043	Crusoe	1				3a	3bg	3ka	10	13	14a	15	16	17				26		37	17b		Cr
20/044	KWS Extase	1				3a	3bg	3ka	10	13	14a	15	16	17	(20)			26		37	17b		Cr

Table 12: Frequency of detection of isolates carrying virulence to the different brown rust resistance gen	ies
and varieties over the past five years. * = missing data.	

Virulence for Resistance	Percentage of	of Isolates Ide	ntified with Vir	ulence for Ge	ne or Variety
Gene or Variety	2016	2017	2018	2019	2020
Lr1	29	68	81	89	100
Lr2a	0	0	0	0	0
Lr2b	0	16	0	0	0
Lr2c	6	48	26	11	12
Lr3a	26	87	48	75	56
Lr3bg	19	81	71	75	56
Lr3ka	29	77	74	93	80
Lr10	29	87	100	100	96
Lr13	32	84	100	100	100
Lr14a	29	87	100	100	100
Lr15	16	84	100	100	100
Lr16	13	58	52	100	100
Lr17	23	87	100	100	100
Lr17b	81	55	100	100	100
Lr20	10	87	77	29	12
Lr23	6	45	39	36	32
Lr24	3	3	0	0	0
Lr26	0	58	100	82	92
Lr28	0	0	6	25	40
Lr37	39	74	100	100	100
Robigus	0	0	6	14	40
Crusoe	71	77	100	100	100
Total Number of Isolates	25	27	31	28	25

**Table 13:** Virulence profile of the isolates chosen for further characterisation in seedling and adult plant tests. Numbers refer to specific *Lr* resistance genes, Ro = Robigus, Cr = Crusoe. Yellow shading = compatible reaction (virulence), blank = avirulence.

Isolate	Host variety										Vi	rulenc	e Prof	ile									
Number	nostvanety	1	2a	2b	2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23	24	26	28	37	17b	Ro	Cr
20/002	KWS Colosseum	1			2c	3a	3bg	3ka	10	13	14a	15	16	17		23		26		37	17b		Cr
20/005	KWS Firefly	1				3a	3bg	3ka	10	13	14a	15	16	17		23		26	28	37	17b	Ro	Cr
20/018	Crusoe	1			2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23		26		37	17b		Cr
20/021	KWS Siskin	1				3a	3bg	3ka	10	13	14a	15	16	17		23		26	(28)	37	17b		Cr
20/032	KWS Extase	1				3a	3bg	3ka	10	13	14a	15	16	17	20	23		26		37	17b		Cr

#### 4.2.3.1. Seedling tests

The five selected isolates were tested in seedling tests containing RL and RL candidate varieties in the controlled environment rooms at NIAB in the spring of 2021. Results are combined with the adult plant test results (Table 14) and are sorted by the reaction on the adult plant trials (see **4.2.3.2**). Many of the RL varieties and candidates tested were resistant at seedling stage to all of the isolates tested. This is unusual and a significant increase from last year, although this did not translate to unusual results at the adult plant level.

A general agreement was seen when the variety seedling test results were compared with those of the initial differential tests; however, several small discrepancies were seen (Table 15). Purification methods have now been used by the UKCPVS to solve the problem of multiple isolates in a sample. Discrepancies seen now are most likely due to environmental issues.

### 4.2.3.2. Adult plant tests

Alongside the seedling tests, the five isolates were also evaluated in the UKCPVS adult plant trials at NIAB in the summer of 2021 which contained RL and candidate varieties. As with the yellow rust trials, the plots were directly inoculated early in the season to help keep natural infection at bay and inoculated every 7-14 days until the flag leaf had fully emerged. The first inoculation was carried out on the 20<sup>th</sup> May 2021 and the first assessment was made on 22<sup>nd</sup> June when the plants were at GS72. The percentage plot infected was assessed and the mean was calculated from three assessments (Table 14). Disease levels were considered good in the trials this year, although disease development was generally later than in previous years due to inclement weather in the preceding months. The susceptible control and current RL variety Crusoe showed the highest levels of disease. Samples were taken from the trials to confirm that isolates used to inoculate the trial were present (Table 15). Tests on these isolates generally agreed with the differential seeding tests, suggesting that the new inoculation techniques are significantly lowering levels of natural infection.

Out of the 48 RL varieties and candidates under evaluation, only two were resistant to all isolates tested with mean percentage plot infection levels of 2% or less – Theodore and Skyfall. During the 2021 field season, the UKCPVS did not receive any reports of higher than expected levels of disease in any particular variety. The most commonly reported variety was Crusoe, which is to be expected due to its low RL rating for brown rust and mirrored in 2021's

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adult plant trials. KWS Firefly was categorised as susceptible for the second year running, in line with its current disease resistance rating of 5 on the Recommended List. There were some interesting reactions to the 5 different isolates, KWS Kinetic was resistant to isolates 20/002 and 20/005, whilst KWS Zyatt was susceptible to 20/005 and 20/032. The candidate RGT Flintoff was resistant to isolate 20/018.

### 4.2.3.3. Off-Season adult plant tests

Off-season adult plant tests were inoculated with one of the adult plant trial isolates, 20/005, and were conducted in spring summer 2021 in growth rooms. Similar to the yellow rust off-season adult plant tests, for the brown rust the RL, RL candidates and control varieties scored lower infection levels than the differential set varieties (Table 16).

**Table 14:** 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.

Veriety	Current RL		Seedling (A	verage Infe	ection Type	)		Adult Plant	: (% plot are	ea infected)	
variety	Rating	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	0.0	0.0	0.0	0.1	0.0
KWS Target	-	1.0	1.6	1.0	2.0	0.0	0.0	0.0	0.0	20.0	0.0
Maris Halberd	-	2.0	2.0	2.0	2.0	3.0	2.5	0.5	0.0	0.0	0.0
Robigus	-	1.0	1.0	1.0	2.0	0.5	0.0	0.0	0.0	0.0	0.0
Theodore	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0
Stigg	-	0.9	0.6	1.2	0.6	0.3	0.0	0.0	6.7	0.0	0.1
Skyfall	8	3.0	3.0	3.0	3.0	3.0	0.5	0.0	0.0	0.0	0.6
Warrior	-	0.0	0.0	0.0	0.0	0.0	0.4	0.0	2.0	0.0	2.8
Sterna	-	3.0	3.0	3.0	3.0	3.0	7.5	10.4	2.0	0.7	3.3
LG Astronomer	9	1.0	0.0	1.0	2.0	0.0	2.0	4.3	0.3	2.7	4.7
KWS Henum	Candidate	1.0	1.0	1.0	1.0	0.0	9.4	2.8	4.0	5.5	5.2
LG Farrier	Candidate	2.0	3.0	3.0	2.0	2.0	7.9	6.3	5.7	4.7	5.4
RGT Galactus	-	1.0	1.0	1.0	2.0	0.3	11.4	11.4	16.7	4.2	7.0
LG Typhoon	Candidate	0.5	0.5	1.0	2.0	0.0	14.4	9.3	8.4	3.5	7.5
Gamin	-	3.0	3.0	3.0	3.0	3.0	15.7	11.2	7.5	11.5	8.0
Mayflower	Candidate	3.0	3.0	3.0	3.0	3.0	13.5	11.0	3.9	8.2	10.2
Avalon	-	3.0	3.0	3.0	3.0	3.0	12.5	18.4	13.4	13.8	10.3
LG Prince	8	1.0	1.0	1.0	2.0	0.1	10.5	11.8	7.5	7.9	10.4
Astound	-	3.0	3.0	3.0	3.0	3.0	6.7	13.5	10.3	10.0	10.7
KWS Kerrin	7	3.0	3.0	3.0	3.0	3.0	1.8	14.3	9.5	12.0	11.3
RGT Wolverine	8	3.0	3.0	3.0	3.0	3.0	4.0	0.0	0.6	14.0	11.7
LG Illuminate	8	1.0	0.0	*	1.0	*	11.0	13.0	6.0	12.5	11.9
LG Quasar	8	1.0	0.0	1.0	2.0	0.2	13.0	11.7	14.0	14.0	12.0
Champion	Candidate	1.0	1.0	1.0	2.0	2.0	14.4	15.9	10.9	11.9	12.2
KWS Dawsum	Candidate	3.0	3.0	3.0	3.0	3.0	10.4	10.9	12.0	7.7	12.3
LG Spotlight	6	3.0	3.0	3.0	3.0	3.0	4.5	0.5	11.8	11.4	13.0
RGT Bairstow	2	1.0	0.2	1.0	3.0	0.0	12.7	12.9	15.5	3.9	13.0
Merit	Candidate	1.0	1.0	1.0	2.0	0.0	7.5	10.0	13.4	6.7	13.4
Sappo	-	2.0	2.0	3.0	2.0	3.0	12.0	11.7	15.5	11.5	13.5
Variety	Current RL Rating		Seedling	(Average Infect	tion Type)			Adult Pla	nt (% 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	Current RL Rating		Seedling (Average Infection Type) Adult Plant (% plot area infected)				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

**Table 15:** Comparison between initial differential test results, variety seedling test results and re-isolations from samples taken from variety adult plant trials for the isolates used in the 2020 variety tests and trials. <sup>1</sup> Diff = Differential test result, <sup>2</sup> Var = Variety seedling test result, <sup>3</sup>Re-Isol = Re-isolation results from adult plant trials, \* = missing data.

Differential		20/002		20/005			20/018			20/021			20/032		
Differential	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>
Armada	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Clement	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Crusoe	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Glasgow	3.0	3.0	3.0	3.0	3.0	3.0	3.0	*	3.0	3.0	3.0	3.0	3.0	3.0	3.0
KWS Firefly	1.0	1.0	2.0	3.0	1.0	3.0	2.0	1.0	2.0	2.0	2.0	3.0	0.0	0.0	2.0
Maris Fundin	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Maris Halberd	2.0	2.0	2.0	1.0	2.0	2.0	3.0	2.0	1.0	2.0	2.0	0.0	3.0	3.0	3.0
Robigus	0.8	1.0	2.0	3.0	1.0	3.0	2.0	1.0	2.0	2.0	2.0	3.0	2.0	0.5	2.0
Sappo	2.0	2.0	2.0	1.0	2.0	2.0	3.0	3.0	2.0	2.0	2.0	1.0	3.0	3.0	3.0
Sterna	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0
Stigg	0.9	0.9	0.6	0.3	0.6	1.2	0.9	1.2	1.2	0.9	0.6	0.9	1.5	0.3	2.1
Warrior	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
Thatcher Lr1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0
Thatcher Lr2a	0.0	1.0	0.0	0.0	1.0	0.0	1.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0
Thatcher Lr2b	1.0	2.0	1.0	0.1	1.0	1.0	2.0	2.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0
Thatcher Lr2c	3.0	2.0	3.0	2.0	2.0	2.0	3.0	3.0	1.0	2.0	2.0	1.0	2.0	2.0	2.0
Thatcher <i>Lr3a</i>	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	0.0	3.0	3.0	3.0
Thatcher Lr3bg	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	1.0	3.0	3.0	3.0
Thatcher Lr3ka	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0
Thatcher Lr10	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Thatcher Lr13	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Thatcher Lr14a	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Thatcher Lr15	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Thatcher Lr16	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Thatcher Lr17	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Thatcher Lr20	2.0	2.0	2.0	1.0	2.0	2.0	3.0	2.0	2.0	2.0	2.0	1.0	3.0	3.0	3.0

Differential		20/002		20/005		20/018			20/021				20/032		
Binoronilai	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>	Diff <sup>1</sup>	Var <sup>2</sup>	Re-Isol <sup>3</sup>
Thatcher Lr23	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	3.0	3.0	2.0	3.0	2.0	3.0
Thatcher Lr24	0.5	0.6	1.2	0.9	1.5	0.6	0.9	1.2	0.3	0.9	0.6	0.1	1.8	1.2	1.8
Thatcher Lr26	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Thatcher Lr28	0.8	0.2	2.0	3.0	0.3	3.0	2.0	1.0	2.0	3.0	2.0	3.0	2.0	0.2	2.0
Thatcher Lr37	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

**Table 16:** Off-season adult plant tests conducted in growth rooms and inoculated with 20/005, one of the isolates selected for the adult plant trials. - = senescence.

Variaty	Average	% leaf area infected				
variety	Leaf 1	Leaf 2	Leaf 3			
Armada	5.0	10.0	15.0			
Astound	25.0	15.0	7.0			
Avalon	20.0	18.0	15.0			
Banguo	18.0	15.0	10.0			
Buster	7.0	10.0	18.0			
Champion	0.0	0.0	0.0			
Consort	35.0	15.0	20.0			
Costello	18.0	7.0	10.0			
Crusoe	50.0	30.0	15.0			
Elation	25.0	15.0	20.0			
Elicit	20.0	10.0	5.0			
Gamin	10.0	7.0	7.0			
Glasgow	25.0	20.0	20.0			
Gleam	25.0	18.0	18.0			
Graham	15.0	5.0	10.0			
KWS Barrel	15.0	5.0	10.0			
KWS Brium	22.0	15.0	20.0			
KWS Cranium	25.0	20.0	5.0			
KWS Dawsum	18.0	18.0	5.0			
KWS Extase	10.0	7.0	3.0			
KWS Eirofly	0.1	0.0	0.0			
KWS Guium	25.0	10.0	15.0			
KWS Henum	23.0	0.0	0.0			
	18.0	15.0	12.0			
	15.0	10.0	3.0			
KWS Kinotic	19.0	10.0	12.0			
	15.0	5.0	12.0			
KWS Fallaulum	18.0	5.0	7.0			
KWS Storling	18.0	7.0	15.0			
KWS Sterning	0.1	7.0	15.0			
	15.0	10.0	15.0			
LC Astronomor	13.0	0.1	15.0			
	15.0	10.0	<u> </u>			
	13.0	10.0	5.0			
	0.0	0.0	0.0			
	0.0	0.1	0.0			
	19.0	12.0	15.0			
LG Skysciapei	10.0	12.0	15.0			
	20.0	10.0	15.0			
LG Typhoon Maria Eundin	10.0	19.0	0.0			
Marie Halbord	10.0	10.0	- 5.0			
Maris Huntaman	10.0	10.0	22.0			
Maris Pangar	10.0	10.0	22.0			
Masset	1.0	20.0	-			
Movflower	12.0	20.0	40.0			
Morit	10.0	7.0	10.0			
Booner	0.0	10.0	0.0			
Reaper DCT Pairotow	10.0	10.0	0.0			
	0.0	0.0	0.0			
	0.0	10.0	0.0			
	0.0		0.0			
	15.0	15.0	20.0			
	15.0	7.0	10.0			
	10.0	1.0	10.0			
RGT Rashid	0.0	0.0	0.0			
RGT Saki	0.0	0.0	0.0			
KGI Silversurfer	0.0	0.0	0.0			

RGT Stokes	18.0	5.0	18.0
RGT Wolverine	10.0	7.0	18.0
Robigus	0.0	0.0	0.0
Sappo	5.0	5.0	-
Skyfall	7.0	5.0	10.0
Soissons	20.0	10.0	15.0
Sterna	5.0	3.0	-
Stigg	0.0	0.0	0.0
Swallow	0.0	0.0	0.0
SY Insitor	30.0	15.0	20.0
Theodore	0.0	0.0	0.0
Tuxedo	18.0	20.0	15.0
Warrior	0.0	0.0	0.0
Thatcher Lr1	45.0	35.0	30.0
Thatcher Lr2a	3.0	1.0	-
Thatcher Lr2b	7.0	5.0	-
Thatcher Lr2c	18.0	10.0	-
Thatcher Lr3a	40.0	30.0	-
Thatcher Lr3bg	45.0	25.0	10.0
Thatcher Lr3ka	35.0	25.0	20.0
Thatcher Lr10	35.0	15.0	5.0
Thatcher Lr13	30.0	20.0	12.0
Thatcher Lr14a	50.0	30.0	20.0
Thatcher Lr15	30.0	20.0	15.0
Thatcher Lr16	40.0	30.0	20.0
Thatcher Lr17	7.0	5.0	-
Thatcher Lr20	22.0	18.0	7.0
Thatcher Lr23	12.0	7.0	5.0
Thatcher Lr24	7.0	3.0	-
Thatcher Lr26	18.0	12.0	5.0
Thatcher Lr28	3.0	1.0	-
Thatcher Lr37	40.0	30.0	20.0
Clement	20.0	18.0	15.0

# 4.3. Wheat Powdery Mildew

### 4.3.1. Samples received

Levels of wheat powdery mildew were low in 2020 and the UKCPVS received 2 samples (Appendix I). The samples came from 2 different varieties and 2 different counties (Figure 5).





## 4.3.2. Pathotyping of isolates

Unfortunately, none of the samples received survived incubation and no isolates were successfully cultured. No seedling tests were carried out in 2020 or 2019. Virulence frequencies are listed for 2014 – 2018 in Table 17 for reference only.

Differential	Known Conoc	l l	Virulence	Frequence	cy by Yea	r
Differential	Known Genes	2014	2015	2016	2017	2018
Galahad	Pm2	72	71	88	100	100
Chul	Pm3b	20	14	8	20	15
Armada	Pm4b	84	64	84	100	96
Flanders	Pm5	76	71	76	84	81
Brimstone	Pm6	80	64	88	96	93
Clement	Pm8	44	50	88	84	93
Maris dove	Mld	60	64	64	68	100
Brock	Pm2,MITa2	88	71	84	96	100
Mercia	Pm5, MITa2	80	79	80	100	93
Tonic	MITo	24	14	28	64	85
Broom	Pm3d	20	14	28	60	85
Sicco	Pm5, MISi2	8	0	8	40	11
Wembley	MISo	8	0	4	44	11
Axona	MIAx	12	14	32	60	78
Amigo	Pm17	0	7	0	8	0
Shamrock	MISh	4	0	0	0	0
Robigus	MIRo	64	64	56	72	85
Warrior		8	0	8	16	74
Stigg		8	0	4	16	74
Crusoe	36	36	72	68	93	
<b>Total Number</b>	of Isolates Tested	25	14	25	25	27

**Table 17:** Virulence frequencies of key wheat powdery mildew resistance genes and varieties over five years of testing.

The wheat powdery mildew isolates are not tested on varieties at the adult plant stage, and so the impact of these population changes can only be assessed through reports from growers, agronomists and trial managers.

## 4.4. Barley Powdery Mildew

#### 4.4.1. Samples received

Like the wheat powdery mildew, low levels of barley powdery mildew were observed in 2020 and the UKCPVS received 1 sample (Appendix I). This came from the winter barley cultivar Bazooka located in Buckinghamshire (Figure 6).



**Figure 6**: Map of the UK with the number of samples of barley powdery mildew received in 2020 from the different counties.

#### 4.4.2. Pathotyping of isolates

From the sample received, 6 single pustule isolates were obtained, and these were characterised using a differential set (Table 18). Virulence for most of the differentials was detected (Table 18). Some changes in virulence frequencies were observed. Virulence for *MILa, MIa12, MIa7, MIAb* and for the additional cultivar Vanessa all decreased. Virulence for *MIa1* and *MIa3* both increased as did virulence for *MIo11* carried by Apex, but these results must be interpreted with caution due to the low sample numbers received and tested. No

virulence was detected for *Mla9, Mlo11* carried by Riviera, *Mla13* nor for the additional cultivars Optic and Propino. The UKCPVS received no reports of unexpected outbreaks of barley powdery mildew during 2020 or 2021, and so it is possible that this variation in the population did not translate into meaningful differences at the adult plant stage. As with the wheat powdery mildew, no adult plant tests were conducted with these isolates. The UKCPVS will continue to monitor the barley powdery mildew population.

**Table 18**: Pathotype results for the barley powdery mildew detached seedling tests. Average infection types of 2.7 and above (yellow shading) indicate a compatible reaction, values between 2.5 and 2.7 (shaded orange) indicate a borderline reaction and values below 2.5 indicate an incompatible reaction. Differential varieties are listed along with the known resistance genes carried by these lines.

Isolate		0	ЧIМ	Mira	MIg	MIg,MI(CP)	MIa6	MILa	Mla12	MIK1	Mla7	MIAb	Mla7,MIAb	Mla1	Mla9	MIo 11	Mlo Riv	Mla13	Mla3	Vanessa	Optic	Propino
Number	Host variety	Golden Promise	W.37/136	W.41/145	Goldfoil	Zephyr	Midas	Lofa	Hassan	H.1063	Porter	Lotta	Triumph	Tyra	Roland	Apex	Riviera	Digger	Ricardo	Vanessa	Optic	Propino
20/1/1	Bazooka	3.3	3.3	3.5	3.0	3.3	3.5	3.0	3.5	0.8	2.8	2.3	1.3	3.5	0.0	2.5	0.5	1.0	1.0	3.3	1.5	0.3
20/1/2	Bazooka	3.3	3.8	3.0	3.0	2.8	3.0	3.5	4.0	2.0	2.5	2.0	1.8	2.8	0.0	1.0	0.5	1.0	1.3	3.0	2.0	0.0
20/1/5	Bazooka	3.0	4.0	3.5	3.0	3.3	3.0	1.8	2.0	2.8	2.8	1.8	1.3	3.0	0.8	2.5	0.3	0.0	3.5	0.0	0.0	1.3
20/1/7	Bazooka	3.3	4.0	3.3	3.3	3.3	3.0	2.0	3.8	1.0	1.8	2.5	1.5	3.5	0.0	2.8	0.0	0.0	2.3	2.8	2.0	2.5
20/1/10	Bazooka	3.3	3.8	3.0	3.0	3.3	3.0	2.8	1.8	3.0	3.0	2.8	2.8	0.0	0.0	2.8	0.0	0.0	1.5	0.0	2.0	0.5
20/1/11	Bazooka	3.0	4.0	3.0	3.0	3.0	3.0	1.8	4.0	0.8	0.0	2.8	0.0	2.8	0.3	2.5	0.0	0.0	0.8	3.0	1.5	0.0

**Table 19**: Virulence frequencies of key barley powdery mildew resistance genes over the past five years of testing. \* = Not tested.

Differential	Known	Vi	rulence	Frequenc	y by Yea	r
Differential	Genes	2016	2017	2018	2019	2020
Golden Promise	0	88	100	100	100	100
W.37/136	Mlh	100	100	100	100	100
W.41/145	Mlra	100	100	100	100	100
Goldfoil	Mlg	100	97	79	100	100
Zephyr	Mlg,Ml(CP)	100	97	79	100	100
Midas	Mla6	100	100	100	100	100
Lofa	MILa	96	84	38	100	50
Hassan	Mla12	96	84	83	100	67
H.1063	Mlk1	31	13	41	25	33
Porter	Mla7	27	53	31	100	50
Lotta	MIAb	35	78	59	75	33
Triumph	Mla7,MlAb	12	22	3	25	17
Tyra	Mla1	73	56	69	25	83
Roland	Mla9	15	16	14	0	0
Apex	mlo 11	15	38	14	0	33
Riviera	mlo 11	0	6	0	0	0
Digger	Mla13	23	25	14	75	0
Ricardo	Mla3	62	75	59	0	17
Vanessa	Van	100	97	100	100	67
Optic		19	25	7	25	0
Propino		77	88	59	0	0
Total Number of Is	26	32	29	4	6	

# 5. Conclusions

The UK *Pst* population continues to show high levels of diversity since the incursion of the Warrior population in 2011. The current population continues to be dominated by isolates from the Red group, and within that group, there are a broad range of virulence profiles which continues to change. Several new combinations of virulence were detected, with one isolate displaying a reaction on *Yr8*. Five isolates displaying previously existing and novel pathotypes were investigated in the adult plant trials. Genotyping has been established and improvements in methodology are ongoing.

A differential set used for the past five years was used to analyse the *P. triticina* population. As seen in previous years, virulence was detected for many of the *Lr* genes tested with notable seedling virulence frequency changes to both *Lr20* and *Lr28*. Seedling variety tests saw an increase in varieties which were resistant to all five races and adult plant trials were successful, and only two of the current RL varieties were resistant to all isolates. Many of the current RL varieties have moderate disease resistance ratings to *P. triticina* and this was reflected in the adult plant trial results.

Small changes in the *Bgh* population were detected, but this should be interpreted with caution due to the very limited number of isolates tested. As in previous years, no unusual outbreaks were reported, and so it is unlikely that these changes have translated into detrimental effects on variety performance.

# 6. Acknowledgements

We would like to thank Dr Lucy James for her contribution to the project, Dr Helen Bates and Dr Anne Webb for their excellent work on the yellow rust genotyping, Dr Diane Saunders and team for whole genome sequencing and fruitful discussions and finally Dr Jane Thomas for her continued help and support.

# 7. Appendix I: Sample Register

lsolate Number	Host Variety	Date Sampled	RL Rating 2020/21	Location	Geno- typed
20/174	Apache	June 2020	-	Lincolnshire	
20/148	AWC18	June 2020	-	East Yorkshire	
20/181	AWC18	June 2020	-	Cambridgeshire	
20/078	Banquo	May 2020	9 Candidate	Lincolnshire	
20/132	Banquo	May 2020	9 Candidate	East Yorkshire	
20/204	Banquo	June 2020	9 Candidate	Norfolk	
20/230	Banquo	June 2020	9 Candidate	Bridgend County Borough	
20/052	BAW76	April 2020	-	Shropshire	
20/126	BAW76	May 2020	-	Lincolnshire	
20/112	BAW77	May 2020	-	Lincolnshire	
20/242	Beluga	June 2020	-	Angus	
20/007	Bennington	March 2020	5	Lincolnshire	
20/074	Brigadier	May 2020	-	Lincolnshire	
20/105	Brigadier	May 2020	-	Essex	
20/085	Brimstone	May 2020	-	Lincolnshire	
20/034	Buster	April 2020	-	Cambridgeshire	
20/075	Claire	May 2020	-	Lincolnshire	
20/109	Claire	May 2020	-	Essex	
20/111	Cordiale	May 2020	-	Essex	
20/167	Cordiale	June 2020	-	East Lothian	
20/171	Cordiale	June 2020	-	Lincolnshire	
20/040	Costello	April 2020	9	East Yorkshire	Y
20/049	Costello	April 2020	9	East Yorkshire	Y
20/303	Crusoe	July 2020	9	Lincolnshire	Y
20/045	Dunston	April 2020	7	Oxfordshire	
20/095	Dunston	May 2020	7	Gloucestershire	
20/248	Dunston	June 2020	7	Warwickshire	
20/029	Elation	April 2020	9	Lincolnshire	
20/203	Elation	June 2020	9	Norfolk	
20/041	Elicit	April 2020	9	East Yorkshire	
20/042	Elicit	April 2020	9	East Yorkshire	
20/231	Elysium	June 2020	-	Bridgend County Borough	
20/257	Elysium	June 2020	-	East Lothian	
20/122	FAL160	May 2020	-	Lincolnshire	
20/166	Faller	June 2020	-	East Lothian	
20/026	Gleam	April 2020	7	North Yorkshire	
20/028	Gleam	April 2020	7	Lincolnshire	
20/030	Gleam	April 2020	7	Lincolnshire	

lsolate Number	Host Variety	Date Sampled	RL Rating 2020/21	Location	Geno- typed
20/055	Gleam	April 2020	7	Shropshire	
20/061	Gleam	May 2020	7	Northumberland	
20/067	Gleam	May 2020	7	Lincolnshire	
20/094	Gleam	May 2020	7	Oxfordshire	
20/158	Gleam	June 2020	7	Suffolk	
20/197	Gleam	June 2020	7	Hampshire	
20/223	Gleam	June 2020	7	North Yorkshire	
20/249	Gleam	June 2020	7	Dorset	
20/270	Gleam	June 2020	7	East Lothian	
20/279	Gleam	June 2020	7	Oxfordshire	
20/285	Gleam	June 2020	7	Northern Ireland	
20/003	Gleam	March 2020	7	Suffolk	
20/005	Gleam	March 2020	7	Essex	
20/010	Gleam	April 2020	7	Lincolnshire	
20/022	Gleam	April 2020	7	Lincolnshire	
20/024	Gleam	April 2020	7	Lincolnshire	
20/225	Gleam	June 2020	7	Bridgend County Borough	
20/145	Grafton	June 2020	-	East Yorkshire	
20/179	Grafton	June 2020	-	Cambridgeshire	
20/001	Graham	October 2019	8	Shropshire	
20/032	Graham	April 2020	8	Lincolnshire	
20/173	Graham	June 2020	8	Lincolnshire	
20/296	Graham	July 2020	8	Shropshire	
20/098	JB Diego	May 2020	-	Oxfordshire	
20/176	JB Diego	June 2020	-	Staffordshire	
20/200	JB Diego	June 2020	-	Hampshire	
20/035	KWS Barrel	April 2020	9	North Yorkshire	
20/155	KWS Barrel	June 2020	9	Suffolk	
20/184	KWS Barrel	June 2020	9	Oxfordshire	
20/206	KWS Barrel	June 2020	9	Norfolk	
20/215	KWS Barrel	June 2020	9	Cambridgeshire	Y
20/274	KWS Barrel	June 2020	9	Hampshire	
20/091	KWS Barrel	May 2020	9	Lincolnshire	
20/103	KWS Basset	May 2020	8	Hertfordshire	
20/104	KWS Basset	May 2020	8	Hertfordshire	
20/064	KWS Cochise	June 2020	5	Lincolnshire	
20/182	KWS Colosseum	June 2020	-	Cambridgeshire	
20/138	KWS Cranium	May 2020	9 Candidate	Lincolnshire	
20/175	KWS Extase	June 2020	9	Lincolnshire	
20/293	KWS Extase	July 2020	9	Lincolnshire	Y
20/297	KWS Extase	July 2020	9	Shropshire	

Isolate Number	Host Variety	Date Sampled	RL Rating 2020/21	Location	Geno- typed
20/300	KWS Extase	July 2020	9	Northumberland	
20/302	KWS Extase	July 2020	9	Norfolk	
20/304	KWS Extase	July 2020	9	Essex	Y
20/305	KWS Extase	July 2020	9	Bridgend County Borough	
20/306	KWS Extase	July 2020	9	Devon	
20/004	KWS Firefly	March 2020	9	East Yorkshire	
20/006	KWS Firefly	March 2020	9	Lincolnshire	Y
20/008	KWS Firefly	March 2020	9	East Yorkshire	
20/009	KWS Firefly	March 2020	9	East Yorkshire	
20/011	KWS Firefly	March 2020	9	Essex	
20/014	KWS Firefly	April 2020	9	Oxfordshire	Y
20/016	KWS Firefly	April 2020	9	Lincolnshire	
20/019	KWS Firefly	April 2020	9	Cambridgeshire	
20/020	KWS Firefly	April 2020	9	Essex	
20/023	KWS Firefly	April 2020	9	Lincolnshire	
20/048	KWS Firefly	April 2020	9	Lincolnshire	
20/057	KWS Firefly	April 2020	9	Cambridgeshire	
20/063	KWS Firefly	May 2020	9	Lincolnshire	
20/076	KWS Firefly	May 2020	9	Lincolnshire	
20/140	KWS Firefly	May 2020	9	Lincolnshire	
20/142	KWS Firefly	June 2020	9	Cambridgeshire	
20/161	KWS Firefly	June 2020	9	Suffolk	
20/188	KWS Firefly	June 2020	9	Oxfordshire	
20/192	KWS Firefly	June 2020	9	Oxfordshire	
20/202	KWS Firefly	June 2020	9	Norfolk	
20/214	KWS Firefly	June 2020	9	Cambridgeshire	
20/243	KWS Firefly	June 2020	9	Cambridgeshire	
20/253	KWS Firefly	June 2020	9	East Lothian	Y
20/288	KWS Firefly	June 2020	9	Northern Ireland	
20/298	KWS Firefly	July 2020	9	Shropshire	
20/044	KWS Jackal	April 2020	9	South Yorkshire	
20/031	KWS Kerrin	April 2020	7	Lincolnshire	
20/070	KWS Kerrin	May 2020	7	Lincolnshire	
20/101	KWS Kerrin	May 2020	7	Oxfordshire	
20/159	KWS Kerrin	June 2020	7	Suffolk	
20/222	KWS Kerrin	June 2020	7	North Yorkshire	
20/235	KWS Kerrin	June 2020	7	Bridgend County Borough	
20/255	KWS Kerrin	June 2020	7	East Lothian	
20/275	KWS Kerrin	June 2020	7	Hampshire	
20/283	KWS Kerrin	June 2020	7	Northern Ireland	
20/021	KWS Kerrin	April 2020	7	Lincolnshire	
20/018	KWS Kinetic	April 2020	6	Cambridgeshire	

Isolate Number	Host Variety	Date Sampled	RL Rating 2020/21	Location	Geno- typed
20/039	KWS Kinetic	April 2020	6	Oxfordshire	
20/069	KWS Kinetic	May 2020	6	Lincolnshire	
20/102	KWS Kinetic	May 2020	6	Norfolk	
20/154	KWS Kinetic	June 2020	6	Suffolk	
20/219	KWS Kinetic	June 2020	6	Cambridgeshire	
20/236	KWS Kinetic	June 2020	6	Bridgend County Borough	
20/241	KWS Kinetic	June 2020	6	Essex	
20/273	KWS Kinetic	June 2020	6	Hampshire	
20/136	KWS Parkin	May 2020	-	North Yorkshire	
20/079	KWS Plectrum	May 2020	7 Candidate	Lincolnshire	
20/149	KWS Plectrum	June 2020	7 Candidate	East Yorkshire	
20/165	KWS Plectrum	June 2020	7 Candidate	Lincolnshire	
20/183	KWS Plectrum	June 2020	7 Candidate	Cambridgeshire	
20/135	KWS Plectrum	June 2020	7 Candidate	Bridgend County Borough	
20/160	KWS Plectrum	June 2020	7 Candidate	Suffolk	
20/169	KWS Plectrum	June 2020	7 Candidate	Somerset	
20/237	KWS Plectrum	June 2020	7 Candidate	Bridgend County Borough	
20/254	KWS Plectrum	June 2020	7 Candidate	East Lothian	
20/292	KWS Plectrum	June 2020	7 Candidate	Northern Ireland	
20/050	KWS Siskin	May 2020	9	Derbyshire	Y
20/060	KWS Siskin	May 2020	9	Derbyshire	Y
20/062	KWS Siskin	May 2020	9	Dorset	Y
20/137	KWS Siskin	May 2020	9	North Yorkshire	Y
20/191	KWS Siskin	June 2020	9	Oxfordshire	Y
20/046	KWS Target	April 2020	-	Cambridgeshire	
20/025	KWS Zyatt	April 2020	7	Essex	
20/065	KWS Zyatt	May 2020	7	West Sussex	
20/066	KWS Zyatt	May 2020	7	Essex	
20/072	KWS Zyatt	May 2020	7	Lincolnshire	
20/164	KWS Zyatt	June 2020	7	Suffolk	
20/187	KWS Zyatt	June 2020	7	Oxfordshire	
20/190	KWS Zyatt	June 2020	7	Oxfordshire	
20/217	KWS Zyatt	June 2020	7	Cambridgeshire	
20/224	KWS Zyatt	June 2020	7	Hampshire	Y
20/245	KWS Zyatt	June 2020	7	Bridgend County Borough	
20/269	KWS Zyatt	June 2020	7	East Lothian	
20/271	KWS Zyatt	June 2020	7	Norfolk	
20/282	KWS Zyatt	June 2020	7	Northern Ireland	
20/301	KWS Zyatt	July 2020	7	Norfolk	
20/115	KWSW396	May 2020	-	Lincolnshire	
20/123	KWSW398	May 2020	-	Lincolnshire	
20/128	KWSW399	May 2020	-	Lincolnshire	

Isolate Number	Host Variety	Date Sampled	RL Rating 2020/21	Location	Geno- typed
20/295	LG Astronomer	June 2020	9 Candidate	Norfolk	
20/092	LG Astronomer	May 2020	9 Candidate	Bridgend County Borough	Y
20/002	LG Illuminate	March 2020	9 Candidate	Cambridgeshire	
20/186	LG Illuminate	June 2020	9 Candidate	Oxfordshire	
20/211	LG Illuminate	June 2020	9 Candidate	Norfolk	
20/218	LG Illuminate	June 2020	9 Candidate	Cambridgeshire	
20/239	LG Illuminate	June 2020	9 Candidate	Bridgend County Borough	
20/260	LG Illuminate	June 2020	9 Candidate	East Lothian	
20/277	LG Illuminate	June 2020	9 Candidate	Oxfordshire	
20/152	LG Prince	June 2020	9 Candidate	Suffolk	
20/210	LG Prince	June 2020	9 Candidate	Norfolk	
20/220	LG Prince	June 2020	9 Candidate	Cambridgeshire	
20/252	LG Prince	June 2020	9 Candidate	East Lothian	
20/238	LG Quasar	June 2020	8 Candidate	Bridgend County Borough	
20/256	LG Quasar	June 2020	8 Candidate	East Lothian	
20/081	LG Seeker	May 2020	7 Candidate	Lincolnshire	
20/264	LG Seeker	June 2020	7 Candidate	East Lothian	
20/100	LG Seeker	May 2020	7 Candidate	Oxfordshire	
20/151	LG Seeker	June 2020	7 Candidate	Suffolk	
20/229	LG Seeker	June 2020	7 Candidate	Bridgend County Borough	
20/291	LG Seeker	June 2020	7 Candidate	Northern Ireland	
20/033	LG Skyscraper	April 2020	8	Lincolnshire	Y
20/036	LG Skyscraper	April 2020	8	North Yorkshire	
20/047	LG Skyscraper	April 2020	8	Lincolnshire	Y
20/287	LG Skyscraper	June 2020	8	Northern Ireland	
20/043	LG Spotlight	April 2020	8	Staffordshire	
20/058	LG Spotlight	May 2020	8	Oxfordshire	
20/080	LG Spotlight	May 2020	8	Lincolnshire	
20/093	LG Spotlight	May 2020	8	Oxfordshire	
20/150	LG Spotlight	June 2020	8	East Yorkshire	
20/157	LG Spotlight	June 2020	8	Suffolk	
20/180	LG Spotlight	June 2020	8	Cambridgeshire	
20/244	LG Spotlight	June 2020	8	Bridgend County Borough	
20/251	LG Spotlight	June 2020	8	East Lothian	
20/286	LG Spotlight	June 2020	8	Northern Ireland	Y
20/117	LGWU156	May 2020	-	Lincolnshire	
20/127	LGWU167	May 2020	-	Lincolnshire	
20/114	LGWU170	May 2020	-	Lincolnshire	
20/056	LGWU173	April 2020	-	Lincolnshire	
20/125	LGWU173	May 2020	-	Lincolnshire	
20/124	LGWU174	May 2020	-	Lincolnshire	
20/116	LGWU175	May 2020	-	Lincolnshire	

lsolate Number	Host Variety	Date Sampled	RL Rating 2020/21	Location	Geno- typed
20/209	Merit	June 2020	9 Candidate	Norfolk	
20/233	Merit	June 2020	9 Candidate	Bridgend County Borough	
20/261	Merit	June 2020	9 Candidate	East Lothian	
20/096	Mulika	May 2020	7	Oxfordshire	
20/278	Myriad	July 2020	-	Warwickshire	
20/172	Rendezvous	June 2020	-	Lincolnshire	
20/193	Revelation	June 2020	-	Oxfordshire	
20/194	Revelation	June 2020	-	Oxfordshire	
20/090	RGT Blossom	May 2020	-	Lincolnshire	
20/163	RGT Blossom	June 2020	-	Suffolk	
20/226	RGT Blossom	June 2020	-	Bridgend County Borough	
20/262	RGT Blossom	June 2020	-	East Lothian	
20/289	RGT Blossom	June 2020	-	Northern Ireland	
20/213	RGT Galactus	June 2020	8 Candidate	Cambridgeshire	
20/037	RGT Gravity	April 2020	8	North Yorkshire	
20/088	RGT Gravity	May 2020	8	Lincolnshire	
20/099	RGT Gravity	May 2020	8	Oxfordshire	
20/156	RGT Gravity	June 2020	8	Suffolk	
20/189	RGT Gravity	June 2020	8	Cambridgeshire	
20/216	RGT Gravity	June 2020	8	Cambridgeshire	
20/232	RGT Gravity	June 2020	8	Bridgend County Borough	
20/267	RGT Gravity	June 2020	8	East Lothian	
20/276	RGT Gravity	June 2020	8	Hampshire	
20/284	RGT Gravity	June 2020	8	Northern Ireland	
20/299	RGT Gravity	June 2020	8	Oxfordshire	
20/207	RGT Illustrious	June 2020	9	Norfolk	
20/089	RGT Lantern	May 2020	-	Lincolnshire	
20/250	RGT Lantern	June 2020	-	East Lothian	
20/141	RGT Quicksilver	May 2020	9 Candidate	Lincolnshire	
20/168	RGT Saki	June 2020	9	Norfolk	Y
20/205	RGT Saki	June 2020	9	Norfolk	
20/212	RGT Saki	June 2020	9	Norfolk	Y
20/280	RGT Saki	June 2020	9	Oxfordshire	
20/068	RGT Silversurfer	May 2020	9 Candidate	Lincolnshire	
20/131	RGT Silversurfer	May 2020	9 Candidate	Norfolk	
20/134	RGT Silversurfer	May 2020	9 Candidate	East Yorkshire	
20/208	RGT Silversurfer	June 2020	9 Candidate	Norfolk	
20/038	RGT Wasabi	April 2020	-	Oxfordshire	
20/082	RGT Wasabi	May 2020	-	Lincolnshire	
20/240	RGT Wasabi	June 2020	-	Bridgend County Borough	
20/263	RGT Wasabi	June 2020	-	East Lothian	
20/290	RGT Wasabi	June 2020	-	Northern Ireland	

lsolate Number	Host Variety	Date Sampled	RL Rating 2020/21	Location	Geno- typed
20/071	RGT Wolverine	May 2020	7 Candidate	Lincolnshire	
20/133	RGT Wolverine	May 2020	7 Candidate	East Yorkshire	
20/143	RGT Wolverine	June 2020	7 Candidate	Lincolnshire	
20/146	RGT Wolverine	June 2020	7 Candidate	East Yorkshire	
20/178	RGT Wolverine	June 2020	7 Candidate	Cambridgeshire	
20/221	RGT Wolverine	June 2020	7 Candidate	Cambridgeshire	
20/268	RGT Wolverine	June 2020	7 Candidate	East Lothian	
20/234	RGT Wolverine	June 2020	7 Candidate	Bridgend County Borough	
20/084	Robigus	May 2020	-	Lincolnshire	
20/108	Robigus	May 2020	-	Essex	
20/118	RW41815	May 2020	-	Lincolnshire	
20/120	RW41818	May 2020	-	Lincolnshire	
20/113	RW41921	May 2020	-	Lincolnshire	
20/129	RW41924	May 2020	-	Lincolnshire	
20/130	RW41943	May 2020	-	Lincolnshire	
20/051	RW41989	April 2020	-	Shropshire	
20/121	SC2902	May 2020	-	Lincolnshire	
20/017	Shabras	April 2020	7	Cambridgeshire	
20/027	Shabras	April 2020	7	North Yorkshire	
20/087	Shabras	May 2020	7	Lincolnshire	
20/139	Shabras	May 2020	7	Warwickshire	
20/196	Shabras	June 2020	7	Hampshire	
20/228	Shabras	June 2020	7	Bridgend County Borough	Y
20/258	Shabras	June 2020	7	East Lothian	
20/281	Shabras	June 2020	7	Oxfordshire	
20/015	Skyfall	April 2020	5	Staffordshire	
20/077	Skyfall	May 2020	5	Lincolnshire	
20/097	Skyfall	May 2020	5	Oxfordshire	
20/162	Skyfall	June 2020	5	Suffolk	
20/185	Skyfall	June 2020	5	Oxfordshire	
20/195	Skyfall	June 2020	5	Suffolk	
20/199	Skyfall	June 2020	5	Hampshire	
20/201	Skyfall	June 2020	5	Hampshire	
20/227	Skyfall	June 2020	5	Bridgend County Borough	
20/265	Skyfall	June 2020	5	East Lothian	
20/272	Skyfall	June 2020	5	Hampshire	
20/294	Skyfall	June 2020	5	Norfolk	
20/110	Solstice	May 2020	-	Essex	
20/083	Spyder	May 2020	-	Lincolnshire	
20/106	Spyder	May 2020	-	Essex	
20/259	Swallow	June 2020	7 Candidate	East Lothian	
20/073	SY Insitor	May 2020	7	Lincolnshire	

Isolate Number	Host Variety	Date Sampled	RL Rating 2020/21	Location	Geno- typed
20/144	SY Insitor	June 2020	7	Lincolnshire	
20/147	SY Insitor	June 2020	7	East Yorkshire	
20/153	SY Insitor	June 2020	7	Suffolk	
20/170	SY Insitor	June 2020	7	Somerset	
20/177	SY Insitor	June 2020	7	Cambridgeshire	
20/198	SY Insitor	June 2020	7	Hampshire	
20/246	SY Insitor	June 2020	7	Bridgend County Borough	
20/266	SY Insitor	June 2020	7	East Lothian	
20/119	SY118483	May 2020	-	Lincolnshire	
20/054	SY119123	April 2020	-	Shropshire	
20/012	Unknown	April 2020	-	Staffordshire	
20/013	Unknown	April 2020	-	Staffordshire	
20/086	Victo	May 2020	-	Lincolnshire	
20/107	Victo	May 2020	-	Essex	
20/247	Zulu	June 2020	-	Warwickshire	Y

# 2020 Wheat Brown Rust Isolate Register

lsolate Number	Host Variety	Date Sampled	RL Rating 2020/21	Location
20/018	Crusoe	June 2020	3	Cambridgeshire
20/019	Crusoe	June 2020	3	Oxfordshire
20/003	Crusoe	June 2020	3	Cambridgeshire
20/036	Crusoe	July 2020	3	Lincolnshire
20/039	Crusoe	July 2020	3	Lincolnshire
20/043	Crusoe	July 2020	3	Yorkshire
20/020	Elation	June 2020	6	Norfolk
20/006	Elicit	June 2020	7	Cambridgeshire
20/007	Graham	June 2020	6	Cambridgeshire
20/001	Graham	June 2020	6	Lincolnshire
20/016	KWS Barrel	June 2020	5	Hampshire
20/012	KWS Barrel	June 2020	5	Cambridgeshire
20/002	KWS Colosseum	June 2020	-	Cambridgeshire
20/025	KWS Cranium	July 2020	5	Oxfordshire
20/035	KWS Cranium	July 2020	5	Lincolnshire
20/041	KWS Cranium	July 2020	5	Yorkshire
20/004	KWS Extase	June 2020	7	Cambridgeshire
20/032	KWS Extase	July 2020	7	Lincolnshire
20/038	KWS Extase	July 2020	7	Norfolk
20/045	KWS Extase	July 2020	7	Devon
20/044	KWS Extase	July 2020	7	Herefordshire
20/005	KWS Firefly	June 2020	6	Cambridgeshire
20/026	KWS Firefly	July 2020	6	Oxfordshire
20/033	KWS Firefly	July 2020	6	Lincolnshire
20/011	KWS Jackal	June 2020	5	Cambridgeshire
20/028	KWS Lili	July 2020	4	Oxfordshire
20/022	KWS Parkin	-	-	Shropshire
20/029	KWS Parkin	July 2020	-	Lincolnshire
20/040	KWS Parkin	July 2020	-	Yorkshire
20/013	KWS Siskin	June 2020	5	Cambridgeshire
20/021	KWS Siskin	-	5	Shropshire
20/031	KWS Zyatt	July 2020	6	Lincolnshire
20/037	KWS Zyatt	July 2020	6	Norfolk
20/027	LG Prince	July 2020	8	Oxfordshire
20/023	LG Skyscraper	July 2020	6	Oxfordshire
20/030	LG Skyscraper	July 2020	6	Lincolnshire
20/015	LG Spotlight	June 2020	7	Cambridgeshire
20/010	LG Sundance	June 2020	6	Cambridgeshire
20/014	RGT Blossom	June 2020	-	Cambridgeshire
20/017	RGT Gravity	June 2020	6	Hampshire

lsolate Number	Host Variety	Date Sampled	RL Rating 2020/21	Location
20/042	RGT Illustrious	July 2020	6	Yorkshire
20/024	RGT Saki	July 2020	8	Oxfordshire
20/034	RGT Saki	July 2020	8	Lincolnshire
20/009	RGT Wasabi	June 2020	-	Cambridgeshire
20/008	Shabras	June 2020	5	Cambridgeshire

# 2020 Wheat Powdery Mildew Isolate Register

Isolate Number	Host Variety	Date Sampled	RL Rating 2020/21	Location
20/001	Crusoe	June 2020	6	Cambridgeshire
20/002	RGT Blossom	June 2020	-	Angus

# 2020 Barley Powdery Mildew Isolate Register

Isolate	Host Variety	Date Sampled	RL Rating	Location
number	nost variety	Date Sampled	2020/21	Eocation
20/001	Bazooka	March 2020	5	Buckinghamshire

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