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United Kingdom Cereal Pathogen Virulence Survey
2018 Annual Report

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1. Summary

The UKCPVS monitors the populations of the important 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 and *Blumeria graminis* f.sp. *hordei* (*Bgh*) causing barley powdery mildew.

Wheat Yellow Rust

Since the incursion of the Warrior population in 2011, the UK *Puccinia striiformis* f.sp. *tritici* population has been changing, with the old UK population now entirely replaced by the new Warrior group. Results from the tests on isolates collected in 2017 showed the new pathotype combinations identified in 2016, such as Red 24, were again detected at high frequencies. Adult plant trials with five key races were confounded by the warm, dry weather in the key inoculation period so the impact of new, complex pathotypes cannot be established this year.

Wheat Brown Rust

Isolates collected in 2017 were tested on a new differential set for the second year, bringing the UKCPVS into line with researchers from other countries. Virulence for most of the resistance genes were detected, however virulence for *Lr24* and *Lr28* remain at low levels as there are few varieties carrying these resistance genes. Variety tests at the seedling and adult plant stages were conducted, however as with the yellow rust trials, warm and dry weather confounded trials this summer. As in the previous year, discrepancies were observed between differential test results and control varieties; however this appeared to be improved on from last year. The cause of this difference is being investigated further, with the adaptation of methods to isolate from single pustules currently in development.

Wheat Powdery Mildew

Low to moderate levels of disease in 2017 led to modest numbers of samples of wheat powdery mildew being received by the UKCPVS. Virulence was seen for most of the differentials tested, with avirulence seen only on Shamrock. Virulence frequencies for most of the differentials increased this year compared to last year with the exception of Maris Dove and Crusoe. For the most part, the virulence frequencies compared well with previous years. Small changes in virulence frequencies were observed however there were no reports of mildew outbreaks during the year and based on this information we suspect that this small population change is therefore unlikely to prove detrimental at the adult plant stage.

Barley Powdery Mildew

Samples of *Blumeria graminis* f.sp. *hordei* were only received from two locations in 2017. Virulence for all of the differentials was detected and was broadly in line with frequencies

observed in previous years. Exceptions were seen for differentials such as Porter and Lotta, however the UKCPVS received no reports of unexpected outbreaks of barley powdery mildew during 2017 so it is possible that this variation in the population will not translate into meaningful differences at the adult plant stage.

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 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 still remain the same and in its 50th 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. A close eye is also kept on the incidence of barley yellow rust, which although rare currently, has been a problem in the past.

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 UK.

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, Justesen, and Brown 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 was 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 Recommended List (RL) ratings that year (Hubbard, Wilderspin, and Holdgate 2017).

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 currently 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, beginning 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 that 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. The most recent change to the population saw the population overcome the moderate resistance in the variety Crusoe in 2014. The causal race is still under investigation by the UKCPVS.

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

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

* 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 trials operators of RL trials. Spores from the infected samples were transferred on to plants of the universally susceptible variety Victo (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 and Table 8. 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 trial consisted of two replicates and one trial was used for each of the isolates under test. Prior to inoculation, natural infection was eliminated as far as possible by the use of a seed treatment and follow-up foliar fungicide applications up to and including a T1 application. Plots were directly inoculated as soon as eventual leaf 2 was fully emerged and then re-inoculated at 2-3 day intervals. The wheat yellow rust trials were inoculated seven times and the wheat brown rust trials were inoculated six times. Assessments were made at the onset of disease development on the upper leaves until senescence.

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 previous differential tests, and assessment was carried out using the same average infection type scoring system.

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.

Where sample numbers were low, 'mobile trap nurseries' were also deployed. Pots of Cerco and Golden Promise were sown in controlled environment rooms and then given to NIAB staff living near arable areas to place in their gardens for up to 14 days, and then returned to the lab where individual pustules were harvested and maintained as normal.

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 14 and Table 16. Each differential was represented by 4 detached leaf sections, giving four replicates. This was to ensure the maximum amount of information 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.

4. Results and Discussion

4.1. Wheat Yellow Rust

4.1.1. Samples Received

In 2017 the UKCVPS received 114 samples of wheat yellow rust from 23 different counties across the UK (Figure 1).

Figure 1: Map of the UK with the number of samples of wheat yellow rust received in 2017 from the different counties. Two samples were from an unknown location.

Disease pressure was more modest compared to that experienced in 2016, partly as a result of the frosts experienced over the winter of 2016/17. No reports were received by the UKCPVS of unexpected varietal performance. In total, samples were received from 23 different varieties consisting of current and past RL varieties, spreader plots and other breeding lines. The full sample register is provided in Appendix 1. 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

Twenty eight 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 genes were detected in the isolates collected in 2017 using the differentials tested at the seedling stage and frequency of virulence to the individual resistance genes remained relatively stable for known resistance genes in comparison to previous years (Table 4). Virulence for *Yr7* was found in all isolates this year, suggesting that either the Blue 7 group of isolates was not found in 2017 or it was mixed in with other isolates. Subsequent tests on some of the isolates collected in 2017 showed that whilst they were occasionally mixed groups of isolates, the isolates classed as Blue 7 were not amongst those found (data not shown). Virulence for Rendezvous, Cadenza and KWS Sterling all continued to increase; presumably as a result of isolates such the Red 24 group becoming more widely distributed. In some of the tests unusual results were reported, for example in the isolate 17/024, where unexpected virulence combinations were seen. In this example, virulence for *Yr8* was seen, which would indicate the Kranich race, however, virulence for Spaldings Prolific and *Yr4* were also detected, which are atypical for the Kranich race. Further tests were done on this isolate and confirmed that it was not a mixture of isolates (data not shown). Comparison with results from other virulence surveys in Europe suggested that it may be an isolate of the PstS14 lineage, which has been found elsewhere across Europe in recent years (www.wheatrust.org). Isolates from this group have been associated with epidemics in Morocco; however damage has been minimal in Europe as a result of these isolates (M. Hovmøller, *pers. Comm.*).

Table 2: Average infection type (a.i.t.) scores for the 37 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.

Isolate code	Host	1	1	2	3a, 4a	3b,4b	4,Su	5	6	2,6	2,6,25	7	7,22,23	6,7	7,17	8	8,19	9	2,9,25	10	15	17	17	17	24	2,25	25,Sd	32	25,32	Sp	Sp	Ro	So	Wa	St		Am				
		Avocet Yr1	Chinese 166	Kalyansona	Vilmorin 23	Hybrid 46	Suwon Omar	Avocet Yr5	Avocet Yr6	Heines Kolben	Heines Peko	AV x Yr 7 NIL	Lee	Cadenza	Apache	Av x Yr8 NIL	Compair	Avocet Yr9	Clement	Moro	AVS x yr15	VPM 1	Rendezvous	AV x Yr17	Avocet Yr24	Heines VII	Strubes Dickkopf	Av x Yr32	Carstens V	Avocet Sp	Spaldings Prolific	Robigus	Solstice	Warrior	KWS Sterling	Claire	Ambition	Crusoe	Avocet S	Vuka	Kranich	Evolution
17/006	Spyder	3.0	3.5	3.0	3.0	3.0	*	0.0	3.0	3.0	3.0	3.0	2.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	3.0	2.0	4.0	3.5	3.0	3.5	0.0	0.0	4.0	4.0	0.0	0.0	4.0	0.0	0.0	3.0	4.0	0.0	3.2
17/009	Shabras	3.0	3.1	3.0	3.0	3.0	3.5	0.0	4.0	3.5	3.0	3.0	3.0	3.0	3.0	0.0	0.0	4.0	3.1	0.0	0.0	3.1	3.0	3.0	0.0	3.0	4.0	3.0	3.0	3.0	3.0	3.5	3.5	2.2	3.0	3.0	2.9	0.0	4.0	4.0	0.2	3.0
17/012	Evolution	3.0	3.0	3.3	3.0	3.0	3.5	0.0	3.5	3.5	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	3.5	3.0	3.0	3.0	1.4	0.0	3.0	3.0	0.0	3.0
17/014	Crusoe	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	3.3	0.0	0.0	3.0	3.2	0.0	0.0	3.5	3.0	3.0	0.0	3.0	3.3	3.0	3.5	3.0	3.0	3.5	3.0	3.0	2.9	3.0	3.0	3.0	3.0	3.5	3.0	1.7
17/016	Revelation	3.0	3.0	3.5	4.0	3.0	4.0	0.0	4.0	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	3.1	3.1	3.1	3.5	3.5	2.4	3.0	3.0	2.8	0.0	3.0	4.0	0.1	3.0
17/017	Reflection	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.1	3.1	3.1	0.0	0.0	3.0	3.1	0.0	0.0	3.0	3.0	3.0	0.0	3.1	3.1	3.0	3.0	3.0	3.0	3.0	3.0	1.7	3.0	3.0	1.5	0.0	3.0	3.5	0.1	3.0
17/024	KWS Lili	0.0	0.6	3.0	3.0	3.0	3.5	0.0	3.0	0.4	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	2.5	1.5	3.0	1.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	2.2	2.7	0.2	0.0	3.0	3.0	1.0	0.3
17/025	Myriad	3.0	3.0	3.5	3.0	3.0	3.4	0.0	3.2	3.1	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.0	3.5	0.0	0.0	3.5	3.2	3.0	0.0	3.5	3.5	3.0	3.1	3.5	3.5	3.5	3.5	2.2	2.8	3.5	2.8	0.0	3.0	4.0	0.2	3.0
17/027	Cordiale	3.0	3.0	3.0	3.0	3.0	4.0	0.0	4.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.0	3.5	0.0	0.0	3.0	2.8	3.0	0.0	3.0	3.0	3.0	3.0	3.0	3.1	3.0	4.0	1.4	3.0	3.0	0.6	0.0	3.0	3.5	0.1	0.3
17/029	KWS Siskin	3.0	4.0	3.0	3.5	3.0	4.0	0.0	3.2	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	3.1	3.5	3.0	3.5	3.0	3.0	3.1	4.0	2.8	3.0	3.3	1.4	0.0	3.0	3.0	0.1	3.0
17/030	Cordiale	3.2	3.1	3.0	3.0	3.0	4.0	0.0	3.2	3.0	3.0	3.5	3.0	4.0	3.2	0.0	0.0	3.0	3.0	0.0	0.0	4.0	3.0	3.0	0.0	3.5	3.8	4.0	4.0	4.0	3.0	4.0	4.0	2.1	3.0	4.0	2.4	0.0	3.0	4.0	0.0	0.9
17/032	Robigus	3.0	3.0	4.0	3.0	3.0	3.5	0.0	3.0	3.5	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	3.2	0.0	3.0	4.0	4.0	4.0	3.8	3.1	3.0	4.0	3.0	3.0	4.0	2.3	0.0	3.0	4.0	0.0	3.0
17/034	Claire	3.0	3.0	3.0	3.0	3.0	3.5	0.0	3.0	3.5	3.0	3.0	3.0	3.1	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	3.0	0.0	4.0	4.0	3.0	3.0	3.0	3.0	3.5	4.0	2.8	3.0	3.1	2.0	0.0	3.0	4.0	0.0	3.0
17/037	Zulu	3.0	3.0	3.0	4.0	3.0	3.0	0.0	3.5	3.0	3.5	3.0	3.0	3.5	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	2.9	3.0	2.0	3.5	3.6	3.0	3.5	3.0	3.5	3.5	3.5	2.7	2.9	3.5	2.9	0.0	4.0	4.0	0.4	3.0
17/039	Britannia	3.0	3.0	3.0	3.0	3.0	3.1	0.0	3.0	3.1	3.0	3.0	3.0	3.1	3.0	0.4	0.0	3.0	3.0	0.0	0.0	3.0	2.9	3.0	0.0	3.0	3.0	3.0	3.1	3.0	3.1	3.0	3.3	2.3	2.5	3.0	2.6	0.0	3.0	3.0	0.0	3.0
17/042	KWS Silverstone	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.5	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.1	3.5	3.5	0.0	3.5	3.5	3.5	3.5	3.7	3.1	3.5	3.5	2.6	3.0	3.0	2.7	0.0	3.0	4.0	0.7	3.0
17/046	KWS Lili	3.0	3.0	3.5	3.0	3.0	*	0.0	3.1	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	3.2	3.2	1.0	2.8	4.0	0.1	0.0	3.0	4.0	0.0	2.9
17/053	KWS Lili	3.0	3.0	3.5	3.0	3.0	*	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.2	3.0	3.0	0.0	0.0	3.0	3.0	3.0	0.0	3.0	4.0	3.5	3.0	3.0	3.0	3.0	3.5	0.0	3.0	3.0	0.0	0.0	3.5	3.5	0.0	1.8
17/057	Skyfall	3.0	3.0	3.0	4.0	3.0	4.0	0.0	3.5	3.5	3.0	3.0	3.0	3.5	3.1	0.0	0.0	3.0	3.0	0.0	0.0	3.0	2.9	4.0	0.0	4.0	4.0	3.0	4.0	3.5	3.5	3.5	4.0	2.2	3.0	3.5	2.3	0.0	3.5	4.0	0.0	2.5
17/060	Spyder	3.0	3.0	3.3	4.0	3.0	3.5	0.0	4.0	3.5	3.0	3.0	3.5	3.0	3.0	0.3	0.0	3.0	3.0	0.0	0.0	3.0	3.0	3.0	0.0	3.1	3.1	3.0	3.1	3.0	3.0	3.2	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.5	3.0	3.0
17/078	Moulton	3.0	3.1	3.0	3.5	3.0	3.2	0.0	4.0	3.0	3.0	3.0	3.0	3.1	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.0	3.0	3.0	0.0	3.3	3.1	3.1	3.1	3.0	3.0	3.5	4.0	2.1	3.0	4.0	1.5	0.0	3.0	3.0	0.1	3.0

17/081	KWS Kerrin	3.0	3.0	3.3	3.0	3.0	3.1	0.0	3.5	3.1	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.0	4.0	0.0	0.0	3.0	3.5	3.0	0.0	3.5	4.0	3.0	4.0	3.3	3.0	4.0	4.0	2.9	3.0	3.1	2.0	0.0	3.0	3.0	1.0	3.0

Isolate code	Host	1	1	2	3a, 4a	3b,4b	4,Su	5	6	2,6	2,6,25	7	7,22,23	6,7	7,17	8	8,19	9	2,9,25	10	15	17	17	17	24	2,25	25,Sd	32	25,32	Sp	Sp	Ro	So	Wa	St		Am					
		Avocet Yr1	Chinese 166	Kalyansona	Vilmorin 23	Hybrid 46	Suwon Omar	Avocet Yr5	Avocet Yr6	Heines Kolben	Heines Peko	AV x Yr 7 NIL	Lee	Cadenza	Apache	Av x Yr8 NIL	Compair	Avocet Yr9	Clement	Moro	AVS x yr15	VPM 1	Rendezvous	AV x Yr17	Avocet Yr24	Heines VII	Strubes Dickkopf	Av x Yr32	Carstens V	Avocet Sp	Spaldings Prolific	Robigus	Solstice	Warrior	KWS Sterling	Claire	Ambition	Crusoe	Avocet S	Vuka	Kranich	Evolution
17/083	KWS Basset	3.3	4.0	4.0	3.5	3.0	4.0	0.0	3.0	3.3	3.0	3.0	3.0	3.0	3.0	0.3	0.0	3.0	3.0	0.0	0.0	3.0	3.0	3.0	0.0	3.2	3.3	3.0	3.1	3.0	3.0	3.5	3.1	2.4	3.0	3.5	2.4	2.0	3.0	3.0	2.5	3.0
17/090	LG Generation	3.0	3.1	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	3.0	3.0	0.0	0.0	3.0	2.9	3.0	0.0	3.0	3.2	3.5	3.0	3.0	3.0	3.2	4.0	2.8	3.0	3.5	1.7	0.0	3.3	3.5	0.0	3.0
17/094	Bennington	3.0	3.0	3.3	3.1	3.0	4.0	0.0	3.2	3.0	3.0	4.0	3.0	3.0	3.0	0.0	0.0	3.0	3.2	0.0	0.0	3.0	3.0	3.0	0.0	3.1	3.0	3.0	4.0	3.0	3.0	3.0	4.0	2.9	3.0	3.0	2.4	0.0	4.0	3.5	0.0	3.0
17/102	Claire	3.0	3.0	3.0	3.0	3.0	4.0	0.0	4.0	3.5	3.0	3.0	3.0	3.1	3.0	0.0	0.0	3.0	3.0	0.0	0.0	3.1	3.0	3.0	0.0	3.0	3.0	3.0	3.5	3.0	3.1	3.2	3.5	3.0	3.0	3.5	1.9	0.0	3.0	4.0	0.6	3.0
17/112	Warrior	3.0	3.5	4.0	3.0	3.0	4.0	0.0	3.5	3.0	3.0	3.0	3.0	4.0	3.0	0.0	0.0	3.1	4.0	0.0	0.0	3.5	3.0	3.0	0.0	3.5	3.5	4.0	4.0	3.0	3.5	4.0	4.0	3.0	4.0	3.0	1.8	0.0	3.5	4.0	0.0	0.8
17/113	Scout	3.0	3.0	4.0	3.0	3.0	4.0	0.0	3.2	3.5	3.0	3.0	3.0	3.0	3.0	0.0	0.0	3.0	4.0	0.0	0.0	3.1	3.0	3.0	0.0	3.0	3.1	3.0	4.0	3.5	3.1	3.0	3.5	2.8	3.0	4.0	3.0	0.0	3.0	3.5	1.2	3.0

Table 3: Pathotypes of the 2016 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.

Isolate code	Host	Genetic Group[1]	Race number[2]	Virulence Profile[3]																								
				1	2	3	4	5	6	7	8	9	10	15	17	24	25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ap	Cr	Ev
17/006	Spyder	Blue	6	1	2	3	4		6	7		9			17		25	32	Re		Ro	So							Ev
17/009	Shabras	Red	28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ap		Ev
17/012	Evolution	Red	24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		Ev
17/014	Crusoe	Red	29	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ap	Cr	
17/016	Revelation	Red	28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	(Wa)	Ca	St		Ap		Ev
17/017	Reflection	Red	28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ap		Ev
17/024	KWS Lili	Red	30		2	3	4		6	7	8	9			17		25	32		Sp	Ro	So		Ca			Ap		
17/025	Myriad	Red	28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ap		Ev
17/027	Cordiale	Red	11	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ap		
17/029	KWS Siskin	Red	24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		Ev
17/030	Cordiale	Red	11	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ap		
17/032	Robigus	Red	24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		Ev
17/034	Claire	Red	24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		Ev
17/037	Zulu	Red	24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		Ev
17/039	Britannia	Red	27	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	(St)		Ap		Ev
17/042	KWS Silverstone	Red	28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	(Wa)	Ca	St		Ap		Ev
17/046	KWS Lili	Red	28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ap		Ev
17/053	KWS Lili	Red	11	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ap		
17/057	Skyfall	Red	11	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ap		(Ev)
17/060	Spyder	*	*	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ap	Cr	Ev
17/078	Moulton	Red	28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ap		Ev
17/081	KWS Kerrin	Red	24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		Ev
17/083	KWS Basset	Red	28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	(Wa)	Ca	St	(Kr)	Ap		Ev
17/090	LG Generation	Red	24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		Ev
17/094	Bennington	Red	24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		Ev
17/102	Claire	Red	24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		Ev
17/112	Warrior	Red	26	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		
17/113	Scout	Red	24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		Ev

[1] Genetic group assigned using data from Diane Saunders, John Innes Centre as part of the BBSRC and AHDB funded IPA "Using field pathogenomics to study wheat yellow rust dispersal and population dynamics at a national and international scale"

[2] Race number assigned by the UKCPVS using pathotype data in Table 2.

[3] Numbers refer to previously designated *Yr* genes, Re = Rendezvous, Sp = Spaldings Prolific, Ro = Robigus, So = Solstice, Wa = Warrior, Am = Ambition, Ca = Cadenza, St = KWS Sterling, Kr = Kranich, Ap = Apache, Cr = Crusoe, Ev = Evolution.

* = Missing data

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.

Virulence For Resistance Gene or Variety	Percentage of Isolates Identified with Virulence for Gene or Variety				
	2013	**2014**	**2015**	**2016**	**2017**
Yr1	100	100	100	100	96
Yr2	100	100	97	100	100
Yr3	100	96	100	100	100
Yr4	100	96	97	94	100
Yr5	0	0	0	0	0
Yr6	100	100	100	100	100
Yr7	92	92	76	90	100
Yr8	0	4	3	6	4
Yr9	100	100	100	100	100
Yr10	0	0	0	0	0
Yr15	0	0	0	0	0
Yr17	100	100	97	100	100
Yr24	0	0	0	0	0
Yr25	92	100	100	98	100
Yr32	100	100	100	100	100
Rendezvous	48	12	38	83	96
Spaldings Prolific	80	88	72	77	96
Robigus	100	100	100	100	100
Solstice	100	85	90	100	100
Warrior	28	23	3	33	46
Cadenza	80	73	55	77	96
KWS Sterling	44	8	24	31	89
Kranich	*	4	7	10	7
Apache	76	65	52	54	96
Crusoe	4	0	0	8	7
Evolution	*	*	*	19	79
Total Number of Isolates	**25**	**26**	**29**	**48**	**28**

4.1.2.2. Virulence frequencies for pathotype groups

Most of the isolates were assigned to different genetic groups using data from the Field Pathogenomics project (Diane Saunders, pers. comm., Table 3). In only one case this information was missing and the isolate could therefore not be assigned a group and race number. Considering the population by genetic group, the frequencies of isolates found in each group differed to that found in 2016 (Table 5). The Red group almost entirely dominated the surveyed isolates, with only one Blue isolate being found. The reason for the sudden decline in the Blue group and the continued proliferation of the Red group is unknown, however it could relate to adaptation of the Red isolates to currently grown varieties and/or the weather conditions in the UK.

Table 5: Pathotype group frequencies from 2013 to 2017

Pathotype Group	**Frequency of Isolates Found (%)**				
	2013	**2014**	**2015**	**2016**	**2017**
Pink	28	19	3	7	0
Blue	20	8	28	28	4
Red	52	69	66	63	93
Purple	0	4	3	2	0
Mix	0	0	0	0	0
Number of isolates	**25**	**26**	**29**	**46**	**28**

4.1.2.3. Commonly detected isolates

In 2017 there were nine different pathotypes detected, five of which were unique to this year. This contrasts quite markedly with the 2016 results where 21 pathotypes were identified, 16 of which were new in 2016. The four pathotypes not unique to 2017 were identified for the first time in 2016. Blue 7 was not identified from any of the isolates tested. Out of the nine pathotypes detected this year, there were two pathotypes that dominated.

The most common group of isolates, represented by 10 isolates, was the group Red 24. This group carried virulence for Yr1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,St,Ap,Ev and was detected for the first time in 2016. Adult plant trials carried out by the UKCPVS in 2017 indicated that this group were behind some of the changes in varietal performance in 2016. It is therefore not a surprise to see that this group has become widely established. The isolates of this group were collected from the varieties Evolution, KWS Siskin, Robigus, Claire, Zulu, KWS Kerrin, LG Generation, Bennington and Scout. The isolates were

collected from a wide area of the UK in Cheshire, Suffolk, Oxfordshire, Herefordshire, Belfast, Lincolnshire and Essex.

The second most common group of isolates was Red 28, which carry virulence for Yr1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Ca,St,Ap,Ev and was identified in eight samples. These isolates are very similar to the dominant group from 2016, Red 11. The difference between the two groups is the additional virulence for Evolution in Red 28. Given that the inclusion of Evolution as a differential is very recent it is possible that these isolates have been found before, but mis-labelled as Red 11. The isolates from this group were collected from the varieties Shabras, Revelation, Reflection, Myriad, KWS Silverstone, KWS Lili, Moulton and KWS Basset and came from Nottinghamshire, East Yorkshire, Suffolk, Norfolk, Herefordshire, Gloucestershire and Belfast. These isolates appear to be present in different locations to the Red 24 isolate; however geographical distribution should be interpreted with caution given the limited sample size.

There were three other isolates identified in 2017 that were particularly interesting to the UKCPVS. Red 30 is discussed above in section 4.1.2.1. An isolate named Red 29 carried virulence for Yr 1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Wa,Ca,St,Kr,Ap,Cr and an un-named isolate had a similar virulence profile but carried additional virulence for Evolution. These two isolates carry very complex combinations of virulence, including that for Crusoe which is rarely detected by the UKCPVS. As with Red 30, the risk posed by these isolates is yet to be established.

4.1.3. Variety testing of isolates from 2017

Five isolates were selected for further testing on the wider set of RL varieties and candidates (Table 6). The isolates were selected to best represent the results of the 28 tested isolates choosing isolates with the most complex virulence profiles where possible. An isolate from the Red 24 and 28 groups were selected to represent the most commonly found isolates last year. The isolates 17/024 and 17/060 representing the Red 30 and the un-named groups were noted to be of interest due to their novelty in 2017 and the isolate 17/112 was chosen to investigate whether the virulence for Evolution is important in the virulence of Red 24 to UK varieties.

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 summer of 2018. Results are

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, Am = Ambition, Ca = Cadenza, St = KWS Sterling, Kr = Kranich, Ap = Apache, Cr = Crusoe, Ev = Evolution. Yellow shading = compatible reaction (virulence), blank = avirulence, * = missing data.

Isolate code	Host	Group	Race number	Virulence Profile																								
				1	2	3	4	5	6	7	8	9	10	15	17	24	25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ap	Cr	Ev
17/009	Shabras	Red	28	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So		Ca	St		Ap		Ev
17/024	KWS Lili[1]	Red	30		2	3	4		6	7	8	9			17		25	32		Sp	Ro	So		Ca			Ap		
17/060	Spyder	*	*	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St	Kr	Ap	Cr	Ev
17/094	Bennington	Red	24	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		Ev
17/112	Warrior	Red	26	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So	Wa	Ca	St		Ap		

[1] This may also be the same as PstS14 identified by others (see Section 4.1.2.1)

Table 7) and are sorted by the reaction on the adult plant trials (see 4.1.3.1). In general, there was good agreement between the control differentials included in this test and the original differential test results. One main difference was the reaction of the Yr8 differentials Compair and Avocet Yr8 for the isolate 17/060. Despite extensive efforts to keep isolates pure, it is very likely that there was more than one isolate in the original sample based on work done by the UKCPVS on isolates collected in 2016 (data not shown). As in previous years, the three RL varieties Costello, KWS Crispin and KWS Siskin were resistant to all isolates tested, along with KWS Trinity, Cougar and the candidate KWS Firefly. There were no varieties that were susceptible this year that had been resistant in previous years. Varieties that are only occasionally susceptible at the seedling stage included KWS Extase, KWS Gator, LG Detroit, SY Loki, Crusoe and Ambition. Virulence for Crusoe was first detected in 2013 and for the second consecutive year has been detected in occasional isolates. This has not translated into a susceptible response at the adult plant stage for this variety.

4.1.3.1. 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 2018 which contained RL and candidate varieties. The new method of inoculation trialled for the first time in 2017 was used again. Plots were treated with fungicides up to and including the T1 application. Leaf two and the flag leaf were then inoculated directly to ensure that only the isolates under investigation were present. The first inoculation was carried out on the 22nd May and the first assessment was made on 15th June when the plants were at GS66. The percentage of leaf area infected was assessed and the mean was calculated from three assessments (Table 7). Disease levels were very low in the trials this year despite being inoculated five times. Hot and dry weather is likely to have impacted on the disease levels this year. Given the low levels of disease recorded (maximum average score: 13.5% in Robigus), further analysis of varietal performance is not possible with this data set. Should another run of dry weather be experienced in the 2019 field season, we will irrigate the trials in advance of inoculations to improve infection conditions.

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.

Variety	Current RL Rating	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		17/009	17/024	17/060	17/094	17/112	17/009	17/024	17/060	17/094	17/112
AMBITION		2.2	0.0	3.0	3.0	0.6	0.0	0.0	0.0	0.0	0.0
BRIGADIER		3.5	3.0	3.1	3.1	3.0	0.0	0.0	0.0	0.0	0.0
COUGAR		0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRUSOE	9	0.1	0.0	4.0	2.9	0.9	0.0	0.0	0.0	0.0	0.0
ELATION	9	3.0	2.8	3.0	3.1	3.0	0.0	0.0	0.0	0.0	0.0
ELICIT	9	3.0	2.4	3.0	3.0	2.5	0.0	0.0	0.0	0.0	0.0
FREISTON	9	3.1	2.9	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
GRAHAM	8	3.0	2.9	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
KWS CRISPIN	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KWS EXTASE	Candidate	1.2	0.3	3.0	3.0	1.5	0.0	0.0	0.0	0.0	0.0
KWS LILI	7	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
KWS SANTIAGO	7	3.0	3.0	3.0	4.0	3.1	0.0	0.0	0.0	0.0	0.0
KWS TRINITY	9	1.3	1.4	1.3	1.5	0.6	0.0	0.0	0.0	0.0	0.0
LG INTERSTELLAR	Candidate	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
LG JIGSAW	Candidate	3.1	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
LG MOTOWN	9	3.0	3.0	3.0	3.2	3.0	0.0	0.0	0.0	0.0	0.0
LG SKYSCRAPER	Candidate	3.1	3.0	3.0	4.0	3.0	0.0	0.0	0.0	0.0	0.0
LG SPOTLIGHT	Candidate	3.0	3.0	3.5	3.0	3.0	0.0	0.0	0.0	0.0	0.0
LG SUNDANCE	9	3.0	2.7	3.0	3.2	3.0	0.0	0.0	0.0	0.0	0.0
NAPIER		3.2	2.5	3.0	3.0	2.8	0.0	0.0	0.0	0.0	0.0
RENDEZVOUS		3.1	2.6	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
REVELATION	9	2.5	2.3	3.1	3.1	3.0	0.0	0.0	0.0	0.0	0.0
RGT GRAVITY	8	3.0	2.1	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
RGT ILLUSTRIOUS	9	3.1	1.7	3.0	3.0	2.1	0.0	0.0	0.0	0.0	0.0
RGT UNIVERSE	Candidate	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
SAVELLO	8	4.0	2.8	3.0	4.0	2.8	0.0	0.0	0.0	0.0	0.0

Variety	Current RL Rating	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		17/009	17/024	17/060	17/094	17/112	17/009	17/024	17/060	17/094	17/112
STRATOSPHERE		3.5	3.0	2.6	3.0	3.0	0.0	0.0	0.0	0.0	0.0
SY LOKI	Candidate	2.8	0.3	3.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0
SY MEDEA	Candidate	3.0	0.9	3.0	3.0	2.7	0.0	0.0	0.0	0.0	0.0
TALON		4.0	3.0	3.5	4.0	3.0	0.0	0.0	0.0	0.0	0.0
KWS BARREL	8	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
KWS SISKIN	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SPYDER	7	3.1	2.5	3.0	4.0	3.0	0.0	0.0	0.0	0.0	0.0
KWS KERRIN	7	4.0	3.0	3.1	4.0	3.0	0.0	0.0	0.0	0.0	0.0
KWS ZYATT	7	3.5	3.0	3.1	3.0	3.3	0.0	0.0	0.0	0.0	0.0
HARDWICKE	8	4.0	2.2	3.0	3.2	2.3	0.0	0.0	0.0	0.0	0.0
WARRIOR		3.0	3.0	3.1	3.0	3.0	0.0	0.0	0.0	0.1	0.0
KWS FIREFLY	Candidate	0.0	1.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0
VISCOUNT	6	3.0	3.0	3.3	3.1	3.0	0.0	0.0	0.1	0.0	0.1
DELPHI		4.0	3.0	3.0	3.0	3.0	0.0	0.0	0.1	0.0	0.0
MOULTON	8	3.0	1.2	2.9	3.0	2.1	0.0	0.0	0.1	0.1	0.0
DUNSTON	7	3.5	3.0	3.0	3.2	3.0	0.0	0.0	0.0	0.0	0.0
GLEAM	7	3.0	0.0	3.0	3.0	2.0	0.0	0.0	0.0	0.0	0.0
KWS STERLING		2.7	2.1	3.0	2.7	3.1	0.0	0.0	0.0	0.0	0.0
KWS GATOR		0.5	3.0	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0
SHABRAS	8	4.0	2.9	3.0	3.5	3.0	0.0	0.0	0.0	0.0	0.0
KWS BASSET	8	4.0	3.0	3.0	3.5	3.0	0.0	0.0	0.0	0.0	0.0
LG DETROIT	Candidate	0.7	0.5	3.0	2.7	1.8	0.0	0.0	0.0	0.0	0.0
LG SABERTOOTH	Candidate	3.0	2.2	3.0	3.1	3.0	0.0	0.0	0.0	0.0	0.0
CORDIALE	4	3.0	2.0	3.0	3.0	3.0	0.0	0.1	0.0	0.1	0.1
LG RHYTHM	Candidate	4.0	*	3.0	3.1	3.0	0.0	0.0	0.0	0.1	0.0
CADENZA		3.0	3.0	3.2	3.0	3.0	0.0	0.0	0.0	0.0	0.1
BENNINGTON	6	3.1	3.0	3.0	3.0	3.0	0.0	0.1	0.3	0.1	0.0
APACHE		3.0	3.0	3.0	2.9	3.0	0.0	0.0	0.0	0.2	0.0
HOBBIT		3.0	*	3.0	3.0	3.0	0.1	0.0	0.0	0.3	0.1
COSTELLO	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0

Variety	Current RL Rating	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		17/009	17/024	17/060	17/094	17/112	17/009	17/024	17/060	17/094	17/112
EVOLUTION	8	2.5	1.9	3.0	3.0	0.0	0.0	0.0	0.0	0.5	0.0
HUSTLER		*	*	3.0	3.0	3.0	0.0	0.0	0.0	0.6	0.0
KWS JACKAL	9	3.0	2.8	3.0	3.0	3.0	0.0	0.0	0.0	0.6	0.0
LEEDS	6	3.0	2.4	3.0	3.0	3.0	0.0	0.0	0.0	0.8	0.0
TORCH		3.0	3.0	3.0	3.0	3.0	0.1	0.0	0.0	1.7	0.2
SKYFALL	6	3.0	3.0	3.0	3.1	3.0	0.1	0.2	0.1	0.7	0.2
CLAIRE		3.1	3.0	3.0	3.0	2.1	0.0	0.1	0.3	0.2	0.1
MYRIAD	4	3.0	2.1	3.0	3.0	3.0	0.0	0.0	0.3	0.9	0.8
JB DIEGO	5	3.0	3.0	3.0	3.2	3.0	0.1	0.1	0.4	2.9	0.2
ZULU	5	3.0	0.0	3.1	3.0	2.9	0.1	0.1	0.1	3.6	0.1
HORNET		4.0	3.0	3.0	3.2	3.2	0.2	0.7	0.2	1.2	0.1
BRITANNIA		4.0	2.3	3.0	3.0	3.0	1.1	0.2	3.2	2.8	0.5
ROBIGUS		4.0	3.0	3.1	3.0	3.0	1.3	1.9	2.9	13.5	4.6
AVOCET SP		3.0	0.1	3.0	3.0	3.1					
AVOCET YR15		0.0	*	0.0	0.0	0.0					
AVOCET YR32		3.0	3.0	3.0	3.0	3.0					
AVOCET YR6		4.0	3.0	3.0	3.0	3.5					
AVOCET YR7		4.0	3.0	3.0	3.0	3.0					
AVOCET YR8		*	3.0	3.0	2.0	2.0					
CARSTENS V		3.0	3.0	3.0	3.0	3.0					
CHINESE 166		3.5	1.3	3.0	3.0	3.0					
CLEMENT		3.0	3.0	3.0	3.0	3.0					
COMPAIR		0.0	3.0	2.9	1.3	0.8					
HEINES KOLBEN		3.0	3.0	3.0	3.0	3.0					
HEINES PEKO		4.0	1.7	3.1	3.0	3.0					
HEINES VII		3.1	3.0	3.0	3.0	3.0					
HYBRID 46		3.0	3.0	3.0	3.0	3.0					
KALYANSONA		3.0	3.0	3.0	3.0	3.0					
KRANICH		0.8	0.1	3.0	3.0	0.5					

Variety	Current RL Rating	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		17/009	17/024	17/060	17/094	17/112	17/009	17/024	17/060	17/094	17/112
LEE		3.0	3.0	3.0	3.0	3.0					
MORO		0.0	0.0	0.0	0.0	0.0					
SOLSTICE		4.0	3.0	3.0	4.0	3.0					
SPALDINGS PROLIFIC		3.0	3.0	3.0	3.1	3.0					
STRUBES DICKKOPF		3.4	3.0	3.0	3.0	3.0					
SUWON OMAR		3.0	3.0	3.0	3.0	3.0					
VILMORIN 23		3.2	3.0	3.1	3.1	3.0					
VPM 1		3.0	3.0	3.0	3.0	3.5					

4.2. Wheat Brown Rust

4.2.1. Samples Received

In 2017, the UKCVPS received 48 samples of wheat brown rust from 12 different counties across the UK (Figure 2).

Figure 2: Map of the UK with the number of samples of wheat brown rust received in 2017 from the different counties.

The full sample register is provided in Appendix 1. As in the past three years, high levels of disease were seen in the variety Crusoe and there was only one report of unusual variety performance in 2017. An untreated plot of the variety Cougar showed higher than expected levels of disease in Lincolnshire and samples were taken. In addition to this sample, samples were received from 36 different varieties, with the most frequent variety being Crusoe. 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 seven isolates were selected for further pathotyping (Table 8). 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 and their reactions, expressed as an average infection type (a.i.t.), were recorded. 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 it was possible to combine the scores for reactions to different resistance genes to infer a pathotype for each of the isolates (Table 9). This was the second year that the UKCPVS adopted a new differential set in order to bring the UKCPVS into line with other virulence surveys across the world (for example Kolmer et al. 2013). As in 2016, virulence for some of the Lr genes was reported for the first time, for example Lr2b, however this does not necessarily indicate a change in the population, rather this was the one of the first couple of years that virulence for these genes had been assessed. Virulence for most of the Lr genes under investigation increased in frequency this year compared to 2016 (Table 10). Some of this increase may reflect changes in the population; however we suspect that some of these changes were due to optimisation of the conditions for using the new differential set. As in previous years virulence for Lr24 and Lr28 is either found at very low levels or not at all. This reflects the use of current varieties that do not carry these resistance genes.

4.2.2.2. Commonly detected races

In 2017 there were 26 different pathotypes detected in the 27 isolates tested, all of which were unique to this year. As discussed previously, this may well reflect the additional resolution afforded to us using the new differential set. In addition to this, 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.)

4.2.3. Variety testing of isolates from 2017

Five isolates from the 27 tested isolates were selected for further testing on the wider set of RL varieties and candidates (Table 11) and were selected to best represent the diversity of the isolates tested.

Table 8: Average infection type (a.i.t.) scores for the 27 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.

Isolate Code	Host Variety	Thatcher Lr1	Thatcher Lr2a	Thatcher Lr2b	Thatcher Lr2c	Thatcher Lr3a	Thatcher Lr3bg	Thatcher Lr3ka	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 (Lr17b)	Robigus (Lr28)
17/001	KWS Kielder	1.0	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	0.3	3.0	0.0	3.0	3.0	2.0	1.0	0.1
17/003	Savello	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	2.9	3.0	0.0
17/004	Bennington	2.0	2.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	2.0	0.0	2.0	3.0	3.0	3.0	0.0
17/005	LG Generation	1.0	1.0	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	0.9	2.0	1.0	3.0	3.0	3.0	3.0	0.0
17/006	Crusoe	2.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	2.0	1.4	2.0	0.0	3.0	3.0	3.0	1.2	0.0
17/010	Solstice	3.0	1.0	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	1.0	2.0	1.0	3.0	3.0	3.0	3.0	0.0
17/011	Buster	1.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	2.0	0.3	2.0	1.0	3.0	3.0	3.0	3.0	0.0
17/014	KWS Santiago	2.0	1.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	1.0	2.0	2.0	3.0	3.0	3.0	2.0	2.0
17/016	Shabras	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	3.0	2.0	2.0	0.1
17/017	Breeding/Research Line	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	1.2	2.0	1.0	3.0	3.0	3.0	2.0	0.0
17/018	Crusoe	1.0	1.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.6	2.0	0.0	2.0	3.0	3.0	3.0	0.0
17/019	Cougar	3.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	0.3	2.0	1.0	3.0	3.0	3.0	0.7	0.0
17/024	Costello	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	0.8	2.0	1.0	3.0	3.0	3.0	2.0	0.0
17/025	Spyder	3.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	0.2	2.0	0.1	3.0	3.0	3.0	1.0	0.0
17/026	Evolution	3.0	1.0	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	0.6	3.0	0.0	3.0	3.0	3.0	3.0	0.0
17/027	Hardwicke	3.0	1.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	2.0	0.0	2.0	1.0	3.0	3.0	3.0	3.0	0.0
17/028	KWS Silverstone	3.0	2.0	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	1.6	2.0	1.0	3.0	3.0	3.0	3.0	0.0
17/029	KWS Trinity	2.0	2.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	2.0	1.3	2.0	1.0	3.0	3.0	3.0	2.0	0.5
17/030	RGT Illustrious	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.2	2.0	0.0	2.0	3.0	2.6	1.5	0.0
17/032	KWS Lili	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	2.0	0.6	2.0	0.0	2.0	3.0	3.0	3.0	0.0
17/033	KWS Zyatt	3.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	1.0	2.0	0.0	3.0	3.0	3.0	3.0	0.0
17/034	KWS Barrel	3.0	2.0	2.0	2.0	3.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	1.0	2.0	1.0	3.0	3.0	3.0	3.0	0.0
17/035	Zulu	2.0	1.0	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	0.6	2.0	1.0	3.0	3.0	3.0	3.0	0.0
17/036	KWS Bassett	2.0	1.0	2.0	2.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.2	2.0	0.0	3.0	3.0	3.0	3.0	0.0

Isolate Code	Host Variety	Thatcher Lr1	Thatcher Lr2a	Thatcher Lr2b	Thatcher Lr2c	Thatcher Lr3a	Thatcher Lr3bg	Thatcher Lr3ka	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 (Lr17b)	Robigus (Lr28)
17/037	Revelation	2.0	1.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.1	2.0	2.0	3.0	3.0	3.0	2.8	2.0
17/039	Graham	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	0.3	2.0	1.0	3.0	3.0	3.0	3.0	0.0
17/040	Shamrock	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	1.2	2.0	1.0	3.0	3.0	3.0	3.0	0.0

Table 9: Pathotypes of the 2017 *Puccinia triticina* isolates based on the differential test results in Table 8. Numbers refer to specific *Lr* resistance genes, Cr = Crusoe, Ro = Robigus

Isolate Number	Host variety	Virulence Profile																				
		1	2a	2b	2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23	24	26	28	37	17b	Ro	Cr
17/001	KWS Kielder				2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23		26		37			
17/003	Savello					3a	3bg	3ka	10	13	14a			17	20	23	24	26		37	17b		Cr
17/004	Bennington	1		2b	2c	3a	3bg	3ka	10	13	14a	15		17	20	23		26			17b		Cr
17/005	LG Generation			2b	2c	3a	3bg	3ka	10	13	14a	15		17	20	23		26		37	17b		Cr
17/006	Crusoe				2c	3a	3bg	3ka	10	13	14a	15		17	20			26		37			Cr
17/010	Solstice	1		2b	2c	3a	3bg	3ka	10	13	14a	15	16	17	20			26		37	17b		Cr
17/011	Buster				2c	3a	3bg	3ka	10	13	14a	15		17	20			26		37	17b		Cr
17/014	KWS Santiago	1				3a	3bg	3ka	10	13	14a	15	16	17	20					37			Cr
17/016	Shabras	1				3a	3bg	3ka	10		14a	15	16	17	20		24			37			
17/017	Breeding/ Research Line	1				3a	3bg	3ka	10	13	14a	15	16	17	20	23				37			Cr
17/018	Crusoe	1				3a	3bg		10	13	14a	15	16	17	20			26			17b		Cr
17/019	Cougar	1				3a	3bg	3ka	10	13	14a	15		17	20	23		26		37			Cr
17/024	Costello				2c	3a	3bg	3ka	10	13	14a	15	16	17	20			26		37			Cr
17/025	Spyder	1			2c	3a	3bg	3ka	10	13	14a	15		17	20	23		26		37			Cr
17/026	Evolution	1		2b	2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23		26		37	17b		Cr
17/027	Hardwicke	1			2c	3a	3bg	3ka	10	13	14a	15		17	20			26		37	17b		Cr
17/028	KWS Silverstone	1			2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23		26		37	17b		Cr
17/029	KWS Trinity	1				3a	3bg		10	13	14a	15		17	20					37			Cr
17/030	RGT Illustrious	1				3a	3bg	3ka	10	13	14a	15	16	17	20			26					(Cr)
17/032	KWS Lili	1			2c	3a	3bg	3ka	10	13	14a	15	16	17	20			26			17b		Cr
17/033	KWS Zyatt	1			2c	3a	3bg	3ka	10	13	14a	15	16	17	20			26		37	17b		Cr
17/034	KWS Barrel	1				3a			10	13	14a	15	16	17	20					37	17b		Cr
17/035	Zulu	1		2b	2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23				37	17b		Cr
17/036	KWS Bassett	1				3a		3ka	10	13	14a	15	16	17	20	23		26		37	17b		Cr
17/037	Revelation	1				3a	3bg	3ka	10	13	14a	15	16	17	20	23				37	17b		Cr
17/039	Graham	1			2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23		26		37	17b		Cr
17/040	Shamrock	1				3a	3bg	3ka	10	13	14a	15	16	17	20	23		26		37	17b		Cr

Table 10: Frequency of detection of isolates carrying virulence to the different brown rust resistance genes and varieties over the past five years. * = missing data.

Virulence For Resistance Gene or Variety	**Percentage of Isolates Identified with Virulence for Gene or Variety**				
	2013	**2014**	**2015**	**2016**	**2017**
Lr1	33	76	46	36	78
Lr2a	*	*	*	0	0
Lr2b	*	*	*	0	19
Lr2c	*	*	*	8	56
Lr3a	17	76	62	32	100
Lr3bg	*	*	*	24	93
Lr3ka	*	*	*	36	89
Lr10	*	*	*	36	100
Lr13	*	*	*	40	96
Lr14a	*	*	*	36	100
Lr15	*	*	*	20	96
Lr16	*	*	*	16	67
Lr17	*	*	*	28	100
Lr17b	83	84	65	100	63
Lr20	22	96	77	12	100
Lr23	*	*	*	8	52
Lr24	17	20	4	4	7
Lr26	50	96	69	0	74
Lr28	28	12	8	0	0
Lr37	67	80	54	48	85
Robigus	50	12	8	0	0
Crusoe	56	92	50	88	89
Total Number of Isolates	**18**	**25**	**26**	**25**	**27**

Table 11: 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 Number	Host variety	Virulence Profile																				
		1	2a	2b	2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23	24	26	28	37	17b	Ro	Cr
17/016	Shabras	1				3a	3bg	3ka	10		14a	15	16	17	20		24			37			
17/018	Crusoe	1				3a	3bg		10	13	14a	15	16	17	20			26			17b		Cr
17/019	Cougar	1				3a	3bg	3ka	10	13	14a	15		17	20	23		26		37			Cr
17/026	Evolution	1		2b	2c	3a	3bg	3ka	10	13	14a	15	16	17	20	23		26		37	17b		Cr
17/028	KWS Silverstone	1			2c	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 summer of 2018. Results are combined with the adult plant test results (Table 12) and are sorted by the reaction on the adult plant trials (see 4.2.3.2). Similar to last year, only five of the RL varieties and candidates tested were resistant to all of the isolates tested (four in 2017). Out of these, only Leeds had been noted as susceptible to another race in the past in the UKCPVS seedling tests. No new virulences were detected to previously resistant varieties in this extended test. A general agreement was seen when these results were compared with those of the initial differential test, however some discrepancies were seen (Table 13). For example, in the initial differential tests, virulence for *Lr1* was not detected in the five isolates under investigation; however in this test, four of the isolates were able to cause disease on the differential variety Glasgow. As before, the UKCPVS suspect that the presence of multiple isolates in the same sample is complicating matters and methods are being developed to eliminate this issue.

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 2018 which contained RL and candidate varieties. As with the yellow rust trials, the adult plant trials were treated with fungicides up to and including the T1 application to keep the natural infection levels in the trial as low as possible. Assessments were made starting at growth stage 73 on 20th June through to growth stage 85 on 4th July. Disease levels were low in the trial and as with the yellow rust trials it is likely that the dry conditions during the inoculation period may have impacted on the amount of disease established in the trials. Susceptible controls Armada and Buster showed variable amounts of disease across the five trials, with the highest score being 25% on one of the Buster plots. Samples were taken from the trials to confirm that isolates used to inoculate the trial were present (Table 13). As with the comparison between the initial differential test results and the variety seedling tests, there were some discrepancies between the re-isolation results and that expected from the other differential and variety seedling tests. Assuming that natural infection was no longer a factor in these trials, the data suggest that other isolates were present at the time of inoculation. As before, possible mixtures of isolates may be confounding these trials and this is under investigation. Due to the poor agreement between tests leading to uncertainty on causal races in the trials, further analysis of these results is not presented.

Table 12: Seedling and adult plant reactions to the five isolates selected for further characterisation. Seedling results are shown as average infection types on a scale of 0-4. Adult plant results are given as a percentage leaf area infected averaged over four assessments. Varieties are ordered in level of disease at adult plant stage. Control varieties are highlighted in green text.

Variety	Current RL Rating	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		17/016	17/018	17/019	17/026	17/028	17/016	17/018	17/019	17/026	17/028
EVOLUTION	7	3.0	3.0	3.0	3.0	2.0	0.0	0.0	0.0	0.0	0.0
KWS EXTASE	C	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0
MARIS RANGER (WBR8 APR)		1.0	0.6	2.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
VISCOUNT	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROBIGUS (*Lr28*)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
LG SPOTLIGHT	C	3.0	3.0	3.0	3.0	3.0	0.0	0.1	0.1	0.0	0.5
REVELATION	8	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.1	0.0	0.0
MYRIAD	5	3.0	3.0	3.0	0.0	3.0	0.0	0.0	0.2	0.1	0.0
KWS TARGET		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
KWS FIREFLY	C	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.0	0.1
RGT GRAVITY	6	3.0	3.0	3.0	3.0	3.0	0.0	0.2	0.1	0.0	0.1
FREISTON	7	3.0	3.0	3.0	3.0	3.0	0.1	0.0	0.0	0.0	0.0
KWS CRISPIN	5	3.0	3.0	3.0	3.0	3.0	0.1	0.0	0.0	0.0	0.0
LG JIGSAW	C	3.0	3.0	3.0	3.0	3.0	0.1	0.0	0.0	0.2	0.0
LEEDS	5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0
MOULTON	7	3.0	3.0	3.0	3.0	3.0	0.1	0.1	0.0	0.1	0.0
KWS KERRIN	7	3.0	3.0	3.0	3.0	3.0	0.1	0.2	0.1	0.1	0.1
RGT ILLUSTRIOUS	6	3.0	3.0	3.0	3.0	3.0	0.1	0.2	0.2	0.4	0.0
KWS SISKIN	5	3.0	3.0	3.0	3.0	3.0	0.1	0.2	0.2	0.4	0.1
DUNSTON	6	3.0	3.0	3.0	3.0	3.0	0.1	0.2	0.5	0.0	0.1
LG SUNDANCE	6	3.0	3.0	3.0	3.0	3.0	0.1	0.5	0.2	0.4	0.1
ELICIT	7	3.0	3.0	3.0	3.0	3.0	0.2	0.2	0.4	0.3	0.0
LG MOTOWN	7	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.2	0.0	0.2
ZULU	5	3.0	3.0	3.0	3.0	3.0	0.7	0.3	0.4	0.0	0.0
STERNA (*Lr3a*)		3.0	3.0	3.0	3.0	3.0	0.8	0.2	0.2	0.1	0.1
HARDWICKE	6	3.0	3.0	3.0	3.0	3.0	0.0	0.7	0.4	0.1	0.0

Variety	Current RL Rating	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		17/016	17/018	17/019	17/026	17/028	17/016	17/018	17/019	17/026	17/028
MARIS HALBERD (*Lr20*)		*	*	*	*	*	0.2	0.7	0.1	0.3	0.3
KWS BARREL	6	3.0	3.0	3.0	3.0	3.0	0.4	1.5	0.5	0.4	0.3
LG RHYTHM	C	0.0	0.1	0.0	0.0	0.0	0.5	0.5	1.0	0.5	0.2
LG DETROIT	C	3.0	3.0	3.0	3.0	3.0	0.0	0.2	1.6	0.1	0.4
JB DIEGO	6	3.0	3.0	3.0	3.0	3.0	0.0	0.2	1.7	0.4	0.1
KWS ZYATT	6	3.0	3.0	3.0	3.0	3.0	0.1	0.4	3.0	0.5	0.0
KWS BASSET	5	3.0	3.0	3.0	3.0	3.0	0.0	0.3	0.4	0.8	0.4
ELATION	6	3.0	3.0	3.0	3.0	3.0	0.1	0.4	0.5	0.9	0.3
SY LOKI	C	3.0	3.0	3.0	3.0	3.0	0.5	0.3	0.5	1.0	0.1
WARRIOR (*Lr24)*		0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1.5	0.0
KWS STERLING		3.0	3.0	3.0	3.0	3.0	0.2	0.1	0.5	1.5	0.1
KWS TRINITY	7	3.0	3.0	3.0	3.0	3.0	0.0	0.1	0.0	1.6	0.0
LG SABERTOOTH	C	3.0	3.0	3.0	3.0	3.0	0.0	0.2	0.1	1.7	0.1
STIGG (*Lr24*)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.2	0.0
TUXEDO		3.0	3.0	3.0	3.0	3.0	0.6	5.0	0.5	0.4	0.4
ARMADA		3.0	3.0	3.0	3.0	3.0	1.5	0.2	0.2	1.5	0.3
RGT UNIVERSE	C	3.0	3.0	3.0	3.0	3.0	0.5	0.8	0.7	0.4	0.4
SY MEDEA	C	2.0	3.0	2.0	2.0	2.0	0.1	1.0	1.5	0.0	0.1
BENNINGTON	7	3.0	3.0	3.0	3.0	3.0	0.1	1.4	0.7	0.1	0.0
LG SKYSCRAPER	C	3.0	3.0	3.0	3.0	3.0	0.1	1.4	0.7	0.1	0.3
KWS JACKAL	5	*	3.0	3.0	3.0	3.0	0.4	4.7	0.4	1.5	0.1
MARIS FUNDIN (*Lr17b*)		3.0	3.0	3.0	3.0	3.0	0.5	0.6	0.4	0.1	0.7
GAMIN (WBR6)		3.0	3.0	3.0	3.0	3.0	0.3	0.7	0.1	0.0	0.6
SKYFALL	9	3.0	3.0	3.0	3.0	3.0	0.0	0.4	1.7	0.3	2.0
LG INTERSTELLAR	C	3.0	3.0	3.0	3.0	3.0	0.8	0.8	0.5	7.3	0.4
SPYDER	7	3.0	3.0	3.0	3.0	3.0	1.4	1.5	0.4	3.8	0.2
GLASGOW (Lr1)		0.0	0.0	1.1	1.0	0.0	0.3	10.5	0.5	2.4	0.6
GRAHAM	6	3.0	3.0	3.0	3.0	3.0	0.1	0.6	0.8	1.4	0.0
SOISSONS (*Lr14a*)		3.0	3.0	3.0	3.0	3.0	0.5	1.0	2.4	0.6	0.5

Variety	Current RL Rating	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		17/016	17/018	17/019	17/026	17/028	17/016	17/018	17/019	17/026	17/028
MASCOT (*Lr37*)		*	*	3.0	*	*	0.2	1.2	1.9	1.1	0.1
COSTELLO	5	2.0	3.0	3.0	3.0	3.0	0.4	1.4	1.5	0.7	0.2
KWS SANTIAGO	5	3.0	3.0	3.0	3.0	3.0	0.4	2.0	3.7	3.9	0.5
GLEAM	6	3.0	3.0	3.0	3.0	3.0	0.4	4.8	1.6	1.6	0.5
SHABRAS	4	3.0	3.0	3.0	3.0	3.0	0.7	0.7	1.1	0.8	0.2
REAPER (*Lr37*)		3.0	3.0	3.0	3.0	3.0	1.8	2.5	0.8	1.4	0.5
CONSORT (*Lr10, Lr13, Lr26*)		3.0	3.0	3.0	3.0	3.0	2.2	4.0	0.8	2.8	0.5
SAVELLO	4	3.0	3.0	3.0	3.0	3.0	3.0	0.4	5.2	9.5	3.2
MARIS HUNTSMAN (*Lr13*)		3.0	3.0	3.0	3.0	3.0	4.7	1.7	4.0	0.5	1.8
AVALON (WBR9 APR)		3.0	3.0	3.0	3.0	3.0	1.1	5.9	3.6	1.3	1.3
BUSTER		*	*	*	*	*	1.4	4.7	7.6	6.3	1.8
CRUSOE	3	3.0	3.0	3.0	3.0	3.0	1.5	26.3	5.3	22.9	2.8
SAPPO (*Lr20*)		3.0	3.0	3.0	3.0	3.0	3.7	8.0	1.8	3.3	3.7
KWS LILI	4	3.0	3.0	3.0	3.0	3.0	11.3	17.5	21.7	3.7	1.8
Thatcher *Lr1*		0.0	0.0	0.2	0.0	0.2					
Thatcher *Lr2a*		2.0	2.0	2.0	2.0	2.0					
Thatcher *Lr2b*		2.0	2.0	2.0	3.0	2.0					
Thatcher *Lr2c*		3.0	2.0	3.0	3.0	3.0					
Thatcher *Lr3a*		3.0	3.0	3.0	3.0	3.0					
Thatcher *Lr3bg*		3.0	3.0	3.0	3.0	3.0					
Thatcher *Lr3ka*		3.0	3.0	3.0	3.0	3.0					
Thatcher *Lr10*		3.0	3.0	3.0	3.0	3.0					
Thatcher *Lr13*		3.0	3.0	3.0	3.0	3.0					
Thatcher *Lr14a*		3.0	3.0	3.0	3.0	3.0					
Thatcher *Lr15*		3.0	3.0	*	3.0	3.0					
Thatcher *Lr16*		3.0	3.0	3.0	8.0	3.0					
Thatcher *Lr17*		3.0	3.0	3.0	3.0	3.0					
Thatcher *Lr20*		3.0	3.0	3.0	3.0	3.0					
Thatcher *Lr23*		2.0	2.0	3.0	3.0	3.0					

Variety	Current RL Rating	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		17/016	17/018	17/019	17/026	17/028	17/016	17/018	17/019	17/026	17/028
Thatcher *Lr24*		0.0	0.0	0.0	0.9	0.9					
Thatcher *Lr26*		3.0	2.0	2.0	3.0	2.0					
Thatcher *Lr28*		0.0	0.0	0.0	0.0	0.0					
Thatcher *Lr37*		3.0	3.0	3.0	3.0	*					
Clement (*Lr26*)		3.0	3.0	3.0	3.0	3.0					

Table 13: 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 2018 variety tests and trials. [1] Diff = Differential test result, [2] Seed = Variety seedling test result, [3]Re-Is = Re-isolation results from adult plant trials, * = missing data

Differential	17/016			17/018			17/019			17/026			17/028		
	Diff[1]	Seed[2]	Re-Is[3]	Diff[1]	Seed[2]	Re-Is[3]	Diff[1]	Seed[2]	Re-Is[3]	Diff[1]	Seed[2]	Re-Is[3]	Diff[1]	Seed[2]	Re-Is[3]
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
Crusoe	3.0	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	3.0
Glasgow	0.0	3.0	0.0	0.0	3.0	1.0	1.1	2.0	3.0	1.0	3.0	3.0	0.0	3.0	0.0
Maris Fundin	3.0	2.0	3.0	3.0	3.0	3.0	3.0	0.7	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Maris Halberd	*	2.7	*	*	3.0	3.0	*	3.0	3.0	*	3.0	*	*	3.0	*
Robigus	0.0	0.1	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
Sappo	3.0	2.0	*	3.0	3.0	3.0	3.0	*	3.0	3.0	0.0	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	3.0	3.0	3.0	3.0
Stigg	0.0	3.0	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
Warrior	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Thatcher Lr1	0.0	2.0	0.0	0.0	1.0	1.0	0.2	3.0	3.0	0.0	3.0	3.0	0.2	3.0	1.0
Thatcher Lr2a	2.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0	1.0	2.0	1.0	1.0	2.0	2.0	2.0
Thatcher Lr2b	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.0	3.0	3.0	0.4	2.0	2.0	2.0
Thatcher Lr2c	3.0	3.0	2.0	2.0	2.0	3.0	3.0	2.0	2.0	3.0	3.0	1.0	3.0	3.0	3.0
Thatcher Lr3a	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 Lr3bg	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 Lr3ka	3.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	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	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	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
Thatcher Lr16	3.0	3.0	2.0	3.0	3.0	2.0	3.0	2.0	3.0	3.0	3.0	2.0	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	3.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Thatcher Lr23	2.0	2.0	3.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Thatcher Lr24	0.0	3.0	0.0	0.0	0.6	0.9	0.0	0.3	0.3	0.9	0.6	0.0	0.9	1.6	0.0

Differential	17/016			17/018			17/019			17/026			17/028		
	Diff[1]	Seed[2]	Re-Is[3]	Diff[1]	Seed[2]	Re-Is[3]	Diff[1]	Seed[2]	Re-Is[3]	Diff[1]	Seed[2]	Re-Is[3]	Diff[1]	Seed[2]	Re-Is[3]
Thatcher Lr26	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	1.0	2.0	2.0	2.0
Thatcher Lr28	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	0.0	0.0	1.0	0.0	1.0	0.0
Thatcher Lr37	3.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	*	3.0	3.0
Clement	3.0	0.6		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

4.3. Wheat Powdery Mildew

4.3.1. Samples received

Levels of wheat powdery mildew were higher than usual in 2017 and the UKCPVS received 35 samples including samples from mobile trap nurseries (appendix 1). The samples came from 27 different varieties and 9 different counties (Figure 3).

Figure 3: Map of the UK with the number of samples of wheat powdery mildew received in 2017 from the different counties.

4.3.2. Pathotyping of isolates

From the 35 samples, multiple isolates were obtained, and 25 were pathotyped using a differential set (Table 14). Virulence was seen for most of the differentials tested, with avirulence seen only on Shamrock. Virulence frequencies for most of the differentials increased this year compared to last year with the exception of Maris Dove and Crusoe (Table 15). Large increases were seen for Sicco and Wembley. Out of the 25 isolates

Table 14: Pathotype results for the wheat 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 Number	Host variety		*Pm2*	*Pm3b*	*Pm4b*	*Pm5*	*Pm6*	*Mld*	*Pm8*	*Pm2,MlTa2*	*Pm5, MlTa2*	*MlTo*	*Pm3d*	*Pm5, MlSi2*	*MlSo*	*MlAx*	*Pm17*	*MlSh*	*MlRo*			
		Cerco	Galahad	Chul	Armada	Flanders	Brimstone	Clement	Maris dove	Brock	Mercia	Tonic	Broom	Sicco	Wembley	Axona	Amigo	Shamrock	Robigus	Warrior	Stigg	Crusoe
17-02-02	Apache	4.0	4.0	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	0.0	0.0	4.0	0.0	1.0	0.0	0.0	0.0	4.0
17-02-03	Apache	3.5	3.5	0.0	3.3	3.5	3.3	3.5	3.3	3.8	3.0	3.5	3.3	0.0	0.0	3.0	0.0	1.8	0.0	0.0	0.0	3.0
17-04-01	RW41525	4.0	4.0	0.0	4.0	3.5	4.0	0.0	4.0	4.0	4.0	4.0	4.0	3.0	3.3	4.0	0.0	2.0	0.0	0.0	0.0	4.0
17-04-02	RW41525	4.0	4.0	3.0	4.0	4.0	4.0	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	1.0	0.0	0.0	0.0	4.0
17-05-01	Armada	3.0	3.0	0.0	3.0	0.8	3.0	3.0	3.3	3.8	3.3	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.5	0.0	0.0	3.5
17-05-02	Armada	3.0	4.0	3.0	4.0	2.0	4.0	4.0	4.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.0	0.0	0.0	4.0
17-08-01	Gleam	3.8	4.0	3.8	4.0	3.5	3.8	4.0	0.0	4.0	4.0	2.0	2.0	0.0	0.0	0.0	0.5	0.0	4.0	0.0	0.0	0.0
17-08-02	Gleam	4.0	3.8	4.0	4.0	3.5	4.0	4.0	0.0	3.5	3.8	3.0	1.5	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0
17-09-01	KWS Crispin	3.3	3.5	2.0	3.8	3.0	3.3	0.0	3.0	1.5	3.0	3.8	3.8	3.5	3.3	3.5	0.0	0.0	3.8	4.0	3.3	3.8
17-09-02	KWS Crispin	3.5	3.5	3.0	3.5	3.0	3.5	0.0	3.5	4.0	3.5	3.3	3.8	3.8	3.8	4.0	0.0	0.5	3.3	3.3	3.0	3.3
17-10-01	Bletchley	4.0	4.0	1.0	4.0	1.5	4.0	4.0	0.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0
17-10-03	Bletchley	4.0	4.0	2.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	2.8	4.0	0.0	1.0	4.0	0.0	0.0	4.0
17-11-01	Cougar	4.0	4.0	0.0	4.0	4.0	4.0	3.0	0.0	3.5	3.0	0.0	0.0	3.5	3.3	0.0	0.0	0.0	3.5	0.0	0.0	0.0
17-11-02	Cougar	3.3	3.8	0.0	4.0	2.3	3.3	4.0	0.0	3.8	3.8	0.0	0.3	0.5	0.8	0.3	0.0	0.0	4.0	0.0	0.0	0.0
17-14-01	RGT Knightsbridge	4.0	4.0	1.8	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	1.0	1.0	4.0	1.5	1.0	4.0	0.0	0.0	4.0
17-14-02	RGT Knightsbridge	4.0	4.0	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0	4.0	3.0	1.0	4.0	0.0	0.0	4.0

Isolate Number	Host variety		*Pm2*	*Pm3b*	*Pm4b*	*Pm5*	*Pm6*	*Mld*	*Pm8*	*Pm2,MlTa2*	*Pm5, MlTa2*	*MlTo*	*Pm3d*	*Pm5, MlSi2*	*MlSo*	*MlAx*	*Pm17*	*MlSh*	*MlRo*			
		Cerco	Galahad	Chul	Armada	Flanders	Brimstone	Clement	Maris dove	Brock	Mercia	Tonic	Broom	Sicco	Wembley	Axona	Amigo	Shamrock	Robigus	Warrior	Stigg	Crusoe
17-17-01	KWS Santiago	3.5	3.8	0.0	3.5	3.3	3.0	3.3	0.0	3.8	3.8	0.0	0.0	0.5	1.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0
17-17-02	KWS Santiago	4.0	4.0	0.0	4.0	3.5	4.0	4.0	0.0	4.0	4.0	0.0	0.0	3.5	3.5	0.0	0.0	0.3	4.0	0.0	0.0	0.0
17-18-01	Gleam	3.0	3.0	0.0	4.0	3.5	3.8	4.0	4.0	4.0	4.0	4.0	3.8	4.0	3.5	4.0	0.0	0.0	3.5	0.0	0.0	3.0
17-18-02	Gleam	4.0	4.0	2.0	4.0	4.0	4.0	4.0	2.0	4.0	4.0	3.0	3.0	4.0	4.0	3.0	1.3	1.0	4.0	0.0	0.0	0.0
17-27-01	KWS Crispin	3.0	3.0	0.0	3.3	3.3	2.0	4.0	3.0	4.0	4.0	3.0	3.0	2.5	2.0	3.0	0.0	1.0	3.0	3.3	3.3	3.0
17-32-01	Cerco	3.0	3.0	0.0	3.0	3.3	3.3	3.5	3.0	3.3	3.3	3.0	3.3	0.0	0.0	3.3	0.0	1.0	0.0	0.0	0.0	3.0
17-32-02	Cerco	3.5	3.5	0.0	3.8	2.8	2.8	4.0	4.0	4.0	4.0	4.0	4.0	0.0	0.0	2.8	0.0	0.3	0.0	0.0	0.0	3.8
17-34-03	Cerco	3.0	3.0	0.0	3.0	3.0	3.0	3.8	3.0	3.5	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	3.0
17-36-01	KWS Kielder	3.3	3.3	2.3	3.8	3.0	3.0	3.0	3.3	3.0	3.0	3.0	3.5	1.8	4.0	3.3	1.0	0.3	2.5	3.0	3.8	3.3

Table 15: Virulence frequencies of key wheat powdery mildew resistance genes and varieties over the past five years of testing.

Differential	Known Genes	Virulence Frequency by Year				
		2013	2014	2015	2016	2017
Galahad	*Pm2*	77	72	71	88	100
Chul	*Pm3b*	11	20	14	8	20
Armada	*Pm4b*	74	84	64	84	100
Flanders	*Pm5*	43	76	71	76	84
Brimstone	*Pm6*	80	80	64	88	96
Clement	*Pm8*	46	60	50	64	84
Maris dove	*Mld*	94	44	64	88	68
Brock	*Pm2,MlTa2*	89	88	71	84	96
Mercia	*Pm5, MlTa2*	77	80	79	80	100
Tonic	*MlTo*	26	24	14	28	64
Broom	*Pm3d*	26	20	14	28	60
Sicco	*Pm5, MlSi2*	3	8	0	8	40
Wembley	*MlSo*	9	8	0	4	44
Axona	*MlAx*	17	12	14	32	60
Amigo	*Pm17*	0	0	7	0	8
Shamrock	*MlSh*	0	4	0	0	0
Robigus	MlRo	51	64	64	56	72
Warrior		6	8	0	8	16
Stigg		6	8	0	4	16
Crusoe		40	36	36	72	68
Total Number of Isolates Tested		**43**	**35**	**25**	**14**	**25**

tested, 16 different pathotypes were identified, 12 of which were unique to 2017. Although there were some differences in virulence frequencies and pathotypes between years, there were once again no reports of unusual mildew outbreaks during the year and based on this information we suspect that this population change is therefore unlikely to have much impact at the adult plant stage. The wheat powdery mildew isolates were 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, higher levels of barley powdery mildew were observed in 2017 compared to 2016. Growers, trial managers and agronomists provided 33 samples from 24 varieties across four counties (Figure 4).

Like the wheat powdery mildew, higher levels of barley powdery mildew were observed in 2017 compared to 2016. Growers, trial managers and agronomists provided 33 samples from 24 varieties across four counties (Figure 4: Map of the UK with the number of samples of barley powdery mildew received in 2017 from the different counties.

4.4.2. Pathotyping of Isolates

From the samples received and collected, 32 isolates were obtained and characterised using a differential set (Table 16). Virulence for all of the differentials was detected and was broadly in line with frequencies observed in previous years (Table 17). Exceptions were seen for differentials such as Porter and Lotta, however the UKCPVS received no reports of unexpected outbreaks of barley powdery mildew during 2017 so it is possible that this variation in the population will 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 and the full impact of any change in the population will not become evident until the next season.

Table 16: 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 Number	Host Variety	0	Mlh	Mlra	Mlg	Mlg,Ml(CP)	Mla6	MlLa	Mla12	Mlk1	Mla7	MlAb	Mla7,MlAb	Mla1	Mla9	mlo 11	mlo?	Mla13	Mla3	Vanessa	Optic	NFC Tipple	Propino
		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	NFC Tipple	Propino
17/1/3	unknown	3.8	4.0	3.8	3.5	3.5	3.5	3.3	3.5	0.0	3.0	3.0	2.5	4.0	0.5	3.0	1.0	0.0	3.0	3.3	1.3	3.5	3.5
17/1/4	unknown	4.0	4.0	3.5	3.5	3.0	3.3	3.5	3.3	1.0	3.3	3.3	2.0	4.0	0.0	3.0	1.5	0.0	3.0	3.3	2.5	3.8	4.0
17/1/5	unknown	3.8	3.5	3.0	3.3	3.3	4.0	1.8	4.0	1.0	1.8	2.0	0.5	4.0	0.0	2.3	0.0	0.0	3.0	4.0	0.8	4.0	3.3
17/2/1	unknown	3.8	4.0	4.0	3.3	4.0	4.0	2.3	2.0	1.0	2.0	3.5	1.5	0.0	0.0	3.0	1.0	0.0	2.8	4.0	0.3	4.0	4.0
17/2/3	unknown	3.8	3.0	3.0	3.0	2.8	3.0	3.3	3.0	2.3	2.0	2.5	1.3	3.0	3.0	1.8	2.0	0.0	2.3	3.3	2.3	3.0	3.3
17/2/6	unknown	3.5	4.0	4.0	3.3	4.0	3.8	3.8	4.0	1.5	2.0	3.0	2.0	2.0	1.3	1.3	2.0	0.0	2.3	4.0	2.5	4.0	4.0
17/3/1	unknown	3.8	3.8	3.3	3.3	3.3	3.3	3.3	3.5	1.0	2.5	3.3	1.8	4.0	0.0	1.8	2.0	3.0	2.8	3.5	3.0	3.5	3.3
17/3/2	unknown	4.0	4.0	3.8	3.5	3.3	3.0	3.5	3.3	1.0	3.3	3.3	2.5	4.0	0.0	3.0	2.3	2.5	3.0	4.0	2.5	4.0	4.0
17/3/5	unknown	3.8	4.0	3.8	3.8	3.3	3.5	3.0	3.3	1.0	2.0	2.8	1.5	2.5	0.0	2.5	1.8	3.3	3.0	4.0	1.3	4.0	3.5
17/4/4	unknown	4.0	4.0	3.8	3.8	4.0	2.8	4.0	4.0	1.0	3.0	3.5	2.0	0.3	0.3	2.8	2.5	0.0	3.8	4.0	3.3	4.0	4.0
17/4/7	unknown	3.8	3.8	3.3	3.0	3.3	3.5	3.0	3.3	1.0	2.8	3.8	2.5	4.0	0.0	2.3	1.0	0.0	3.3	3.3	2.8	3.5	4.0
17/5/1	unknown	3.8	4.0	4.0	4.0	4.0	4.0	3.8	4.0	1.0	3.3	3.5	3.0	3.8	0.0	3.8	1.8	0.0	1.8	3.5	2.8	0.0	0.0
17/5/2	unknown	3.5	4.0	3.8	0.0	0.0	3.5	4.0	4.0	4.0	4.0	3.0	2.5	4.0	0.3	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0
17/5/3	unknown	4.0	3.8	3.5	3.3	3.3	4.0	2.5	3.5	1.0	1.0	1.8	0.8	4.0	0.0	1.5	0.3	0.0	3.0	4.0	2.0	4.0	3.8
17/5/5	unknown	3.3	4.0	4.0	3.8	3.5	3.8	3.5	4.0	1.0	3.0	3.5	1.8	4.0	0.0	2.8	2.0	0.0	1.8	3.5	2.0	0.0	0.0
17/6/3	Propino	4.0	4.0	3.8	3.0	3.5	3.5	3.8	3.8	2.0	2.3	3.3	2.0	4.0	2.8	2.5	1.3	3.5	3.5	3.3	2.3	3.8	3.8
17/6/4	Propino	3.3	3.8	3.8	3.3	3.3	3.5	3.0	3.3	2.3	2.5	3.3	1.8	2.5	0.0	2.0	2.0	2.5	2.8	3.3	2.5	3.5	3.5
17/6/5	Propino	3.8	3.8	4.0	3.8	3.8	3.5	4.0	3.5	1.3	3.5	4.0	3.3	4.0	2.8	2.8	2.0	3.3	2.5	3.8	3.0	3.8	4.0
17/28/1	unknown	4.0	4.0	3.8	3.5	3.5	3.3	3.3	3.3	2.3	3.0	3.3	3.3	4.0	4.0	3.0	2.8	3.3	3.5	3.5	3.0	3.3	3.8
17/28/2	unknown	3.5	3.8	3.5	3.3	3.5	3.5	3.5	3.5	1.8	3.5	3.3	3.0	4.0	3.5	2.0	2.0	3.5	2.8	3.8	3.0	3.5	3.8
17/28/3	unknown	3.0	4.0	4.0	3.0	3.3	3.0	3.5	3.3	2.5	3.5	3.5	3.0	4.0	2.3	3.0	1.5	3.3	3.0	3.3	2.8	3.0	3.0
SW 1	Golden Promise	3.8	4.0	4.0	4.0	4.0	3.5	3.3	3.5	3.8	2.0	3.8	2.0	0.0	0.3	2.3	1.8	0.0	3.3	3.8	1.5	4.0	4.0

Isolate Number	Host Variety	0	Mlh	Mlra	Mlg	Mlg,Ml(CP)	Mla6	MlLa	Mla12	Mlk1	Mla7	MlAb	Mla7,MlAb	Mla1	Mla9	mlo 11	mlo?	Mla13	Mla3	Vanessa	Optic	NFC Tipple	Propino
		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	NFC Tipple	Propino
SW 3	Golden Promise	3.3	4.0	3.8	3.8	3.0	3.8	3.8	3.8	1.0	1.5	3.0	1.3	4.0	0.0	2.3	3.0	0.0	2.8	4.0	2.3	4.0	4.0
AH 2	Golden Promise	3.0	4.0	3.3	3.5	3.5	3.8	2.0	1.3	1.0	1.8	2.0	0.5	0.0	0.0	1.8	0.3	0.0	3.0	4.0	0.3	4.0	3.5
AH 4	Golden Promise	4.0	4.0	3.0	3.3	3.5	3.3	4.0	0.5	1.0	0.5	0.8	0.3	0.0	0.0	2.0	1.5	0.0	1.0	4.0	0.0	0.0	0.0
NIAB 2	Golden Promise	3.0	4.0	3.5	3.5	3.3	4.0	3.5	4.0	1.0	1.8	1.8	1.0	0.0	1.3	2.3	1.3	0.0	2.5	3.8	1.8	3.8	3.3
NIAB 3	Golden Promise	3.5	4.0	4.0	3.8	3.5	4.0	3.0	2.3	1.0	3.3	3.5	1.8	0.0	0.0	3.3	1.8	0.0	3.5	4.0	0.3	4.0	4.0
NIAB 6	Golden Promise	3.0	3.5	3.3	3.3	3.3	4.0	3.3	3.0	2.8	1.3	2.0	0.3	4.0	2.5	1.8	1.8	0.0	3.0	3.8	1.5	3.8	3.3
AW 4	Golden Promise	3.5	3.8	3.0	3.3	3.3	3.3	2.0	3.3	0.3	2.8	3.5	1.8	0.3	0.0	1.5	0.0	0.0	2.8	3.5	2.3	3.8	3.8
AW 5	Golden Promise	3.8	4.0	4.0	3.8	3.3	3.3	2.8	3.5	1.0	2.8	3.3	3.0	0.0	0.0	2.3	1.3	3.0	3.0	4.0	2.3	3.8	3.8
AW 6	Golden Promise	4.0	4.0	4.0	3.8	4.0	4.0	3.3	4.0	1.5	3.3	3.5	2.3	0.0	0.0	2.3	1.5	2.0	3.0	4.0	1.3	4.0	4.0
JS 1	Golden Promise	3.3	3.5	3.5	3.3	3.5	3.3	3.0	1.0	2.8	3.0	3.0	3.0	0.0	0.0	3.0	1.5	0.0	3.3	3.3	0.3	3.3	3.5

Table 17: Virulence frequencies of key barley powdery mildew resistance genes over the past five years of testing. * = Not tested.

Differential	Known Genes	Virulence Frequency by Year				
		2013	2014	2015	2016	2017
Golden Promise	*0*	93	96	98	88	100
W.37/136	*Mlh*	100	100	100	100	100
W.41/145	*Mlra*	100	100	100	100	100
Goldfoil	*Mlg*	93	100	88	100	97
Zephyr	*Mlg,Ml(CP)*	83	96	88	100	97
Midas	*Mla6*	90	93	98	100	100
Lofa	*MlLa*	55	93	90	96	84
Hassan	*Mla12*	90	89	93	96	84
H.1063	*Mlk1*	45	41	43	31	13
Porter	*Mla7*	48	74	35	27	53
Lotta	*MlAb*	17	78	38	35	78
Triumph	*Mla7,MlAb*	7	11	5	12	22
Tyra	*Mla1*	34	37	58	73	56
Roland	*Mla9*	0	0	15	15	16
Apex	*mlo 11*	3	15	8	15	38
Riviera	*mlo 11*	0	4	0	0	6
Digger	*Mla13*	7	11	5	23	25
Ricardo	*Mla3*	34	63	53	62	75
Vanessa	*Van*	86	81	98	100	97
Optic		10	26	18	19	25
NFC Tipple		14	56	58	77	88
Propino		21	52	65	65	88
KWS Meridian		0	4	15	15	*
Total Number of Isolates		**27**	**29**	**27**	**40**	**32**

5. Conclusions

The UK Pst population continues to show high levels of diversity since the incursion of the Warrior population in 2011. New groups of isolates were detected in 2016, with Red 24 being the key group behind changes in the resistance ratings for varieties such as Britannia, Myriad, Reflection and Zulu. Isolates from the same group continued to be detected in 2017 at a high frequency, although no isolates from the Blue 7 were detected. New, complex, combinations of virulence were detected, although the impacts of these were not able to be assessed in the adult plant tests due to dry conditions in the summer.

A new differential set was used for the second year to analyse the P. triticina population. Differences in reactions of differentials between years make cross-year comparisons difficult. Virulence was detected for many of the Lr genes tested and seedling and adult plant variety tests highlighted that most varieties were susceptible to at least one of the races under evaluation; however the possible presence of multiple isolates has made more detailed isolate x variety interactions impossible. Further work into isolating from single pustules is underway.

Small changes in the Bgt and Bgh populations were detected, but as in previous years no unusual outbreaks were reported so it is unlikely that these changes have translated into detrimental effects on variety performance.

6. Appendix 1: Sample Register

2017 Wheat Yellow Rust Isolate Register

Isolate Number	Host Variety	Date received	RL Rating 2017/18	Location
17/097	Alchemy	16/06/2017		Berkshire
17/040	Alchemy	26/04/2017		Dorset
17/111	Alchemy	13/07/2017		Essex
17/099	Apache	22/06/2017		Lincolnshire
17/077	Belgrade	05/06/2017	6	Cheshire
17/059	Belgrade	15/05/2017	6	Devon
17/036	Belgrade	26/04/2017	6	Herefordshire
17/020	Belgrade	13/04/2017	6	Lincolnshire
17/064	Bennington	15/05/2017	7	Devon
17/094	Bennington	15/06/2017	7	Lincolnshire
17/109	Bennington	23/06/2017	7	Norfolk
17/049	Bennington	08/05/2017	7	Oxfordshire
17/039	Britannia	26/04/2017	4	Dorset
17/114	Britannia	13/07/2017	4	Essex
17/005	Britannia	17/03/2017	4	Unknown
17/008	Cimmyt or watkins line	21/03/2017		Oxfordshire
17/102	Claire	22/06/2017	5	Lincolnshire
17/034	Claire	24/04/2017	5	Oxfordshire
17/023	Cordiale	13/04/2017	4	Essex
17/030	Cordiale	20/04/2017	4	Kent
17/104	Cordiale	22/06/2017	4	Lincolnshire
17/027	Cordiale	13/04/2017	4	Norfolk
17/052	Cougar	08/05/2017		Oxfordshire
17/014	Crusoe		9	Essex
17/092	Derby	15/06/2017		Oxfordshire
17/012	Evolution	05/04/2017	8	Cheshire
17/013	Glasgow	05/04/2017		Cambridgeshire
17/082	Gleam	09/06/2017		Belfast
17/051	Gleam	08/05/2017		Oxfordshire
17/002	Grafton	06/02/2017	6	Northumberland
17/050	Graham	08/05/2017	8	Oxfordshire
17/105	Invicta	22/06/2017		Lincolnshire
17/035	Invicta	24/04/2017		Oxfordshire
17/098	JB Diego	16/06/2017	5	Berkshire
17/075	JB Diego	05/06/2017	5	Cheshire
17/068	JB Diego	30/05/2017	5	County Londonderry
17/055	JB Diego	08/05/2017	5	Leicestershire
17/108	JB Diego	23/06/2017	5	Northamptonshire

Isolate Number	Host Variety	Date received	RL Rating 2017/18	Location
17/041	JB Diego	26/04/2017	5	Staffordshire
17/083	KWS Basset	09/06/2017	8	Belfast
17/022	KWS Croft	13/04/2017		Essex
17/081	KWS Kerrin	09/06/2017	7	Belfast
17/046	KWS Lili	08/05/2017	7	East Yorkshire
17/021	KWS Lili	13/04/2017	7	Lincolnshire
17/053	KWS Lili	08/05/2017	7	Oxfordshire
17/024	KWS Lili	13/04/2017	7	Wiltshire
17/085	KWS Silverstone	09/06/2017	7	Belfast
17/042	KWS Silverstone	27/04/2017	7	Herefordshire
17/073	KWS Silverstone	31/05/2017	7	Lincolnshire
17/093	KWS Silverstone	15/06/2017	7	Lincolnshire
17/043	KWS Siskin	06/05/2017	9	Norfolk
17/029	KWS Siskin	20/04/2017	9	Suffolk
17/067	Leeds	30/05/2017	6	County Londonderry
17/001	LG Bletchley	03/01/2017		Cambridgeshire
17/084	LG Generation	09/06/2017		Belfast
17/090	LG Generation	15/06/2017		Cheshire
17/070	LG Generation	30/05/2017		County Londonderry
17/062	LG Generation	15/05/2017		Devon
17/019	LG Generation	12/04/2017		Herefordshire
17/047	LG Generation	08/05/2017		Oxfordshire
17/015	LG Motown	06/04/2017	9	Suffolk
17/078	Moulton	09/06/2017	8	Gloucestershire
17/061	Myriad	15/05/2017	4	Devon
17/025	Myriad	13/04/2017	4	Norfolk
17/096	ORC Wakelyns pop	16/06/2017		Berkshire
17/072	Reflection	30/05/2017	3	County Londonderry
17/063	Reflection	15/05/2017	3	Devon
17/056	Reflection	10/05/2017	3	East Yorkshire
17/010	Reflection	04/04/2017	3	Herefordshire
17/018	Reflection	12/04/2017	3	Herefordshire
17/026	Reflection	13/04/2017	3	Norfolk
17/058	Reflection	15/05/2017	3	North Yorkshire
17/003	Reflection	10/03/2017	3	Northamptonshire
17/017	Reflection	10/04/2017	3	Suffolk
17/103	Rendezvous	22/06/2017		Lincolnshire
17/016	Revelation	07/04/2017	9	East Yorkshire
17/045	Revelation	08/05/2017	9	East Yorkshire
17/080	RGT Knightsbridge	09/06/2017		Belfast
17/044	RGT Knightsbridge	08/05/2017		Cambridgeshire
17/076	RGT Knightsbridge	05/06/2017		Cheshire

Isolate Number	Host Variety	Date received	RL Rating 2017/18	Location
17/069	RGT Knightsbridge	30/05/2017		County Londonderry
17/048	RGT Universe	08/05/2017		Oxfordshire
17/100	Robigus	22/06/2017		Lincolnshire
17/032	Robigus	24/04/2017		Oxfordshire
17/113	Scout	13/07/2017		Essex
17/079	Shabras	09/06/2017	8	Belfast
17/009	Shabras	30/03/2017	8	Nottinghamshire
17/054	Shabras	08/05/2017	8	Oxfordshire
17/110	Skyfall	26/06/2017	6	Kent
17/057	Skyfall	10/05/2017	6	Northamptonshire
17/089	SO1516	15/06/2017		Cheshire
17/091	Solstice	15/06/2017		Kent
17/106	Solstice	22/06/2017		Lincolnshire
17/066	Solstice	18/05/2017		Norfolk
17/033	Solstice	24/04/2017		Oxfordshire
17/065	Solstice	18/05/2017		Suffolk
17/060	Spyder	15/05/2017	6	Devon
17/038	Spyder	26/04/2017	6	Herefordshire
17/006	Spyder	17/03/2017	6	Unknown
17/011	Talon	04/04/2014		Cambridgeshire
17/028	unknown	14/04/2017		Cambridgeshire
17/086	Verso	09/06/2017		Belfast
17/074	Verso	05/06/2017		Cheshire
17/087	Verso	15/06/2017		Cheshire
17/095	Verso	15/06/2017		Lincolnshire
17/107	Victo	22/06/2017		Lincolnshire
17/007	Victo	21/03/2017		Oxfordshire
17/031	Victo	24/04/2017		Oxfordshire
17/004	Vuka	14/03/2017		Cambridgeshire
17/112	Warrior	13/07/2017		Essex
17/101	Warrior	22/06/2017		Lincolnshire
17/088	Zulu	15/06/2017	5	Cheshire
17/071	Zulu	30/05/2017	5	County Londonderry
17/037	Zulu	26/04/2017	5	Herefordshire

2017 Wheat Brown Rust Isolate Register

Isolate Number	Host Variety	Date Received	RL Rating 2017/18	Location
17/004	Bennington	05/06/2017	7	Devon
17/011	Buster	15/06/2017		Oxfordshire
17/024	Costello	23/06/2017	5	Norfolk
17/019	Cougar	16/06/2017		Lincolnshire
17/006	Crusoe	08/06/2017	3	West Sussex
17/007	Crusoe	08/06/2017	3	West Sussex
17/008	Crusoe	08/06/2017	3	West Sussex
17/009	Crusoe	15/06/2017	3	Lincolnshire
17/018	Crusoe	16/06/2017	3	Dorset
17/023	Crusoe	23/06/2017	3	Unknown
17/013	Elation	16/06/2017		Lincolnshire
17/026	Evolution	28/06/2017	8	Cambridgeshire
17/012	Freiston	16/06/2017	7	Lincolnshire
17/039	Graham	30/06/2017	5	Herefordshire
17/027	Hardwicke	28/06/2017	6	Cambridgeshire
17/046	Kranich	13/07/2017		Essex
17/034	KWS Barrel	28/06/2017	6	Cambridgeshire
17/036	KWS Bassett	28/06/2017	5	Cambridgeshire
17/015	KWS Crispin	16/06/2017	6	Lincolnshire
17/001	KWS Kielder	12/05/2017	8	Somerset
17/032	KWS Lili	28/06/2017	5	Cambridgeshire
17/014	KWS Santiago	16/06/2017	6	Lincolnshire
17/020	KWS Santiago	23/06/2017	6	Kent
17/042	KWS Santiago	30/06/2017	6	Herefordshire
17/028	KWS Silverstone	28/06/2017	8	Cambridgeshire
17/031	KWS Siskin	28/06/2017	5	Cambridgeshire
17/041	KWS Siskin	30/06/2017	5	Herefordshire
17/029	KWS Trinity	28/06/2017	8	Cambridgeshire
17/033	KWS Zyatt	28/06/2017	6	Cambridgeshire
17/038	Leeds	28/06/2017	5	Cambridgeshire
17/005	LG Generation	05/06/2017		Devon
17/044	Napier	13/07/2017		Essex
17/017	Ore Wakelyns Population	16/06/2017		Berkshire
17/037	Revelation	28/06/2017	8	Cambridgeshire
17/045	RGT Gravity	13/07/2017		Essex
17/030	RGT Illustrious	28/06/2017	7	Cambridgeshire
17/003	Savello	25/05/2017	4	Cambridgeshire
17/016	Shabras	16/06/2017	4	Lincolnshire
17/040	Shamrock	30/06/2017		Herefordshire

17/010	Solstice	15/06/2017	5	Kent
17/021	Solstice	23/06/2017	5	Kent
17/043	Solstice	15/06/2017		Kent
17/048	Solstice	19/09/2017		Kent
17/025	Spyder	28/06/2017	7	Cambridgeshire
17/022	Stigg	23/06/2017		Unknown
17/002	Unknown	10/05/2017		Cambridgeshire
17/047	Unknown	04/09/2017		Cambridgeshire
17/035	Zulu	28/06/2017	4	Cambridgeshire

2017 Wheat Powdery Mildew Isolate Register

Isolate number	Host Variety	Date sampled/received	RL Rating 2016/17	Location
17/002	Apache	25/01/2017		Cambridgeshire
17/005	Armada	15/03/2017		Cambridgeshire
17/015	Belgrade	05/06/2017	9	Cheshire
17/010	LG Bletchley	21/04/2017		Herefordshire
17/032	Cerco	27/06/2017		Cambridgeshire
17/033	Cerco	30/06/2017		Cambridgeshire
17/034	Cerco	25/07/2017		Suffolk
17/035	Cerco	26/07/2017		Cambridgeshire
17/011	Cougar	21/04/2017		Herefordshire
17/031	Dunston	16/06/2017	5	Dorset
17/007	Elicit	04/04/2017		Herefordshire
17/020	Freiston	09/06/2017	7	County Antrim
17/029	Freiston	16/06/2017	7	Lincolnshire
17/008	Gleam	05/04/2017		Cambridgeshire
17/018	Gleam	09/06/2017		County Antrim
17/026	Graham	15/06/2017	8	Cheshire
17/013	JB Diego	05/06/2017	6	Cheshire
17/009	KWS Crispin	21/04/2017	9	Herefordshire
17/027	KWS Crispin	15/06/2017	9	Cheshire
17/001	KWS Kielder	02/12/2017		Yorkshire
17/036	KWS Kielder	28/07/2017		Cambridgeshire
17/017	KWS Santiago	09/06/2017	5	County Antrim
17/028	KWS Trinity	15/06/2017	8	Cheshire
17/016	Leeds	09/06/2017	3	County Antrim
17/019	Revelation	09/06/2017	6	County Antrim
17/021	RGT Gravity	09/06/2017		County Antrim
17/030	RGT Gravity	16/06/2017		Lincolnshire
17/014	RGT Knightsbridge	05/06/2017		Cheshire
17/004	RW41525	15/03/2017		Cambridgeshire
17/025	KWS Siskin	15/06/2017	9	Cheshire
17/006	Skyfall	04/04/2017	6	Herefordshire
17/022	Skyfall	15/06/2017	6	Lincolnshire
17/003	Solstice	27/01/2017		Hampshire
17/023	Spyder	15/06/2017	9	Cheshire
17/012	Verso	05/06/2017		Cheshire
17/024	Zulu	15/06/2017	7	Cheshire

2017 Barley Powdery Mildew Isolate Register

Isolate number	Host Variety	Date sampled/received	RL Rating 2016/17	Location
17/017	AC10/181/16	22/05/2017		County Londonderry
17/021	Bazooka	22/05/2017	4	County Londonderry
17/024	Belfry	22/05/2017	5	County Londonderry
17/010	Belmont	22/05/2017		County Londonderry
17/007	California	22/05/2017	6	County Londonderry
17/013	Cassata	22/05/2017		County Londonderry
17/016	Coref	22/05/2017		County Londonderry
17/020	Craft	22/05/2017	6	County Londonderry
17/026	Electrum	22/05/2017		County Londonderry
17/019	Funky	22/05/2017	6	County Londonderry
029 SW	Golden Promise			Cambridgeshire
030 AH	Golden Promise			Cambridgeshire
031 NIAB	Golden Promise			Cambridgeshire
032 AW	Golden Promise			Cambridgeshire
033 JS	Golden Promise			Suffolk
17/011	KWS Cassia	22/05/2017	4	County Londonderry
17/009	KWS Cresswell	22/05/2017	5	County Londonderry
17/014	KWS Glacier	22/05/2017	3	County Londonderry
17/023	KWS Infinity	22/05/2017	4	County Londonderry
17/012	KWS Orwell	22/05/2017	3	County Londonderry
17/008	KWS Tower	22/05/2017	5	County Londonderry
17/001	Not recorded			Cambridgeshire
17/002	Not recorded			Cambridgeshire
17/003	Not recorded			Cambridgeshire
17/004	Not recorded	24/05/2017		Bedfordshire
17/005	Not recorded	26/05/2017		Cambridgeshire
17/006	Propino	26/05/2017		Cambridgeshire
17/028	RL BRW discard	31/05/2017		Cambridgeshire
17/027	Sunningdale	22/05/2017	5	County Londonderry
17/022	SY Venture	22/05/2017	6	County Londonderry
17/025	SY213139	22/05/2017		County Londonderry
17/018	Talisman	22/05/2017	6	County Londonderry
17/015	Volume	22/05/2017	5	County Londonderry

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