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# United Kingdom Cereal Pathogen Virulence Survey (UKCPVS)

# 2019 Annual Report

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# 1. Summary

The United Kingdom Cereal Pathogen Virulence Survey (UKCPVS) monitors populations of important cereal pathogens:

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

***Wheat yellow rust***

Since the incursion of the Warrior population in 2011, the UK *Pst* population has shown high levels of diversity. Isolates from the Red group, which has a broad range of virulence profiles, dominate the population. New combinations of virulence were detected and these were investigated in the adult plant trials. Natural infection may have confounded the results. However, a potential isolate was identified that could explain the unexpected levels of yellow rust observed on KWS Zyatt and Dunston in 2019 in some parts of the country. This isolate has been put forward for use in the National List and Recommended List trials.

***Wheat brown Rust***

The *Pt* population was analysed with the current differential set for a third year. This detected virulence for many of the *Lr* genes tested. 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. Three isolates were identified that may explain unexpected levels of brown rust on KWS Firefly. One of these isolates has been put forward for use in the National List and Recommended List trials.

***Wheat and barley powdery mildew***

Low-to-moderate levels of disease in 2018 led to modest numbers of samples of wheat and barley powdery mildew being received by the UKCPVS. Small changes in the *Bgt* and *Bgh* populations were detected but, as in previous years, no unusual outbreaks were reported. As a result, it is unlikely that these changes have translated into detrimental effects on variety performance.

# 2. Introduction

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

### 2.1.1. Establishment of the survey

Wheat production in the UK is threatened annually by a number of pests and diseases. In our cool maritime climate the foliar diseases Septoria leaf blotch and yellow (stripe) rust are easily found. Warmer summers have also led to the sighting of brown (leaf) rust at the end of the season which can be serious if left unchecked on susceptible varieties. Current methods of control are based principally on fungicidal inputs, however for the latter two diseases host resistance plays an important role due to the high levels offered in some UK wheat varieties. Host resistance to the rust fungi is however subject to change and should be monitored as part of a virulence survey due 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 principles remain the same and in its 50$^{th}$ 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 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 9. 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 five 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 15 and Table 17. 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 2018 the UKCVPS received 134 samples of wheat yellow rust from 18 different counties across the UK (Figure 1).


Figure 1: Map of the UK with the number of samples of wheat yellow rust received in 2018 from the different counties.

Similar to the previous season, disease pressure was more modest compared to that experienced in 2016, partly as a result of the frosts experienced over the winter of 2017/18. No reports were received by the UKCPVS of unexpected varietal performance. In total, samples were received from 49 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

Thirty isolates were selected for further pathotyping (Table 2). The isolates were selected based on their county of origin and the resistance rating of the host. Isolates were assessed for their reactions on a differential set and their reactions, expressed as an average infection type (a.i.t.), were recorded. Isolates were classified as virulent if the a.i.t. score was 2.7 or above. Scores between 2.4 and 2.7 were considered borderline. Using these scores it was possible to combine the scores for reactions to different resistance genes to infer a pathotype for each of the isolates (Table 3). No new virulences to individual genes were detected in the isolates collected in 2018 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 Rendezvous, Warrior, KWS Sterling and Evolution were found at lower frequencies than in previous years. It is unclear at this stage whether these changes are significant. It is possible that this could indicate further changes in pathogen population, however these tests were carried out in new facilities at NIAB and it is possible that there may have been some environmental influence on the results.

#### 4.1.2.1. Virulence frequencies for pathotype groups

Some of the isolates were assigned to different genetic groups using tools developed in the Field Pathogenomics project (Diane Saunders, *pers. comm.*, Table 3). In the cases where this information was missing, the isolates were classed according to the pathotype data only based on results from previous years. Considering the population by genetic group, the frequencies of isolates found in each group was similar to that found in 2017 (Table 5). The Red group almost entirely dominated the surveyed isolates, with only one Purple isolate being found.

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

| 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 |
| 18/001 | Graham | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | * | 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 | 4.0 | 3.2 | 2.0 | 0.4 | 3.0 | 0.2 | 0.0 | 3.0 | 3.5 | 0.2 | 3.0 |
| 18/002 | Reflection | 4.0 | 3.0 | 4.0 | 3.0 | 3.0 | 3.0 | 0.0 | 4.0 | 3.5 | 3.0 | * | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | * | 3.0 | 0.0 | 0.0 | 3.0 | 3.0 | * | 0.0 | 3.5 | 3.5 | 3.0 | 3.5 | 3.0 | 3.0 | 3.5 | 3.0 | 2.0 | * | 3.0 | 2.2 | 0.0 | 4.0 | 3.5 | 0.4 | 3.0 |
| 18/003 | Victo/Vuka | 3.0 | 3.0 | 3.5 | 3.0 | 3.0 | 3.0 | 0.0 | 4.0 | 3.5 | 3.0 | * | 3.0 | 2.6 | 2.6 | 0.0 | 0.0 | * | 3.0 | 0.0 | 0.0 | 3.5 | 3.0 | * | 0.0 | 3.0 | 3.5 | 3.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 2.0 | * | 3.0 | 0.3 | 0.2 | 3.0 | 3.0 | 0.3 | 3.0 |
| 18/004 | Invicta | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | * | 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 | 4.0 | 3.2 | 2.0 | 0.4 | 3.0 | 0.2 | 0.0 | 3.0 | 3.5 | 0.2 | 3.0 |
| 18/006 | Hacksta | 4.0 | 3.0 | 3.0 | 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 | 4.0 | 3.0 | 0.0 | 0.0 | 3.0 | 1.6 | 3.0 | 0.0 | 3.2 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 2.2 | 2.2 | 4.0 | 2.3 | 1.5 | 3.0 | 3.0 | 1.7 | 0.0 |
| 18/009 | Leeds | 0.0 | 1.8 | 3.0 | 3.0 | 1.8 | 3.0 | 0.0 | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | 4.0 | 3.0 | 0.0 | 0.0 | 3.0 | 1.4 | 3.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.5 | 2.1 | 1.1 | 4.0 | 0.0 | 0.0 | 3.0 | 4.0 | 0.0 | 0.5 |
| 18/010 | Brimstone | 4.0 | 3.0 | 4.0 | 3.1 | 2.5 | 3.0 | 0.0 | 3.0 | 4.0 | 3.0 | 4.0 | 3.5 | 3.0 | 3.0 | 0.0 | 0.0 | 4.0 | 3.0 | 0.0 | 0.0 | 3.0 | 2.2 | 3.0 | 0.0 | 3.0 | 3.0 | 3.5 | 3.0 | 3.5 | 3.0 | 4.0 | 3.0 | 2.0 | 2.0 | 4.0 | 2.0 | 1.6 | * | 4.0 | 0.9 | 0.4 |
| 18/011 | Spyder | 3.0 | 3.0 | 3.5 | 3.0 | 3.0 | 4.0 | * | 4.0 | 3.0 | 3.0 | 4.0 | * | 3.0 | 3.0 | 0.0 | 0.0 | 3.0 | 3.0 | 0.0 | 0.0 | 3.5 | 3.0 | 3.0 | 0.0 | 3.0 | 4.0 | 4.0 | 4.0 | 3.0 | 3.0 | 4.0 | 3.0 | 1.8 | 2.7 | 4.0 | 0.3 | 0.0 | 3.0 | 3.0 | 0.4 | * |
| 18/014 | LG Rhythm | 3.0 | 3.0 | 3.2 | 3.4 | 3.0 | 3.0 | 0.0 | 4.0 | 3.0 | 3.0 | 4.0 | 4.0 | 2.7 | 3.0 | 0.5 | 0.0 | 4.0 | 3.0 | 0.0 | 0.0 | 3.4 | 3.0 | 4.0 | 0.0 | 4.0 | 3.5 | 3.5 | 3.2 | 3.2 | 3.2 | 4.0 | 3.0 | 3.0 | 1.6 | 3.0 | 2.9 | 0.3 | 3.0 | 3.0 | 0.1 | 0.3 |
| 18/022 | Dunston | 3.5 | 3.1 | 3.9 | 3.8 | 3.0 | 3.0 | 0.0 | 3.0 | 3.5 | 3.5 | 3.5 | 3.0 | 3.0 | 2.2 | 0.0 | 0.0 | 3.0 | 3.0 | 0.0 | 0.0 | 3.0 | 2.8 | 3.0 | 0.0 | 3.5 | 3.2 | 3.5 | 3.0 | 3.5 | 3.0 | 4.0 | 3.0 | 2.5 | 1.4 | 3.0 | 3.0 | 0.0 | 3.0 | 3.3 | 0.0 | 0.6 |
| 18/026 | Zulu | * | 3.0 | 3.0 | 3.0 | 3.0 | 3.5 | 0.0 | 4.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 0.0 | 0.0 | * | 3.0 | 0.0 | 0.0 | 3.0 | 2.0 | 3.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.2 | 3.0 | 3.0 | 4.0 | 3.1 | 2.6 | 2.1 | 4.0 | 2.6 | 0.0 | * | 4.0 | 0.0 | 2.0 |
| 18/030 | Revelation | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 0.0 | 0.0 | 4.0 | 3.0 | 0.0 | 0.0 | 3.0 | 2.5 | 3.0 | 0.0 | 3.0 | 3.5 | 3.5 | 3.2 | 3.5 | 3.0 | 4.0 | 3.1 | 3.0 | 2.1 | 4.0 | 2.3 | 0.0 | 4.0 | 4.0 | 0.3 | 0.3 |
| 18/032 | JB Diego | 4.0 | 3.0 | 4.0 | 3.0 | 2.8 | 3.0 | 0.0 | 4.0 | 3.3 | 3.0 | 3.0 | 3.1 | 3.0 | 3.0 | 0.0 | 0.0 | 4.0 | 3.0 | 0.0 | 0.0 | 3.0 | 2.1 | 3.0 | 0.0 | 3.0 | 4.0 | 3.5 | 3.0 | 3.0 | 3.0 | 4.0 | 3.5 | 2.0 | 2.0 | 3.0 | 0.0 | 0.0 | * | 3.0 | 2.0 | 0.5 |
| 18/041 | Freiston | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.2 | 0.0 | 4.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 0.0 | 0.0 | 4.0 | 3.0 | 0.0 | 0.0 | 3.0 | 2.1 | 3.0 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.0 | 3.0 | 4.0 | 3.5 | 2.8 | 2.0 | 4.0 | 1.7 | 0.0 | * | 3.0 | 0.5 | 0.4 |
| 18/048 | JB Diego | 4.0 | 3.0 | 3.5 | 4.0 | 3.0 | 3.0 | 0.0 | 4.0 | 3.0 | 3.0 | 3.0 | 3.5 | 3.0 | 3.0 | 0.0 | 0.0 | 4.0 | 3.2 | 0.0 | 0.0 | 3.0 | 3.0 | 3.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.8 | 2.9 | 4.0 | 2.1 | 0.0 | 3.0 | 3.0 | 2.0 | 0.6 |
| 18/056 | Skyfall | 3.0 | 3.5 | 3.0 | 3.0 | 3.0 | 3.5 | * | 3.5 | 4.0 | 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 | * | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.5 | 3.0 | 1.5 | 2.1 | 4.0 | 0.3 | 0.0 | 3.0 | 3.0 | 0.0 | 3.0 |
| 18/061 | Buster | 3.0 | 3.5 | 3.0 | 3.0 | 3.0 | 4.0 | * | 4.0 | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | 2.8 | 0.0 | 0.0 | * | 3.0 | 0.0 | 0.0 | 3.0 | 3.0 | 3.0 | * | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.8 | 1.9 | 2.9 | 3.0 | 0.3 | 0.0 | 3.0 | 3.8 | 0.0 | 3.0 |
| 18/064 | Beluga | 4.0 | 3.0 | 3.1 | 3.1 | 3.0 | 3.5 | 0.0 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | 4.0 | 3.0 | 0.0 | 0.0 | 3.0 | 2.0 | 3.0 | 0.0 | 3.0 | 4.0 | * | 4.0 | 3.0 | 3.0 | 4.0 | 3.7 | 2.0 | 1.1 | 4.0 | 2.0 | 0.0 | 4.0 | 3.5 | 0.0 | 0.2 |
| 18/065 | JB Diego | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | 3.0 | 3.0 | 0.0 | 0.0 | 3.0 | 2.0 | 3.0 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.0 | 3.0 | 4.0 | 4.0 | 2.9 | 2.1 | 4.0 | 0.0 | 0.0 | 3.0 | 3.0 | 0.0 | 0.3 |
| 18/066 | RGT Universe | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 0.0 | 0.0 | 4.0 | 3.0 | 0.0 | 0.0 | 3.0 | 3.0 | 3.0 | 0.0 | 3.2 | 3.0 | 4.0 | 3.0 | 3.5 | 3.0 | 3.0 | 3.0 | 2.3 | 2.1 | 4.0 | 2.2 | 0.0 | 3.5 | 4.0 | 0.0 | 0.0 |
| 18/085 | Gleam | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | 3.0 | 3.0 | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | * | 3.0 | 0.0 | 0.0 | 3.5 | 3.0 | 3.0 | 0.0 | 3.0 | 3.5 | 3.0 | 3.5 | 3.0 | 3.0 | 4.0 | 3.5 | 2.5 | 1.7 | 4.0 | 1.7 | 0.0 | * | 3.0 | 0.2 | 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 |
| 18/102 | Zulu | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.4 | 2.8 | 0.0 | 0.0 | 4.0 | 3.0 | 0.0 | 0.0 | 3.0 | 3.0 | 3.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.5 | 2.2 | 0.4 | 4.0 | 2.2 | 0.0 | 3.0 | 3.0 | 0.5 | 0.0 |
| 18/104 | Shabras | 3.0 | 3.0 | 4.0 | 3.5 | 3.0 | 3.5 | * | 4.0 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 0.0 | 0.0 | 3.0 | 3.0 | 0.0 | 0.0 | 4.0 | 3.0 | 3.0 | 0.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 4.0 | 3.8 | 1.8 | 2.6 | 3.0 | 0.1 | 0.0 | 3.0 | 3.0 | 0.0 | 3.0 |
| 18/115 | LG Rhythm | 3.5 | 3.0 | 3.5 | 4.0 | 3.0 | 4.0 | * | 3.5 | 4.0 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 0.0 | 0.0 | * | 3.0 | 0.0 | 0.0 | 3.0 | 3.0 | 3.0 | 0.0 | 3.0 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 4.0 | 3.0 | 1.7 | 2.0 | 4.0 | 1.0 | 1.0 | 4.0 | 3.0 | 0.0 | 3.0 |
| 18/118 | Bennington | 3.0 | 3.5 | 4.0 | 4.0 | 3.0 | 3.5 | * | 4.0 | 3.5 | 3.5 | 3.0 | 4.0 | 3.0 | 3.0 | 0.0 | 0.0 | 3.0 | 3.0 | 0.0 | 0.0 | 3.5 | 3.0 | 3.0 | 0.0 | 3.5 | 3.0 | 4.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.5 | 2.4 | 0.7 | 3.0 | 0.2 | 0.0 | 3.0 | 3.5 | 0.0 | 3.0 |
| 18/125 | Zulu | 4.0 | 3.0 | 3.0 | 3.0 | 2.1 | 3.0 | 0.0 | 4.0 | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | 2.2 | 0.0 | 0.0 | 4.0 | 3.0 | 0.0 | 0.0 | 3.0 | 2.1 | 3.0 | 0.0 | 4.0 | 3.5 | 3.3 | 3.2 | 3.5 | 3.0 | 4.0 | 3.5 | 2.0 | 2.0 | 3.5 | 2.6 | 0.0 | 4.0 | 3.5 | 0.2 | 0.6 |
| 18/126 | Gleam | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 | * | 4.0 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.8 | 0.0 | 0.0 | * | 3.0 | 0.0 | 0.0 | 3.0 | 3.0 | 3.0 | 0.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 4.0 | 3.1 | 1.8 | 1.0 | 3.0 | 0.8 | 0.0 | 3.0 | 3.0 | 0.1 | 2.7 |
| 18/127 | KWS Zyatt | 3.0 | 3.3 | 3.0 | 3.1 | 2.0 | 3.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | 4.0 | 3.0 | 0.0 | 0.0 | 4.0 | 3.0 | 4.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.8 | 3.0 | 3.0 | 2.0 | 0.0 | 4.0 | 3.0 | 2.2 | 0.0 |
| 18/132 | Robigus | 4.0 | 4.0 | 4.0 | 4.0 | 3.0 | 3.0 | 0.0 | 4.0 | 3.2 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 0.0 | 0.0 | 3.5 | 3.0 | 0.0 | 0.0 | 3.0 | 2.8 | 3.0 | 0.0 | 3.0 | 3.1 | 3.3 | 3.5 | 3.0 | 3.0 | 4.0 | 3.0 | 2.0 | 0.6 | 3.0 | 2.1 | 0.0 | 3.0 | 3.0 | 2.0 | 2.0 |
| 18/133 | Moro | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | 3.1 | 3.5 | 3.0 | * | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | * | 3.1 | 0.0 | 0.0 | 3.0 | 3.0 | 3.0 | 0.0 | 3.0 | 3.1 | 3.0 | 3.2 | 3.0 | 3.0 | 3.5 | 3.2 | 2.0 | 3.0 | 3.0 | 0.0 | 0.0 | 3.0 | 3.2 | 0.0 | 3.0 |

Table 3: Pathotypes of the 2018 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 |
| 18/001 | Graham | (Red) | 27 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | | | Ap | | Ev |
| 18/002 | Reflection | (Red) | 27 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | * | | Ap | | Ev |
| 18/003 | Victo/Vuka | Red | 60 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | (Ca) | * | | (Ap) | | Ev |
| 18/004 | Invicta | (Red) | 27 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | | | Ap | | Ev |
| 18/006 | Hacksta | Red | 3 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | | Sp | Ro | So | | Ca | | | Ap | | |
| 18/009 | Leeds | Purple | 5 | | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | | Sp | Ro | So | | Ca | | | Ap | | |
| 18/010 | Brimstone | (Red) | 3 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | | Sp | Ro | So | | Ca | | | Ap | | |
| 18/011 | Spyder | (Red) | 11 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | St | | Ap | | |
| 18/014 | LG Rhythm | (Red) | 23 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | Wa | Ca | | | Ap | | |
| 18/022 | Dunston | (Red) | 21 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | (Wa) | Ca | | | | | |
| 18/026 | Zulu | (Red) | 3 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | | Sp | Ro | So | (Wa) | Ca | | | Ap | | |
| 18/030 | Revelation | Red | 47 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | (Re) | Sp | Ro | So | Wa | Ca | | | | | |
| 18/032 | JB Diego | (Red) | 3 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | | Sp | Ro | So | | Ca | | | Ap | | |
| 18/041 | Freiston | Red | 43 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | | Sp | Ro | So | Wa | Ca | | | Ap | | |
| 18/048 | JB Diego | Red | 26 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | Wa | Ca | St | | Ap | | |
| 18/056 | Skyfall | (Red) | 27 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | | | Ap | | Ev |
| 18/061 | Buster | (Red) | 28 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | St | | Ap | | Ev |
| 18/064 | Beluga | (Red) | 3 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | | Sp | Ro | So | | Ca | | | Ap | | |
| 18/065 | JB Diego | (Red) | 43 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | | Sp | Ro | So | Wa | Ca | | | Ap | | |
| 18/066 | RGT Universe | (Red) | 21 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | | | | | |
| 18/085 | Gleam | (Red) | 27 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | (Wa) | Ca | | | Ap | | Ev |
| 18/102 | Zulu | * | * | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | | | | Ap | | |
| 18/104 | Shabras | (Red) | 27 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | (St) | | Ap | | Ev |
| 18/115 | LG Rhythm | (Red) | 27 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | | | Ap | | Ev |
| 18/118 | Bennington | (Red) | 27 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | (Wa) | Ca | | | Ap | | Ev |
| 18/125 | Zulu | Red | 8 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | | Sp | Ro | So | | Ca | | | | | |
| 18/126 | Gleam | Red | 27 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | | | Ap | | Ev |
| 18/127 | KWS Zyatt | (Red) | 24 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | Wa | Ca | St | | Ap | | |
| 18/132 | Robigus | Red | 5 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | | | Ap | | |
| 18/133 | Moro | Red | 28 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | St | | Ap | | Ev |

[1] Genetic group assigned using data from Diane Saunders, John Innes Centre. Only a limited number of samples were tested in this season, other groups are assigned in parentheses based on pathotype data only.
[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 | | | | |
|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 |
| *Yr1* | 100 | 100 | 100 | 96 | 97 |
| *Yr2* | 100 | 97 | 100 | 100 | 100 |
| *Yr3* | 96 | 100 | 100 | 100 | 100 |
| *Yr4* | 96 | 97 | 100 | 100 | 100 |
| *Yr5* | 0 | 0 | 0 | 0 | 0 |
| *Yr6* | 100 | 100 | 100 | 100 | 100 |
| *Yr7* | 92 | 76 | 89 | 100 | 100 |
| *Yr8* | 4 | 3 | 3 | 4 | 0 |
| *Yr9* | 100 | 100 | 100 | 100 | 100 |
| *Yr10* | 0 | 0 | 0 | 0 | 0 |
| *Yr15* | 0 | 0 | 0 | 0 | 0 |
| *Yr17* | 100 | 97 | 100 | 100 | 100 |
| *Yr24* | 0 | 0 | 0 | 0 | 0 |
| *Yr25* | 100 | 100 | 97 | 100 | 100 |
| *Yr32* | 100 | 100 | 100 | 100 | 100 |
| Rendezvous | 12 | 38 | 87 | 96 | 67 |
| Spaldings Prolific | 88 | 72 | 82 | 96 | 100 |
| Robigus | 100 | 100 | 100 | 100 | 100 |
| Solstice | 85 | 90 | 100 | 100 | 100 |
| Warrior | 23 | 3 | 37 | 46 | 20 |
| Cadenza | 73 | 55 | 76 | 96 | 93 |
| KWS Sterling | 8 | 24 | 32 | 89 | 17 |
| Kranich | 4 | 7 | 8 | 7 | 0 |
| Apache | 65 | 52 | 55 | 96 | 83 |
| Crusoe | 0 | 0 | 5 | 7 | 0 |
| Evolution | * | * | 16 | 75 | 43 |
| **Total Number of Isolates** | **26** | **29** | **38** | **28** | **30** |

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

| Pathotype Group* | Frequency of Isolates Found (%) | | | | |
|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 |
| Pink | 19 | 3 | 8 | 0 | 0 |
| Blue | 8 | 28 | 29 | 3 | 0 |
| Red | 69 | 66 | 63 | 93 | 93 |
| Purple | 4 | 3 | 0 | 0 | 3 |
| Other | 0 | 0 | 0 | 4 | 4 |
| **Number of isolates** | **26** | **29** | **46** | **28** | **30** |

* Due to the limited number of isolates that were genotyped this year, this grouping is based on a mixture of genotype and pathotype groups.

#### 4.1.2.2. Commonly detected isolates

In 2018 there were 14 different pathotypes detected (Table 3), three of which were unique to this year. This contrasts with the 2017 results where 9 pathotypes were identified. Out of the 14 pathotypes detected this year, there were two pathotypes that dominated.

The most common group of isolates, represented by 9 isolates, was the group Red 27. This group carried virulence for *Yr 1,2,3,4,6,7,9,17,25,32,Re,Sp,Ro,So,Ca,Ap,Ev* and was detected for the first time in 2017. The isolates of this group were collected from the varieties Graham, Reflection, Invicta, Skyfall, Gleam, Shabras, LG Rhythm, Bennington and Britannia. The isolates were collected from a wide area of the UK in Devon, Norfolk, Lincolnshire, Warwickshire, Herefordshire, Leicestershire and East Lothian.

The second most common group of isolates was Red 23, which carry virulence for *Yr1,2,3,4,6,7,9,17,25,32,Sp,Ro,So,Ca,Ap* and was identified in five samples. This group has been identified every year since 2013 so it is unsurprising to identify these isolates now. The isolates from this group were collected from the varieties Hacksta, Brimstone, Zulu, JB Diego and Beluga and came from Cambridgeshire, Oxfordshire, Shropshire, Suffolk and Angus.

There was one other isolate identified in 2018 that was particularly interesting to the UKCPVS. The isolate was 18/009, was identified as being from the Purple group and had virulence for *Yr 2,3,4,6,7,9,17,25,32,Sp,Ro,So,Ca,Ap*. This group has historically had isolates from the old Kranich group. The economic importance of these new isolates is to be confirmed, the first step being the varietal seedling and adult plant tests reported in 4.1.3.

### 4.1.3. Variety testing of isolates from 2018

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 30 tested isolates choosing isolates with the most complex virulence profiles where possible. The isolate 18/009 was selected as the only isolate from the Purple group this year and the isolates 18/003, 18/030 and 18/065 were all selected as novel pathotypes for this year.

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 |
| 18/002 | Reflection | (Red) | 27 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | Ca | * | | Ap | | Ev |
| 18/003 | Victo/Vuka | Red | 60 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | Re | Sp | Ro | So | | (Ca) | * | | (Ap) | | Ev |
| 18/009 | Leeds | Purple | 5 | | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | | Sp | Ro | So | | Ca | | | Ap | | |
| 18/030 | Revelation | Red | 47 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | (Re) | Sp | Ro | So | Wa | Ca | | | | | |
| 18/065 | JB Diego | (Red) | 43 | 1 | 2 | 3 | 4 | | 6 | 7 | | 9 | | | 17 | | 25 | 32 | | Sp | Ro | So | Wa | Ca | | | Ap | | |

#### 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 2019. Results are combined with the adult plant test results (Table 7) and are sorted by the reaction on the adult plant trials (see 4.1.3.2). In general, there was good agreement between the control differentials included in this test and the original differential test results (Table 8). Some variation was seen in the "supplementary" differentials. These are differentials that are included as they carry currently uncharacterised resistance genes. For example, the reaction on the variety Warrior was 2.0 in the original differential test for isolate 18/002 and 2.8 in the seedling variety test, moving it from an avirulent reaction, to a virulent reaction. The reasons for these discrepancies are unclear, although it is possible that despite our best efforts, some of the isolates are mixtures at the differential test stage. Following subsequent rounds of multiplication it's possible that one or more of the isolates are more heavily selected for, hence the differences. As in previous years, the three RL varieties Costello, KWS Crispin and KWS Siskin were resistant to all isolates tested, along with KWS Jackal, KWS Parkin, RGT Saki and Theodore. 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 Cougar, Crusoe, Evolution, KWS Extase and LG Detroit. Virulence for Crusoe was first detected in 2013 and continues to be detected in occasional isolates. This has not translated into a susceptible response at the adult plant stage for this variety. The isolate 18/002 had a noticeably wider virulence profile on this extended variety set, with virulence for 50 out of the 64 varieties tested. This included some of the rare virulences for varieties such as KWS Extase and Crusoe. The impact of this was investigated in the adult plant trials using the same isolates.

#### 4.1.3.2. Adult plant tests

Alongside the seedling tests, the five isolates were also evaluated in the UKCPVS adult plant trials at NIAB in the summer of 2019 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 22$^{nd}$ May and the first assessment was made on 15$^{th}$ 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 moderate in the trials this year despite being inoculated five times. As in 2018, hot and dry

weather is likely to have impacted on the disease levels this year, although levels were higher than in 2018. In combination with results from the control varieties included in the trials, the results suggested that the trials were generally infected with the correct races. The trials produced lower levels of disease in comparison with other inoculated yellow rust trials due to the delayed epidemic as a result of the new method used. As expected, the susceptible controls Reflection and Robigus produced the highest levels of disease with up to 42.5% as an average of the percentage leaf area infected assessments.

Out of the 42 RL varieties and candidates under evaluation, 29 were resistant to all isolates tested. It is worth noting that some of the known susceptible RL varieties and controls were resistant in these trials, which is inconsistent with reports from other parts of the country. For example, more disease would have been expected on the varieties Leeds, Skyfall and Torch. It is surprising that these varieties have lower levels of disease given the higher levels seen in other control plots. One explanation may be that some low levels of natural infection managed to get established in the Robigus and Reflection plots early in the season. Samples were taken from all of the trials once the disease was established and these were tested on the standard differential set (Table 8). These tests showed some disagreement with original differential tests, suggesting that there may have been some natural infection in the trial. A new method was implemented in the 2017 field season to eliminate natural infection as much as possible. This involved applying fungicides throughout the spring and stopping when the final leaf 2 emerged. The first year of this method was very successful but in 2018 this was less effective due to the hot weather conditions. This led to no disease developing in the trials. In this field season close attention was paid to the development of the crops and the weather forecast. In this scenario it appears that the fungicide programme may not have been robust enough and further optimisation of this method is required.

During the 2019 field season, the UKCPVS received many reports of higher than expected levels of disease in some varieties. The most commonly reported varieties were KWS Zyatt and Dunston. In these adult plant trials, these two varieties were noticeably more susceptible in the trial inoculated with 18/002. Although it is not absolutely clear whether it was this isolate that caused the disease in this trial, samples and isolates collected will be used as part of the National and Recommended List trials. This will help to understand this potential race change alongside the differential tests that are due to be carried out on other samples collected this season.

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) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18/002 | 18/003 | 18/009 | 18/030 | 18/065 | 18/002 | 18/003 | 18/009 | 18/030 | 18/065 |
| Apache | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Costello | 8.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Crusoe | 8.9 | 2.8 | 1.8 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Elicit | 8.8 | 3.0 | 3.0 | 3.0 | 3.0 | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Graham | 8.3 | 3.0 | 2.9 | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| KWS Crispin | 8.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| KWS Extase | 8.6 | 3.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| KWS Jackal | 8.7 | 2.2 | 1.9 | 0.8 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| KWS Parkin | Candidate | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| KWS Siskin | 8.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| LG Detroit | 8.7 | 3.0 | 2.1 | 0.5 | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| LG Motown | 8.8 | 2.4 | 2.9 | 3.0 | 2.3 | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| LGW110 | | * | * | * | * | * | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Rendezvous | | 3.0 | 2.0 | 3.0 | 2.9 | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| RGT Saki | Candidate | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Stratosphere | | 3.0 | 2.8 | 3.0 | 3.0 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Theodore | Candidate | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Elation | 8.6 | 3.0 | 2.2 | 3.0 | 3.0 | 2.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| LG Sundance | 8.7 | 2.9 | 2.0 | 3.0 | 3.0 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SY Insitor | Candidate | 2.7 | 2.9 | 3.0 | 3.0 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Ambition | | 3.0 | 3.0 | 2.5 | 2.9 | 3.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Kranich | | 3.0 | 2.3 | 2.1 | 2.9 | 2.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| LG Skyscraper | 7.9 | 3.0 | 2.8 | 3.0 | 3.0 | 1.9 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 |
| Revelation | 8.7 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 |
| RGT Illustrious | 8.8 | 1.9 | 1.9 | 1.3 | 0.9 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Warrior | | 2.8 | 2.1 | 2.2 | 2.2 | 3.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |

| Variety | Current RL Rating | Seedling (Average Infection Type) | | | | | Adult Plant (% leaf area infected) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18/002 | 18/003 | 18/009 | 18/030 | 18/065 | 18/002 | 18/003 | 18/009 | 18/030 | 18/065 |
| KWS Firefly | 8.7 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| LG Rhythm | Candidate | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.1 | 0.0 | 0.1 | 0.1 | 0.2 |
| Shabras | 7.4 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.2 |
| Leeds | 6.4 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 |
| Torch | | 3.0 | 3.0 | 3.0 | 3.0 | 3.5 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 |
| Cougar | | 2.0 | 1.7 | 0.3 | 1.4 | 2.5 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| KWS Barrel | 8.5 | 2.5 | 2.4 | 2.9 | 3.0 | 2.7 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| KWS Sterling | | 3.0 | 1.8 | 1.7 | 0.7 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 |
| Gleam | 6.9 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.3 | 0.0 | 0.7 | 0.2 | 0.1 |
| KWS Lili | 7.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.3 | 0.6 | 0.1 | 0.8 | 0.3 |
| Skyfall | 5.4 | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 | 0.7 | 0.1 | 0.1 | 0.2 | 0.3 |
| RGT Gravity | 8.4 | 3.0 | 0.1 | 2.9 | 2.4 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Viscount | 6.5 | 3.0 | 3.0 | 3.0 | 0.0 | 3.0 | 1.0 | 0.1 | 0.5 | 0.5 | 0.6 |
| KWS Basset | 8.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 3.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Delphi | | 3.0 | 3.0 | 3.5 | 3.0 | 3.0 | 3.2 | 0.0 | 0.2 | 0.3 | 0.2 |
| LG Spotlight | 8.2 | 4.0 | 3.0 | 3.0 | 3.0 | 3.9 | 3.9 | 0.0 | 0.0 | 0.1 | 0.0 |
| Elysium | Candidate | 3.0 | 3.0 | 4.0 | 3.2 | 4.0 | 4.8 | 0.0 | 0.0 | 0.1 | 0.1 |
| KWS Zyatt | 7.5 | 3.0 | 2.6 | 2.9 | 3.0 | 3.0 | 5.0 | 0.0 | 0.1 | 0.8 | 0.1 |
| RGT Wasabi | Candidate | 3.0 | 3.0 | 4.0 | 4.0 | 4.0 | 6.7 | 0.0 | 0.0 | 0.2 | 0.1 |
| KWS Kerrin | 7.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 7.1 | 0.0 | 0.0 | 1.5 | 0.1 |
| RGT Blossom | Candidate | 3.0 | 2.2 | 2.9 | 3.0 | 2.4 | 9.2 | 0.0 | 0.0 | 0.1 | 0.0 |
| KWS Santiago | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 14.0 | 0.0 | 0.0 | 0.1 | 0.0 |
| KWS Kinetic | Candidate | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 32.2 | 0.0 | 0.1 | 0.1 | 0.1 |
| RGT Lantern | Candidate | 3.0 | 2.7 | 4.0 | 3.5 | 3.0 | 2.6 | 0.2 | 0.3 | 4.7 | 0.4 |
| Cadenza | | 3.0 | 2.9 | 3.0 | 3.0 | 2.9 | 2.8 | 0.0 | 0.1 | 2.0 | 0.9 |
| Dunston | 7.3 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 8.3 | 0.0 | 0.1 | 4.7 | 0.2 |
| Hobbit | | 3.0 | 3.0 | 4.0 | 3.0 | 3.5 | 3.4 | 0.6 | 1.2 | 11.0 | 3.1 |
| LG Graduate | Candidate | 3.5 | 4.0 | 4.0 | 3.2 | 4.0 | 6.3 | 0.5 | 0.9 | 2.2 | 9.7 |
| Cordiale | | 3.0 | 2.7 | 3.0 | 3.0 | 3.0 | 6.9 | 0.3 | 1.6 | 6.4 | 4.3 |

| Variety | Current RL Rating | Seedling (Average Infection Type) | | | | | Adult Plant (% leaf area infected) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18/002 | 18/003 | 18/009 | 18/030 | 18/065 | 18/002 | 18/003 | 18/009 | 18/030 | 18/065 |
| Bennington | 6.1 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 12.3 | 0.5 | 7.3 | 12.2 | 10.2 |
| KWS Gator | | 3.0 | 2.9 | 3.0 | 3.0 | 3.0 | 6.1 | 6.0 | 6.8 | 9.8 | 2.9 |
| Zulu | 4.7 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 15.0 | 5.8 | 21.2 | 18.0 | 19.3 |
| Claire | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 18.8 | 7.6 | 14.5 | 21.0 | 33.8 |
| Robigus | | 4.0 | 3.0 | 3.0 | 4.0 | 3.0 | 22.5 | 35.0 | 27.5 | 37.5 | 33.8 |
| Solstice | | 3.0 | 2.9 | 3.0 | 3.0 | 3.0 | 25.2 | 13.3 | 12.0 | 22.7 | 15.2 |
| Britannia | | 3.0 | 3.0 | 4.0 | 3.0 | 4.0 | 29.7 | 7.0 | 13.8 | 20.7 | 17.7 |
| Robigus | | * | * | * | * | * | 38.0 | 16.7 | 23.3 | 30.8 | 31.0 |
| Reflection | | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 38.8 | 42.5 | 29.8 | 43.3 | 38.0 |
| Avocet S | | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | * | * | * | * | * |
| Avocet Sp | | 3.0 | 2.5 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Avocet Yr1 | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Avocet Yr15 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | * | * | * | * | * |
| Avocet Yr17 | | 3.0 | 3.0 | 4.0 | 3.0 | 3.5 | * | * | * | * | * |
| Avocet Yr24 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | * | * | * | * | * |
| Avocet Yr27 | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Avocet Yr32 | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Avocet Yr5 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | * | * | * | * | * |
| Avocet Yr6 | | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Avocet Yr7 | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Avocet Yr8 | | 2.1 | 2.9 | 0.0 | 0.2 | 0.2 | * | * | * | * | * |
| Avocet Yr9 | | 3.0 | 3.1 | 3.0 | 3.0 | 3.3 | * | * | * | * | * |
| Carstens V | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Chinese 166 | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Clement | | 3.5 | 3.1 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Compair | | 1.0 | 0.0 | 0.0 | 0.0 | 0.3 | * | * | * | * | * |
| Evolution | | 1.7 | 2.3 | 2.2 | 1.8 | 3.0 | * | * | * | * | * |
| Heines Kolben | | 3.0 | 2.9 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Heines Peko | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |

| Variety | Current RL Rating | Seedling (Average Infection Type) | | | | | Adult Plant (% leaf area infected) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18/002 | 18/003 | 18/009 | 18/030 | 18/065 | 18/002 | 18/003 | 18/009 | 18/030 | 18/065 |
| Heines VII | | 3.0 | 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 | * | * | * | * | * |
| Lee | | 3.0 | 3.2 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Moro | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | * | * | * | * | * |
| Opata | | 3.0 | 2.0 | 3.0 | 3.0 | 2.9 | * | * | * | * | * |
| Spaldings Prolific | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Strubes Dickkopf | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Suwon Omar | | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Vilmorin 23 | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| VPM1 | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Vuka | | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| **Mean** | | | | | | | **5.2** | **2.1** | **2.5** | **3.9** | **3.5** |
| **LSD** | | | | | | | **8.1** | **3.9** | **9.0** | **5.8** | **7.8** |

Table 8 Comparison between initial differential test results, variety seedling test results and re-isolations from samples taken from variety adult plant trials for the isolates used in the 2019 variety tests and trials. [1] Diff = Differential test result, [2] Re-Is = Re-isolation results from adult plant trials, [3]Seed = Variety seedling test result, * = missing data

| Differential | 18/002 | | | 18/003 | | | 18/009 | | | 18/030 | | | 18/065 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diff[1] | Re-Is[2] | Seed[3] | Diff | Re-Is | Seed | Diff | Re-Is | Seed | Diff | Re-Is | Seed | Diff | Re-Is | Seed |
| Avocet Yr1 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.2 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Chinese 166 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.2 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Kalyansona | 4.0 | 3.0 | 3.0 | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Vilmorin 23 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Hybrid 46 | 3.0 | * | 3.0 | 3.0 | * | 3.0 | 1.8 | * | 3.0 | 3.0 | * | 3.0 | 3.0 | * | 3.0 |
| Suwon Omar | 3.0 | 3.0 | 3.5 | 3.0 | 3.2 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.5 | 3.0 |
| Avocet Yr5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Avocet Yr6 | 4.0 | 3.0 | 3.5 | 4.0 | 3.1 | 3.0 | 3.5 | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.5 | 3.0 |
| Heines Kolben | 3.5 | 3.0 | 3.0 | 3.5 | 3.0 | 2.9 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Heines Peko | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Avocet Yr7 | * | 3.0 | 3.0 | * | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Lee | 3.0 | 3.0 | 3.0 | 3.0 | 3.5 | 3.2 | 3.0 | 3.2 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Avocet Yr8 | 0.0 | 0.0 | 2.1 | 0.0 | 0.0 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 |
| Compair | 0.0 | 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 | 0.3 |
| Avocet Yr9 | * | 3.0 | 3.0 | * | 4.0 | 3.1 | 4.0 | 3.0 | 3.0 | 4.0 | 4.0 | 3.0 | 3.0 | 3.5 | 3.3 |
| Clement | 3.0 | 3.0 | 3.5 | 3.0 | 3.0 | 3.1 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Moro | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Avocet Yr15 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| VPM 1 | 3.0 | 3.0 | 3.0 | 3.5 | 3.1 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Avocet Yr17 | * | 4.0 | 3.0 | * | 3.5 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.5 |
| Avocet Yr24 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Heines VII | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 |
| Strubes Dickkopf | 3.5 | 3.0 | 3.0 | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.5 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 |
| Avocet Yr32 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.5 | 3.0 | 3.5 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 |
| Carstens V | 3.5 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.2 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 |
| Rendezvous | 3.0 | 2.1 | 3.0 | 3.0 | 2.2 | 2.0 | 1.4 | 2.1 | 3.0 | 2.5 | 2.5 | 2.9 | 2.0 | 2.0 | 2.8 |
| Avocet Sp | 3.0 | 3.0 | 3.0 | 4.0 | 3.1 | 2.5 | 3.0 | 3.0 | 3.0 | 3.5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Spaldings Prolific | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 |

| Differential | 18/002 | | | 18/003 | | | 18/009 | | | 18/030 | | | 18/065 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diff | Re-Iso | Seed | Diff | Re-Iso | Seed | Diff | Re-Iso | Seed | Diff | Re-Iso | Seed | Diff | Re-Iso | Seed |
| Robigus | 3.5 | * | 4.0 | 4.0 | 3.0 | 3.0 | 4.0 | 3.1 | 3.0 | 4.0 | 3.5 | 4.0 | 4.0 | 4.0 | 3.0 |
| Solstice | 3.0 | 3.0 | 3.0 | 4.0 | 3.0 | 2.9 | 3.5 | 3.1 | 3.0 | 3.1 | 3.1 | 3.0 | 4.0 | 3.0 | 3.0 |
| Warrior | 2.0 | 3.0 | 2.8 | 2.0 | 3.0 | 2.1 | 2.1 | 2.7 | 2.2 | 3.0 | 3.0 | 2.2 | 2.9 | 3.0 | 3.0 |
| Cadenza | 3.0 | 2.7 | 3.0 | 2.6 | 2.6 | 2.9 | 3.0 | 2.8 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 |
| KWS Sterling | * | 3.0 | 3.0 | * | 1.7 | 1.8 | 1.1 | 1.5 | 1.7 | 2.1 | 2.5 | 0.7 | 2.1 | 3.0 | 0.0 |
| Kranich | 0.4 | 2.4 | 3.0 | 0.3 | 0.3 | 2.3 | 0.0 | 0.3 | 2.1 | 0.3 | 0.3 | 2.9 | 0.0 | 0.2 | 2.3 |
| Apache | 3.0 | 2.4 | 3.0 | 2.6 | 2.9 | 3.0 | 3.0 | 2.5 | 3.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Crusoe | 0.0 | 0.0 | 2.8 | 0.2 | 0.0 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| Evolution | 3.0 | 2.4 | 1.7 | 3.0 | 0.2 | 2.3 | 0.5 | 0.6 | 2.2 | 0.3 | 0.1 | 1.8 | 0.3 | 0.6 | 3.0 |

## 4.2. Wheat brown rust

### 4.2.1. Samples received

In 2018, the UKCPVS received 55 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 2018 from the different counties.

The full sample register is provided in Appendix 1. Samples were received from 32 different varieties, with the most frequent variety being KWS Siskin. There no unexpected outbreaks of brown rust on established varieties. The host varieties in the sample register have not all been confirmed and it is entirely possible that a sample listed as coming from a resistant variety may turn out to be another more susceptible variety. For this reason the sample register is included as an indicator of what was received but should not be used to infer any breakdowns in resistance or changes in rating at this stage.

### 4.2.2. Pathotyping of isolates

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

Thirty one isolates were selected for further pathotyping (Table 9). 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 10). This was the third 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). No new virulences were detected. The frequency of detection of virulence for the *Lr* genes monitored remained stable and were at similar levels to 2017 (Table 11). 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 2018 there were 24 different pathotypes detected in the 31 isolates tested, most 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.*)

### 4.2.1. Variety testing of isolates from 2018

Five isolates from the 31 tested isolates were selected for further testing on the wider set of RL varieties and candidates (Table 12) and were selected to best represent the diversity of the isolates tested.

Table 9: Average infection type (a.i.t.) scores for the selected isolates against the UKCPVS differential set. Yellow shading indicates a compatible reaction; orange shading indicates a borderline reaction. Compatible interactions classify the isolate as virulent against a particular resistance gene or variety.

| Isolate | 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) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18/001 | KWS Siskin | 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 | 3.0 | 0.3 | 2.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/002 | Jaidor | 1.0 | 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 | 0.3 | 2.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/009 | Moulton | 3.0 | 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 | 2.0 | 0.3 | 2.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/011 | Graham | 2.0 | 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 | 0.6 | 2.0 | 0.1 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/012 | Cougar | 2.0 | 2.0 | 2.1 | 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 | 0.2 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/014 | KWS Firefly | 3.0 | 2.0 | 1.0 | 2.0 | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 2.0 | 0.6 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/015 | Freiston | 3.0 | 1.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 0.6 | 2.0 | 1.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/016 | KWS Kerrin | 3.0 | 0.0 | 1.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 0.3 | 1.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/019 | KWS Trinity | 3.0 | 1.0 | 2.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 1.5 | 2.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/021 | Spyder | 3.0 | 1.0 | 1.0 | 1.0 | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 0.6 | 1.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/022 | RGT Illustrious | 3.0 | 1.0 | 1.0 | 3.0 | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.1 | 0.7 | 1.0 | 0.2 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/026 | Bennington | 3.0 | 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 | 0.3 | 1.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/028 | SY Medea | 3.0 | 2.0 | 2.0 | 3.0 | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 0.0 | 1.0 | 0.2 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/029 | Elicit | 3.0 | 1.0 | 1.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 2.0 | 3.0 | 0.2 | 1.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/030 | Buster | 3.0 | 1.0 | 2.0 | 3.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 1.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/032 | Dunston | 3.0 | 0.0 | 0.0 | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 2.0 | 2.0 | 0.2 | 1.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/033 | KWS Lili | 3.0 | 0.0 | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 0.6 | 1.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/034 | LG Sundance | 3.0 | 0.0 | 1.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 3.0 | 0.6 | 1.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/035 | Skyfall | 3.0 | 1.0 | 1.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 0.6 | 1.0 | 0.5 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |

| Isolate | 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) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18/036 | KWS Barrel | 3.0 | 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 | 3.0 | 1.2 | 1.1 | 0.2 | 3.0 | 3.0 | 3.0 | 3.0 | 0.6 |
| 18/038 | KWS Zyatt | 3.0 | 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 | 3.0 | 0.0 | 1.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/039 | Revelation | 3.0 | 0.0 | 0.4 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 0.6 | 1.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/041 | KWS Santiago | 3.0 | 0.1 | 1.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 1.6 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 1.8 |
| 18/042 | Robigus | 3.0 | 0.1 | 1.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 1.6 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 1.8 |
| 18/043 | Robigus | 1.0 | 2.0 | 2.0 | 3.0 | 1.0 | 1.1 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 1.2 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| 18/045 | LG Motown | 3.0 | 0.0 | 1.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 2.0 | 0.3 | 1.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/046 | Evolution | 3.0 | 0.0 | 0.0 | 1.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 0.3 | 0.2 | 0.4 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/048 | KWS Firefly | 3.0 | 1.0 | 1.0 | 1.0 | 2.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 2.0 | 1.0 | 0.3 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| 18/049 | Costello | 3.0 | 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 | 3.0 | 0.9 | 1.0 | 1.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.3 |
| 18/051 | Crusoe | 2.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 1.2 | 0.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |
| 18/055 | Hereford | 3.0 | 0.0 | 1.0 | 2.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 3.0 | 0.6 | 1.0 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 | 0.0 |

Table 10: Pathotypes of the 2018 *Puccinia triticina* isolates based on the differential test results in Table 9. 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 |
| 18/001 | KWS Siskin | | | | 2c | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | 23 | | 26 | | 37 | 17b | | Cr |
| 18/002 | Jaidor | (1) | | | 2c | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/009 | Moulton | 1 | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/011 | Graham | | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | 23 | | 26 | | 37 | 17b | | Cr |
| 18/012 | Cougar | (1) | | | 2c | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/014 | KWS Firefly | 1 | | | | | | | 10 | 13 | 14a | 15 | 16 | 17 | | | | 26 | (28) | 37 | 17b | | Cr |
| 18/015 | Freiston | 1 | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/016 | KWS Kerrin | 1 | | | | (3a) | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/019 | KWS Trinity | 1 | | | | 3a | 3bg | | 10 | 13 | 14a | 15 | 16 | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/021 | Spyder | 1 | | | | (3a) | | | 10 | 13 | 14a | 15 | | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/022 | RGT Illustrious | 1 | | | 2c | | | | 10 | 13 | 14a | 15 | 16 | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/026 | Bennington | 1 | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/028 | SY Medea | 1 | | | 2c | (3a) | | | 10 | 13 | 14a | 15 | | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/029 | Elicit | 1 | | | 2c | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | | 23 | | 26 | | 37 | 17b | | Cr |
| 18/030 | Buster | 1 | | | 2c | (3a) | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | | (24) | 26 | | 37 | 17b | | Cr |
| 18/032 | Dunston | 1 | | | | | | 3ka | 10 | 13 | 14a | 15 | | 17 | | | | 26 | | 37 | 17b | | Cr |
| 18/033 | KWS Lili | 1 | | | | (3a) | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/034 | LG Sundance | 1 | | | | | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | 23 | | 26 | | 37 | 17b | | Cr |
| 18/035 | Skyfall | 1 | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | | 23 | | 26 | | 37 | 17b | | Cr |
| 18/036 | KWS Barrel | 1 | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | 23 | | 26 | | 37 | 17b | | Cr |
| 18/038 | KWS Zyatt | 1 | | | | (3a) | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | 23 | | 26 | | 37 | 17b | | Cr |
| 18/039 | Revelation | 1 | | | | (3a) | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/041 | KWS Santiago | 1 | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | 23 | | 26 | (28) | 37 | 17b | | Cr |
| 18/042 | Robigus | 1 | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | 23 | | 26 | (28) | 37 | 17b | | Cr |
| 18/043 | Robigus | | | | 2c | | | | 10 | 13 | 14a | 15 | 16 | 17 | | 23 | | 26 | 28 | 37 | 17b | Ro | Cr |
| 18/045 | LG Motown | 1 | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | (20) | | | 26 | | 37 | 17b | | Cr |
| 18/046 | Evolution | 1 | | | | | | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/048 | KWS Firefly | 1 | | | | | | | 10 | 13 | 14a | 15 | 16 | 17 | | | | 26 | 28 | 37 | 17b | Ro | Cr |

| 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 |
| 18/049 | Costello | 1 | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | 23 | | 26 | | 37 | 17b | | Cr |
| 18/051 | Crusoe | | | | | (3a) | | | 10 | 13 | 14a | 15 | | 17 | 20 | | | 26 | | 37 | 17b | | Cr |
| 18/055 | Hereford | 1 | | | | | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | 23 | | 26 | | 37 | 17b | | Cr |

Table 11: 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** | | | | |
|---|---|---|---|---|---|
| | **2014** | **2015** | **2016** | **2017** | **2018** |
| *Lr1* | 61 | 39 | 29 | 68 | 81 |
| *Lr2a* | * | * | 0 | 0 | 0 |
| *Lr2b* | * | * | 0 | 16 | 0 |
| *Lr2c* | * | * | 6 | 48 | 26 |
| *Lr3a* | 61 | 52 | 26 | 87 | 48 |
| *Lr3bg* | * | * | 19 | 81 | 71 |
| *Lr3ka* | * | * | 29 | 77 | 74 |
| *Lr10* | * | * | 29 | 87 | 100 |
| *Lr13* | * | * | 32 | 84 | 100 |
| *Lr14a* | * | * | 29 | 87 | 100 |
| *Lr15* | * | * | 16 | 84 | 100 |
| *Lr16* | * | * | 13 | 58 | 52 |
| *Lr17* | * | * | 23 | 87 | 100 |
| *Lr17b* | 68 | 55 | 81 | 55 | 100 |
| *Lr20* | 77 | 65 | 10 | 87 | 77 |
| *Lr23* | * | * | 6 | 45 | 39 |
| *Lr24* | 16 | 3 | 3 | 3 | 0 |
| *Lr26* | 71 | 52 | 0 | 58 | 100 |
| *Lr28* | 10 | 6 | 0 | 0 | 6 |
| *Lr37* | 65 | 45 | 39 | 74 | 100 |
| Robigus | 10 | 6 | 0 | 0 | 6 |
| Crusoe | 74 | 42 | 71 | 77 | 100 |
| **Total Number of Isolates** | **25** | **26** | **25** | **27** | **31** |

Table 12: 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 |
| 18/001 | KWS Siskin | | | | 2c | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | 23 | | (26) | | 37 | 17b | | Cr |
| 18/011 | Graham | | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | 23 | | (26) | | 37 | 17b | | Cr |
| 18/030 | Buster | 1 | | | 2c | (3a) | 3bg | 3ka | 10 | 13 | 14a | 15 | | 17 | 20 | | (24) | (26) | | 37 | 17b | | Cr |
| 18/038 | KWS Zyatt | 1 | | | | (3a) | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | 23 | | (26) | | 37 | 17b | | Cr |
| 18/041 | KWS Santiago | 1 | | | | 3a | 3bg | 3ka | 10 | 13 | 14a | 15 | 16 | 17 | 20 | 23 | | (26) | (28) | 37 | 17b | | Cr |

#### 4.2.1.1. 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 2019. Results are combined with the adult plant test results (Table 13) and are sorted by the reaction on the adult plant trials (see 4.2.1.2). Similar to previous years, only four of the RL varieties and candidates tested were resistant to all of the isolates tested (five in 2018). Virulence for LG Motown and LG Rhythm was detected for the first time this year. A general agreement was seen when these results were compared with those of the initial differential test, however some discrepancies were seen (Table 14). The most commonly found discrepancies were found in the differentials Thatcher *Lr23* and Thatcher *Lr26* and this is similar to what has been seen in previous years. For this reason, Clement was included as an additional differential for *Lr26* and this seemed to have better agreement across the tests. Further purification methods have now been used by the UKCPVS to solve the problem of multiple isolates in a sample. Discrepancies seen now are most likely due to environmental issues.

#### 4.2.1.2. 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 2019 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. The trials were inoculated for the first time on the 15th May and were inoculated seven times. The first assessment was made on 25th June when the plants were at GS73. The percentage of leaf area infected was assessed and the mean was calculated from three assessments. Disease levels were higher in the trials this year compared to last year. Similar to last year, dry conditions during the inoculation and assessment period may have impacted on the amount of disease established in the trials. Susceptible control Buster showed variable amounts of disease across the five trials, with the highest score being 25.67%. The highest levels of disease were generally recorded in the current variety Crusoe. Samples were taken from the trials to confirm that isolates used to inoculate the trial were present (Table 14). Tests on these isolates showed some disagreement with original differential tests, suggesting that there may have been some natural infection in the trial. As discussed above, the new method for keeping out natural infection may need some further refinement. It is clear from the results however that the isolates used to inoculate the trial were not the only ones present in the trial and specific variety x isolate interactions are difficult.

Out of the 42 RL varieties and candidates under evaluation, only 5 were resistant to all isolates tested. There was a good range of disease across all of the varieties, and this reflects the range of resistance ratings currently seen in the Recommended List. During the 2019 field season, the UKCPVS received reports of higher than expected levels of disease in the variety KWS Firefly. In these adult plant trials, this variety was noticeably more susceptible in the trial inoculated with 18/030, 18/038 and 18/041. Although it is not absolutely clear whether it was these isolates that caused the disease in these trials, samples and isolates collected will be used as part of the National and Recommended List trials. This will help to understand this potential race change alongside the differential tests that are due to be carried out on other samples collected this season.

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

| Variety | Current RL Rating | Seedling (Average Infection Type) | | | | | Adult Plant (% leaf area infected) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18/001 | 18/011 | 18/030 | 18/038 | 18/041 | 18/001 | 18/011 | 18/030 | 18/038 | 18/041 |
| Theodore | C | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.5 |
| KWS Target | | 0.0 | 0.3 | 0.0 | 0.5 | 3.0 | 0.2 | 1.0 | 0.9 | 0.0 | 0.0 |
| Stigg | | 0.3 | 0.5 | 0.0 | 1.5 | 0.9 | 0.2 | 0.0 | 3.6 | 0.2 | 0.0 |
| Leeds | 7 | 0.0 | 0.0 | 0.0 | 0.6 | 3.0 | 0.2 | 0.4 | 2.2 | 0.4 | 0.7 |
| Robigus | | 0.0 | 0.1 | 0.0 | 0.5 | 3.0 | 0.4 | 1.3 | 1.9 | 0.3 | 0.8 |
| Warrior | | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 0.2 | 2.0 | 0.1 | 0.0 |
| Maris Ranger | | * | * | * | * | * | 0.5 | 0.7 | 1.3 | 0.0 | 0.2 |
| RGT Saki | C | 0.0 | 0.0 | 0.0 | 1.4 | 2.0 | 0.8 | 2.8 | 2.0 | 2.3 | 2.2 |
| Viscount | 9 | 0.0 | 0.0 | 0.0 | 0.6 | 2.0 | 0.9 | 1.4 | 2.5 | 3.0 | 1.2 |
| Skyfall | 8 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.4 | 2.8 | 1.5 | 1.0 | 1.2 |
| Elysium | C | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.5 | 2.0 | 3.9 | 3.3 | 2.2 |
| LG Graduate | C | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 1.7 | 3.3 | 1.2 | 4.7 |
| Sterna | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 6.4 | 1.7 | 0.9 | 1.8 | 3.0 |
| Revelation | 8 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 1.6 | 2.0 | 4.2 | 2.7 | 3.8 |
| RGT Illustrious | 6 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.4 | 2.0 | 6.7 | 5.6 | 5.9 |
| KWS Firefly | 8 | 0.1 | 0.1 | 0.0 | 0.3 | 2.0 | 3.3 | 3.0 | 4.4 | 5.0 | 4.0 |
| Gamin | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.5 | 5.0 | 3.0 | 4.9 | 5.5 |
| RGT Wasabi | C | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 4.5 | 5.0 | 2.9 | 4.2 |
| Zulu | 7 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 4.8 | 4.8 | 5.7 | 4.0 |
| KWS Kerrin | 7 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.8 | 4.0 | 5.4 | 4.7 | 4.0 |
| Maris Halberd | | 3.0 | 3.0 | 3.0 | 2.0 | 2.0 | 4.5 | 2.8 | 6.4 | 8.3 | 4.7 |
| KWS Extase | 7 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.4 | 4.4 | 3.7 | 6.9 | 2.9 |
| LG Spotlight | 6 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.1 | 5.0 | 6.4 | 6.2 | 4.2 |
| LG Skyscraper | 5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.9 | 6.2 | 6.7 | 6.0 | 6.7 |
| Maris Fundin | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 5.4 | 4.2 | 5.8 | 7.2 | 7.0 |
| Armada | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 7.2 | 4.7 | 6.5 | 6.5 | 7.6 |
| Elicit | 7 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.3 | 4.0 | 4.5 | 5.0 | 7.9 |

| Variety | Current RL Rating | Seedling (Average Infection Type) | | | | | Adult Plant (% leaf area infected) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18/001 | 18/011 | 18/030 | 18/038 | 18/041 | 18/001 | 18/011 | 18/030 | 18/038 | 18/041 |
| RGT Lantern | C | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.6 | 4.8 | 4.5 | 4.4 | 13.0 |
| RGT Gravity | 6 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 5.5 | 6.3 | 6.7 | 5.7 | 8.9 |
| Bennington | 7 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 5.6 | 7.2 | 8.5 | 7.0 | 4.4 |
| LG Motown | 7 | 0.0 | 2.0 | 3.0 | 3.0 | 3.0 | 4.8 | 9.2 | 7.0 | 6.0 | 5.9 |
| KWS Basset | 5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.0 | 4.7 | 4.2 | 10.2 | 7.7 |
| KWS Jackal | 5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.7 | 5.4 | 3.8 | 7.3 | 8.8 |
| Reaper | | * | * | * | * | * | 6.2 | 5.5 | 5.9 | 9.9 | 11.5 |
| KWS Crispin | 5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 6.5 | 3.7 | 4.7 | 10.0 | 7.7 |
| KWS Zyatt | 6 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 6.4 | 5.4 | 11.4 | 11.2 | 9.2 |
| KWS Santiago | | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 6.5 | 7.2 | 9.5 | 11.7 | 10.5 |
| SY Insitor | C | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 7.1 | 7.3 | 7.1 | 10.3 | 7.3 |
| Graham | 6 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 5.5 | 8.8 | 8.2 | 5.0 | 9.4 |
| Tuxedo | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 4.4 | 10.2 | 13.5 | 9.6 | 6.8 |
| LG Rhythm | | 0.2 | 2.0 | 3.0 | 3.0 | 3.0 | 6.6 | 7.9 | 9.8 | 10.4 | 7.5 |
| Soissons | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 6.7 | 7.4 | 10.8 | 8.2 | 10.9 |
| Gleam | 6 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 6.7 | 8.7 | 8.8 | 10.5 | 9.8 |
| KWS Parkin | C | 0.1 | 2.0 | 2.0 | 3.0 | 3.0 | 7.1 | 12.5 | 14.5 | 17.2 | 12.7 |
| Sappo | | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 8.3 | 4.2 | 11.4 | 7.4 | 9.0 |
| Consort | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 11.0 | 7.2 | 8.5 | 11.0 | 12.8 |
| LG Sundance | 6 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 13.1 | 6.3 | 8.3 | 9.8 | 10.9 |
| Maris Huntsman | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 10.3 | 6.7 | 14.5 | 13.5 | 12.1 |
| KWS Sterling | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 14.4 | 8.9 | 5.6 | 11.4 | 11.8 |
| Glasgow | | 0.3 | 2.0 | 3.0 | 3.0 | 3.0 | 14.3 | 14.4 | 15.8 | 5.0 | 11.2 |
| Dunston | 6 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 7.5 | 7.8 | 8.2 | 10.8 | 5.2 |
| Shabras | 5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 8.2 | 8.4 | 8.4 | 8.0 | 5.2 |
| KWS Siskin | 5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 13.6 | 8.2 | 8.9 | 10.3 | 6.4 |
| KWS Kinetic | C | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 8.8 | 12.5 | 12.6 | 9.2 | 9.9 |
| KWS Barrel | 5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 10.1 | 10.4 | 11.5 | 8.5 | 11.9 |
| LG Detroit | 5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 11.0 | 9.8 | 10.9 | 10.1 | 14.3 |
| Costello | 5 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 11.7 | 13.5 | 9.7 | 8.8 | 11.8 |
| Elation | 6 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 12.5 | 13.7 | 10.1 | 11.8 | 9.7 |

| Variety | Current RL Rating | Seedling (Average Infection Type) | | | | | Adult Plant (% leaf area infected) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 18/001 | 18/011 | 18/030 | 18/038 | 18/041 | 18/001 | 18/011 | 18/030 | 18/038 | 18/041 |
| Mascot | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 7.3 | 9.4 | 11.7 | 15.9 | 13.9 |
| RGT Blossom | C | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 10.6 | 13.0 | 8.9 | 16.1 | 13.4 |
| Avalon | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 17.3 | 8.6 | 18.2 | 11.7 | 13.6 |
| KWS Lili | 4 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 20.7 | 14.9 | 18.5 | 13.7 | 12.1 |
| Buster | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 25.7 | 15.5 | 16.0 | 22.0 | 21.5 |
| Crusoe | 3 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 34.2 | 27.0 | 35.0 | 29.2 | 24.8 |
| Thatcher Lr1 | | 2.0 | 1.1 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Thatcher Lr2a | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | * | * | * | * | * |
| Thatcher Lr2b | | 2.0 | 2.0 | 2.0 | 1.0 | 1.0 | * | * | * | * | * |
| Thatcher Lr2c | | 3.0 | 3.0 | 3.0 | 2.0 | 2.0 | * | * | * | * | * |
| 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 | 3.0 | * | * | * | * | * |
| Thatcher Lr16 | | 3.0 | 2.0 | 2.0 | 3.0 | 2.0 | * | * | * | * | * |
| 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 | 2.0 | 2.0 | 2.0 | * | * | * | * | * |
| Thatcher Lr24 | | 0.9 | 1.5 | 2.2 | 1.2 | 0.9 | * | * | * | * | * |
| Thatcher Lr26 | | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | * | * | * | * | * |
| Thatcher Lr28 | | 0.4 | 0.0 | 0.0 | 0.2 | 3.0 | * | * | * | * | * |
| Thatcher Lr37 | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| Clement | | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | * | * | * | * | * |
| **Mean** | | * | * | * | * | * | **6.9** | **6.5** | **7.7** | **7.7** | **7.5** |
| **LSD** | | * | * | * | * | * | **4.3** | **4.6** | **4.1** | **4.5** | **3.5** |

Table 14: 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 2019 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 | 18/001 | | | 18/011 | | | 18/030 | | | 18/038 | | | 18/041 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 |
| Clement | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Crusoe | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Glasgow | 0.3 | 0.6 | 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 |
| Maris Fundin | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Maris Halberd | 3.0 | * | 2.0 | 3.0 | * | 2.0 | 3.0 | * | 0.4 | 2.0 | * | 2.0 | 2.0 | * | 2.0 |
| Robigus | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 2.0 | 0.0 | 0.0 | 2.0 | 0.5 | 0.0 | 2.0 | 3.0 | 1.8 | 1.0 |
| Sappo | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 2.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 |
| Sterna | 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 | 3.0 |
| Stigg | 0.3 | 0.0 | 0.9 | 0.5 | 0.0 | 2.0 | 0.0 | 0.0 | 0.9 | 1.5 | 0.0 | 0.7 | 0.9 | 0.0 | 0.9 |
| Warrior | 0.0 | 0.0 | 3.0 | 0.0 | 0.0 | 3.0 | 0.0 | 0.0 | 3.0 | 0.0 | 0.0 | 3.0 | 0.1 | 0.0 | 3.0 |
| Thatcher Lr1 | 2.0 | 1.0 | 3.0 | 1.1 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Thatcher Lr2a | 1.0 | 2.0 | 3.0 | 1.0 | 2.0 | 3.0 | 1.0 | 1.0 | 3.0 | 1.0 | 1.0 | 3.0 | 1.0 | 0.1 | 3.0 |
| Thatcher Lr2b | 2.0 | 2.0 | 3.0 | 2.0 | 2.0 | 3.0 | 2.0 | 2.0 | 3.0 | 1.0 | 1.0 | 3.0 | 1.0 | 1.0 | 3.0 |
| Thatcher Lr2c | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 2.0 | 3.0 | 2.0 | 2.0 | 3.0 |
| Thatcher Lr3a | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 2.5 | 3.0 | 3.0 | 3.0 | 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 | 3.0 | 3.0 | 3.0 | 3.0 |
| Thatcher Lr3ka | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 1.2 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 |
| Thatcher Lr10 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 |
| Thatcher Lr13 | 3.0 | 3.0 | 1.8 | 3.0 | 3.0 | 1.5 | 3.0 | 3.0 | 1.2 | 3.0 | 3.0 | 0.6 | 3.0 | 3.0 | 0.0 |
| Thatcher Lr14a | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.7 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Thatcher Lr15 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Thatcher Lr16 | 3.0 | 3.0 | 1.0 | 2.0 | 2.0 | 0.0 | 2.0 | 2.0 | 0.2 | 3.0 | 3.0 | 1.0 | 2.0 | 3.0 | 0.0 |
| Thatcher Lr17 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 1.0 | 3.0 | 3.0 | 1.0 | 3.0 | 3.0 | 1.0 | 3.0 | 3.0 | 1.0 |
| Thatcher Lr20 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 |
| Thatcher Lr23 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 2.0 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 |

| Differential | 18/001 | | | 18/011 | | | 18/030 | | | 18/038 | | | 18/041 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diff[1] | Seed[2] | Re-ls[3] | Diff[1] | Seed[2] | Re-ls[3] | Diff[1] | Seed[2] | Re-ls[3] | Diff[1] | Seed[2] | Re-ls[3] | Diff[1] | Seed[2] | Re-ls[3] |
| Thatcher Lr24 | 0.9 | 0.3 | 3.0 | 1.5 | 0.6 | 3.0 | 2.2 | 3.0 | 3.0 | 1.2 | 0.0 | 3.0 | 0.9 | 1.6 | 3.0 |
| Thatcher Lr26 | 3.0 | 2.0 | 3.0 | 3.0 | 2.0 | 3.0 | 2.0 | 1.0 | 3.0 | 3.0 | 1.0 | 3.0 | 3.0 | 2.0 | 3.0 |
| Thatcher Lr28 | 0.4 | 0.0 | 3.0 | 0.0 | 0.1 | 3.0 | 0.0 | 0.0 | 3.0 | 0.2 | 0.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| Thatcher Lr37 | 3.0 | 3.0 | 0.4 | 3.0 | 3.0 | 2.0 | 3.0 | 3.0 | 1.0 | 3.0 | 3.0 | 0.0 | 3.0 | 3.0 | 0.2 |

## 4.3. Wheat powdery mildew

### 4.3.1. Samples received

Levels of wheat powdery mildew were more modest in 2018 and the UKCPVS received 36 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 2018 from the different counties.

### 4.3.2. Pathotyping of isolates

From the 35 samples, multiple isolates were obtained, and 27 were pathotyped using a differential set (Table 15). Virulence was seen for most of the differentials tested, with avirulence seen only for Amigo and Shamrock. Virulence frequencies for most of the differentials remained in line with previous years (Table 16). The frequency of Maris Dove, Tonic, Broom, Warrior, Stigg and Crusoe virulences increased compared to last year, whilst

Table 15: 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* | *MId* | *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 |
| 18/02/02 | Skyfall | 4.0 | 3.5 | 0.8 | 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 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| 18/06/01 | KWS Zyatt | 4.0 | 4.0 | 0.5 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 0.3 | 0.3 | 4.0 | 1.3 | 1.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| 18/07/03 | KWS Trinity | 4.0 | 4.0 | 3.0 | 4.0 | 3.5 | 4.0 | 4.0 | 3.8 | 3.8 | 4.0 | 4.0 | 4.0 | 0.0 | 0.0 | 4.0 | 0.0 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| 18/08/01 | RGT Illustrious | 4.0 | 4.0 | 2.8 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 2.5 | 1.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| 18/08/02 | RGT Illustrious | 4.0 | 4.0 | 1.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.8 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 0.5 | 0.3 | 4.0 | 4.0 | 4.0 | 4.0 |
| 18/08/03 | RGT Illustrious | 4.0 | 4.0 | 0.3 | 4.0 | 3.0 | 4.0 | 0.3 | 4.0 | 4.0 | 4.0 | 0.0 | 0.3 | 3.5 | 3.3 | 0.0 | 0.0 | 0.0 | 4.0 | 0.0 | 0.0 | 0.0 |
| 18/09/02 | KWS Lili | 4.0 | 4.0 | 1.0 | 4.0 | 0.8 | 3.8 | 3.8 | 3.5 | 3.5 | 3.3 | 4.0 | 4.0 | 0.0 | 0.0 | 4.0 | 0.5 | 0.5 | 3.8 | 3.8 | 4.0 | 3.8 |
| 18/09/03 | KWS Lili | 4.0 | 4.0 | 0.0 | 3.8 | 4.0 | 4.0 | 4.0 | 3.8 | 4.0 | 3.5 | 4.0 | 4.0 | 0.0 | 0.0 | 4.0 | 0.0 | 0.0 | 4.0 | 4.0 | 4.0 | 3.8 |
| 18/10/03 | KWS Barrel | 4.0 | 4.0 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.3 | 4.0 | 4.0 | 4.0 | 0.0 | 0.0 | 4.0 | 0.0 | 0.8 | 4.0 | 3.8 | 4.0 | 4.0 |
| 18/12/01 | KWS Siskin | 3.5 | 3.5 | 0.0 | 4.0 | 3.8 | 3.8 | 4.0 | 3.5 | 4.0 | 4.0 | 4.0 | 4.0 | 0.0 | 0.0 | 2.3 | 0.0 | 1.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| 18/12/03 | KWS Siskin | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.3 | 0.0 | 0.0 | 3.0 | 0.0 | 0.3 | 3.0 | 3.0 | 3.0 | 3.0 |
| 18/16/01 | LG Rhythm | 4.0 | 4.0 | 2.5 | 4.0 | 4.0 | 3.3 | 3.8 | 3.5 | 4.0 | 3.5 | 3.8 | 3.8 | 0.0 | 0.0 | 4.0 | 0.3 | 0.0 | 4.0 | 4.0 | 3.5 | 4.0 |
| 18/18/02 | KWS Santiago | 4.0 | 3.8 | 1.5 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.0 | 4.0 | 4.0 | 0.8 | 0.8 | 3.0 | 0.0 | 0.0 | 4.0 | 4.0 | 3.8 | 3.5 |
| 18/19/01 | Dunston | 3.0 | 3.3 | 1.0 | 2.8 | 0.0 | 2.5 | 3.0 | 3.0 | 3.3 | 1.5 | 3.0 | 3.0 | 0.0 | 0.3 | 2.8 | 0.3 | 1.3 | 0.5 | 0.0 | 0.0 | 2.8 |
| 18/23/02 | Leeds | 3.8 | 3.3 | 0.5 | 4.0 | 3.5 | 4.0 | 4.0 | 3.3 | 3.3 | 3.0 | 3.8 | 3.5 | 0.0 | 0.3 | 0.0 | 0.5 | 0.3 | 4.0 | 4.0 | 3.8 | 4.0 |
| 18/24/02 | SY Medea | 3.0 | 3.0 | 0.0 | 3.3 | 0.0 | 2.3 | 0.8 | 4.0 | 3.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.3 | 0.3 | 0.0 |

| 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 |
| 18/24/03 | SY Medea | 4.0 | 4.0 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.8 | 4.0 | 4.0 | 4.0 | 0.0 | 0.0 | 4.0 | 0.0 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| 18/25/01 | Skyfall | 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 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| 18/25/02 | Skyfall | 3.5 | 3.8 | 0.0 | 4.0 | 3.5 | 3.3 | 3.8 | 3.8 | 3.3 | 3.5 | 3.0 | 3.5 | 0.0 | 0.0 | 3.8 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 4.0 |
| 18/26/01 | LG Rhythm | 4.0 | 3.8 | 0.3 | 3.8 | 4.0 | 4.0 | 4.0 | 3.8 | 3.3 | 3.5 | 4.0 | 4.0 | 0.0 | 0.3 | 4.0 | 0.0 | 0.5 | 4.0 | 4.0 | 3.8 | 4.0 |
| 18/26/03 | LG Rhythm | 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 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| 18/35/02 | KWS W308 | 4.0 | 4.0 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.8 | 4.0 | 3.5 | 3.8 | 4.0 | 0.0 | 0.3 | 3.5 | 0.0 | 0.8 | 4.0 | 4.0 | 4.0 | 4.0 |
| 18/39/01 | Hardwicke | 4.0 | 4.0 | 0.3 | 4.0 | 4.0 | 4.0 | 4.0 | 3.5 | 4.0 | 4.0 | 4.0 | 4.0 | 0.0 | 0.0 | 4.0 | 0.0 | 0.5 | 3.8 | 4.0 | 3.5 | 4.0 |
| 18/39/02 | Hardwicke | 4.0 | 4.0 | 1.0 | 4.0 | 1.8 | 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 |
| 18/40/01 | Dunston | 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 | 0.8 | 1.8 | 0.0 | 0.0 | 0.0 | 4.0 |
| 18/41/01 | Basset | 3.5 | 4.0 | 3.3 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.5 | 3.8 | 3.3 | 4.0 | 0.3 | 1.0 | 4.0 | 0.0 | 0.5 | 4.0 | 4.0 | 4.0 | 4.0 |
| 18/42/02 | Freiston | 3.5 | 3.3 | 0.5 | 3.3 | 2.3 | 3.3 | 3.0 | 3.8 | 3.8 | 3.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 0.0 | 0.8 | 3.5 | 0.0 | 0.0 | 3.3 |

Table 16: 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 | | | | |
|---|---|---|---|---|---|---|
| | | 2014 | 2015 | 2016 | 2017 | 2018 |
| Galahad | *Pm2* | 72 | 71 | 88 | 100 | 100 |
| Chul | *Pm3b* | 20 | 14 | 8 | 20 | 15 |
| Armada | *Pm4b* | 84 | 64 | 84 | 100 | 96 |
| Flanders | *Pm5* | 76 | 71 | 76 | 84 | 81 |
| Brimstone | *Pm6* | 80 | 64 | 88 | 96 | 93 |
| Clement | *Pm8* | 44 | 50 | 88 | 84 | 93 |
| Maris dove | *Mld* | 60 | 64 | 64 | 68 | 100 |
| Brock | *Pm2,MlTa2* | 88 | 71 | 84 | 96 | 100 |
| Mercia | *Pm5, MlTa2* | 80 | 79 | 80 | 100 | 93 |
| Tonic | *MlTo* | 24 | 14 | 28 | 64 | 85 |
| Broom | *Pm3d* | 20 | 14 | 28 | 60 | 85 |
| Sicco | *Pm5, MlSi2* | 8 | 0 | 8 | 40 | 11 |
| Wembley | *MlSo* | 8 | 0 | 4 | 44 | 11 |
| Axona | *MlAx* | 12 | 14 | 32 | 60 | 78 |
| Amigo | *Pm17* | 0 | 7 | 0 | 8 | 0 |
| Shamrock | *MlSh* | 4 | 0 | 0 | 0 | 0 |
| Robigus | MlRo | 64 | 64 | 56 | 72 | 85 |
| Warrior | | 8 | 0 | 8 | 16 | 74 |
| Stigg | | 8 | 0 | 4 | 16 | 74 |
| Crusoe | | 36 | 36 | 72 | 68 | 93 |
| **Total Number of Isolates Tested** | | **43** | **25** | **14** | **25** | **27** |

the frequency of virulence for Sicco and Wembley decreased to levels more in line with 2016 and before. From the 27 isolates tested, 12 different pathotypes were identified, 8 of which were unique to 2018. 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, modest levels of barley powdery mildew were observed in 2018. Growers, trial managers and agronomists provided 27 samples from 14 varieties across nine counties (Figure 4).


Figure 4: Map of the UK with the number of samples of barley powdery mildew received in 2018 from the different counties.

### 4.4.2. Pathotyping of isolates

From the samples received and collected, 29 isolates were obtained and characterised using a differential set (Table 17). Virulence for most of the differentials was detected and was broadly in line with frequencies observed in previous years (Table 18). Exceptions were seen for differentials such as Lofa, H.1063 and Porter. The UKCPVS received no reports of unexpected outbreaks of barley powdery mildew during 2018 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 17: 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 | 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 | Propino |
| 18-1-1 | Craft | 3.8 | 4.0 | 4.0 | 3.5 | 3.5 | 3.5 | 1.8 | 1.5 | 3.0 | 2.5 | 3.0 | 1.3 | 3.5 | 0.0 | 2.0 | 0.3 | 0.0 | 2.8 | 3.3 | 0.0 | 1.5 |
| 18-1-3 | Craft | 4.0 | 4.0 | 4.0 | 4.0 | 2.8 | 3.0 | 2.0 | 1.0 | 2.5 | 1.0 | 2.0 | 0.3 | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 0.3 | 4.0 | 0.0 | 0.0 |
| 18-2-2 | Coref | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.0 | 4.0 | 3.3 | 2.5 | 2.8 | 1.8 | 4.0 | 0.0 | 2.3 | 0.0 | 0.0 | 3.3 | 4.0 | 2.0 | 4.0 |
| 18-2-3 | Coref | 3.5 | 4.0 | 3.3 | 3.0 | 3.0 | 3.0 | 2.3 | 3.3 | 3.3 | 1.8 | 2.8 | 0.8 | 0.0 | 0.0 | 0.3 | 0.3 | 0.0 | 2.0 | 3.8 | 1.5 | 3.3 |
| 18-3-3 | Belmont | 4.0 | 4.0 | 4.0 | 3.3 | 4.0 | 4.0 | 3.0 | 4.0 | 1.3 | 2.0 | 3.5 | 1.3 | 3.5 | 0.0 | 2.0 | 0.5 | 0.0 | 3.3 | 4.0 | 2.3 | 3.8 |
| 18-4-2 | Amistar | 3.8 | 4.0 | 3.8 | 3.3 | 3.8 | 3.3 | 2.0 | 1.5 | 1.0 | 3.0 | 2.8 | 1.3 | 0.0 | 0.0 | 2.5 | 0.0 | 0.0 | 1.0 | 4.0 | 0.3 | 0.0 |
| 18-4-4 | Amistar | 3.3 | 4.0 | 3.5 | 3.3 | 2.8 | 3.0 | 2.5 | 2.8 | 1.0 | 1.0 | 2.0 | 0.3 | 3.5 | 0.0 | 1.8 | 0.0 | 0.0 | 3.3 | 3.0 | 0.8 | 3.0 |
| 18-5-1 | Unknown | 3.5 | 4.0 | 3.3 | 0.0 | 0.0 | 3.0 | 3.0 | 3.8 | 1.0 | 3.3 | 2.5 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 3.8 | 0.8 | 0.0 |
| 18-5-2 | Unknown | 3.0 | 4.0 | 3.5 | 3.3 | 3.0 | 3.3 | 3.3 | 3.5 | 1.0 | 1.5 | 3.0 | 0.3 | 4.0 | 0.0 | 2.0 | 0.0 | 0.0 | 3.0 | 3.0 | 2.0 | 3.3 |
| 18-6-2 | Unknown | 3.5 | 3.8 | 3.5 | 3.3 | 3.3 | 3.0 | 2.0 | 3.0 | 2.5 | 2.8 | 3.0 | 1.3 | 4.0 | 4.0 | 2.8 | 0.5 | 0.0 | 2.5 | 3.8 | 1.3 | 3.0 |
| 18-7-1 | SY Venture | 3.8 | 3.8 | 3.8 | 0.0 | 0.0 | 3.0 | 2.3 | 4.0 | 1.0 | 1.0 | 1.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.0 | 4.0 | 2.0 | 2.0 |
| 18-7-2 | SY Venture | 3.5 | 3.8 | 3.3 | 1.0 | 1.0 | 3.0 | 1.8 | 3.3 | 1.0 | 1.0 | 1.3 | 0.0 | 0.8 | 0.0 | 0.3 | 0.0 | 0.0 | 3.0 | 3.5 | 1.5 | 2.0 |
| 18-8-1 | KWS Orwell | 4.0 | 4.0 | 3.8 | 3.8 | 3.8 | 4.0 | 2.5 | 4.0 | 4.0 | 2.0 | 3.5 | 1.5 | 0.0 | 0.0 | 2.3 | 0.8 | 0.0 | 4.0 | 4.0 | 2.5 | 4.0 |
| 18-9-3 | KWS Infinity | 4.0 | 3.8 | 3.0 | 3.5 | 3.3 | 3.3 | 2.5 | 4.0 | 1.0 | 2.0 | 3.8 | 0.8 | 3.5 | 0.8 | 1.8 | 0.0 | 0.0 | 3.0 | 3.0 | 2.3 | 3.5 |
| 18-10-1 | LG Mountain | 3.5 | 4.0 | 3.0 | 3.0 | 3.0 | 3.0 | 1.5 | 3.0 | 2.8 | 2.8 | 2.5 | 1.8 | 3.8 | 0.0 | 2.3 | 1.5 | 0.0 | 3.0 | 3.8 | 1.3 | 2.0 |
| 18-10-2 | LG Mountain | 3.3 | 4.0 | 3.3 | 0.0 | 0.0 | 2.8 | 1.8 | 2.0 | 1.0 | 1.8 | 0.0 | 1.0 | 3.3 | 0.0 | 0.0 | 0.0 | 3.3 | 1.5 | 3.8 | 0.3 | 0.0 |
| 18-11-1 | Unknown | 4.0 | 4.0 | 4.0 | 0.0 | 0.0 | 3.8 | 3.8 | 3.8 | 3.3 | 2.3 | 3.0 | 1.0 | 0.0 | 4.0 | 0.0 | 0.0 | 0.0 | 1.8 | 3.8 | 1.3 | 0.3 |
| 18-12-1 | Unknown | 4.0 | 4.0 | 4.0 | 0.0 | 0.0 | 3.8 | 3.8 | 4.0 | 3.3 | 3.5 | 3.8 | 3.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.8 | 4.0 | 2.3 | 3.0 |

| 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 | 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 | Propino |
| 18-12-4 | Unknown | 4.0 | 4.0 | 3.3 | 3.3 | 3.8 | 3.3 | 2.0 | 4.0 | 1.0 | 2.8 | 3.0 | 2.3 | 4.0 | 0.5 | 2.8 | 1.3 | 0.0 | 3.3 | 4.0 | 1.5 | 3.3 |
| 18-13-1 | SY Venture | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 2.8 | 2.0 | 4.0 | 3.3 | 2.3 | 0.5 | 4.0 | 0.0 | 3.0 | 0.8 | 0.0 | 3.8 | 4.0 | 0.0 | 2.8 |
| 18-14-2 | Unknown | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.8 | 4.0 | 4.0 | 1.3 | 2.0 | 2.8 | 2.3 | 4.0 | 0.0 | 2.3 | 2.0 | 0.0 | 2.3 | 3.8 | 2.0 | 1.5 |
| 18-15-2 | Unknown | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 3.8 | 4.0 | 3.5 | 2.0 | 4.0 | 1.3 | 4.0 | 0.0 | 3.3 | 0.3 | 0.0 | 3.5 | 4.0 | 3.0 | 4.0 |
| 18-16-1 R | KWS Tower | 3.3 | 4.0 | 3.3 | 3.5 | 3.5 | 3.0 | 2.0 | 3.3 | 1.8 | 2.5 | 3.0 | 1.8 | 3.5 | 0.0 | 2.0 | 0.0 | 0.0 | 2.0 | 3.5 | 1.3 | 3.0 |
| 18-17-2 | KWS Orwell | 4.0 | 4.0 | 4.0 | 3.3 | 3.8 | 3.5 | 3.8 | 3.5 | 2.8 | 2.8 | 2.8 | 1.8 | 3.8 | 3.8 | 1.8 | 2.0 | 4.0 | 3.8 | 3.3 | 2.8 | 4.0 |
| 18-18-3 | KWS Orwell | 3.3 | 4.0 | 3.3 | 3.5 | 3.5 | 3.3 | 2.0 | 3.0 | 2.8 | 1.8 | 1.3 | 0.5 | 4.0 | 0.0 | 1.5 | 1.0 | 0.0 | 2.0 | 3.0 | 0.5 | 0.0 |
| 18-19-5 | Unknown | 3.5 | 4.0 | 3.5 | 3.3 | 2.8 | 3.5 | 2.5 | 4.0 | 1.0 | 1.8 | 2.5 | 0.8 | 4.0 | 1.0 | 1.3 | 1.0 | 3.3 | 3.3 | 4.0 | 1.8 | 3.0 |
| 18-24-3 | Unknown | 4.0 | 4.0 | 3.8 | 3.3 | 2.8 | 4.0 | 2.5 | 3.5 | 1.0 | 1.8 | 2.5 | 0.8 | 3.8 | 0.0 | 1.8 | 0.3 | 0.0 | 3.5 | 4.0 | 1.3 | 3.5 |
| 18-26-2 | Unknown | 3.3 | 4.0 | 3.3 | 3.3 | 3.5 | 3.5 | 2.3 | 4.0 | 2.0 | 3.0 | 3.0 | 2.5 | 3.3 | 0.8 | 2.0 | 0.3 | 0.0 | 1.0 | 3.0 | 2.3 | 2.8 |
| 18-27-3 | KWS Infinity | 4.0 | 3.5 | 3.5 | 3.3 | 3.0 | 3.3 | 3.5 | 3.5 | 3.3 | 2.5 | 2.3 | 1.0 | 3.5 | 3.5 | 0.8 | 0.8 | 3.0 | 2.3 | 3.8 | 1.8 | 2.0 |

Table 18: 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 | | | | |
|---|---|---|---|---|---|---|
| | | 2014 | 2015 | 2016 | 2017 | 2018 |
| Golden Promise | *0* | 96 | 98 | 88 | 100 | 100 |
| W.37/136 | *Mlh* | 100 | 100 | 100 | 100 | 100 |
| W.41/145 | *Mlra* | 100 | 100 | 100 | 100 | 100 |
| Goldfoil | *Mlg* | 100 | 88 | 100 | 97 | 79 |
| Zephyr | *Mlg,Ml(CP)* | 96 | 88 | 100 | 97 | 79 |
| Midas | *Mla6* | 93 | 98 | 100 | 100 | 100 |
| Lofa | *MlLa* | 93 | 90 | 96 | 84 | 38 |
| Hassan | *Mla12* | 89 | 93 | 96 | 84 | 83 |
| H.1063 | *Mlk1* | 41 | 43 | 31 | 13 | 41 |
| Porter | *Mla7* | 74 | 35 | 27 | 53 | 31 |
| Lotta | *MlAb* | 78 | 38 | 35 | 78 | 59 |
| Triumph | *Mla7,MlAb* | 11 | 5 | 12 | 22 | 3 |
| Tyra | *Mla1* | 37 | 58 | 73 | 56 | 69 |
| Roland | *Mla9* | 0 | 15 | 15 | 16 | 14 |
| Apex | *mlo 11* | 15 | 8 | 15 | 38 | 14 |
| Riviera | *mlo 11* | 4 | 0 | 0 | 6 | 0 |
| Digger | *Mla13* | 11 | 5 | 23 | 25 | 14 |
| Ricardo | *Mla3* | 63 | 53 | 62 | 75 | 59 |
| Vanessa | *Van* | 81 | 98 | 100 | 97 | 100 |
| Optic | | 26 | 18 | 19 | 25 | 7 |
| NFC Tipple | | 56 | 58 | 77 | 88 | * |
| Propino | | 52 | 65 | 65 | 88 | 59 |
| **Total Number of Isolates** | | **27** | **40** | **26** | **32** | **29** |

# 5. Conclusions

The UK *Pst* population continues to show high levels of diversity since the incursion of the Warrior population in 2011. The current population continues to be dominated by isolates from the Red group, and within that group there are a broad range of virulence profiles. New combinations of virulence were detected and these were investigated in the adult plant trials. Natural infection may have confounded the results, however a potential isolate that could explain the outbreak on KWS Zyatt and Dunston in 2019 in some parts of the country was identified and has been put forward for further use in the National List and Recommended List trials.

A new differential set was used for the third year to analyse the *P. triticina* population. 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 analysis of isolate x variety interactions impossible. Three isolates were identified that may explain the outbreak of brown rust on the variety KWS Firefly and one of them has been put forward for use in the National List and Recommended List trials.

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

**2018 Wheat yellow rust isolate register**

| Isolate Number | Host Variety | Date Sampled | RL Rating 2018/19 | Location |
|---|---|---|---|---|
| 18/075 | Apache | June 2018 | | Lincolnshire |
| 18/100 | Apache | June 2018 | | Lincolnshire |
| 18/064 | Beluga | June 2018 | | Angus |
| 18/118 | Bennington | June 2018 | 6 | East Lothian |
| 18/010 | Brimstone | May 2018 | | Oxfordshire |
| 18/076 | Brimstone | June 2018 | | Lincolnshire |
| 18/097 | Brimstone | June 2018 | | Lincolnshire |
| 18/017 | Britannia | May 2018 | | Fife |
| 18/061 | Buster | June 2018 | | Oxfordshire |
| 18/072 | Buster | June 2018 | | Lincolnshire |
| 18/088 | Buster | June 2018 | | Lincolnshire |
| 18/044 | Cadenza | June 2018 | | Kent |
| 18/021 | Claire | May 2018 | | Fife |
| 18/062 | Claire | June 2018 | | Angus |
| 18/080 | Claire | June 2018 | | Lincolnshire |
| 18/096 | Claire | June 2018 | | Lincolnshire |
| 18/057 | Cordiale | June 2018 | 4 | Oxfordshire |
| 18/077 | Cordiale | June 2018 | 4 | Lincolnshire |
| 18/093 | Cordiale | June 2018 | 4 | Lincolnshire |
| 18/022 | Dunston | May 2018 | 7 | Lincolnshire |
| 18/040 | Dunston | June 2018 | 7 | Lincolnshire |
| 18/083 | Dunston | June 2018 | 7 | Lincolnshire |
| 18/101 | Dunston | June 2018 | 7 | Lincolnshire |
| 18/106 | Dunston | June 2018 | 7 | East Yorkshire |
| 18/121 | Dunston | June 2018 | 7 | East Yorkshire |
| 18/045 | Flame | June 2018 | | Kent |
| 18/041 | Freiston | June 2018 | 9 | Lincolnshire |
| 18/038 | Gallant | June 2018 | | Lincolnshire |
| 18/024 | Gleam | May 2018 | 7 | Shropshire |
| 18/070 | Gleam | June 2018 | 7 | Lincolnshire |
| 18/085 | Gleam | June 2018 | 7 | Herefordshire |
| 18/103 | Gleam | June 2018 | 7 | Leicestershire |
| 18/126 | Gleam | June 2018 | 7 | Suffolk |
| 18/001 | Graham | December 2017 | 8 | Devon |
| 18/052 | Graham | June 2018 | 8 | Essex |
| 18/074 | Graham | June 2018 | 8 | Lincolnshire |
| 18/090 | Graham | June 2018 | 8 | Lincolnshire |

| Isolate Number | Host Variety | Date Sampled | RL Rating 2018/19 | Location |
|---|---|---|---|---|
| 18/108 | Graham | June 2018 | 8 | East Yorkshire |
| 18/120 | Graham | June 2018 | 8 | East Yorkshire |
| 18/006 | Hacksta | April 2018 | | Cambridgeshire |
| 18/018 | Horatio | May 2018 | | Fife |
| 18/007 | Hornet | April 2018 | | Cambridgeshire |
| 18/004 | Invicta | April 2018 | | Lincolnshire |
| 18/060 | Invicta | June 2018 | | Oxfordshire |
| 18/069 | Invicta | June 2018 | | Lincolnshire |
| 18/099 | Invicta | June 2018 | | Lincolnshire |
| 18/131 | Invicta | July 2018 | | Lincolnshire |
| 18/023 | JB Diego | May 2018 | 5 | Cambridgeshire |
| 18/027 | JB Diego | May 2018 | 5 | Lincolnshire |
| 18/032 | JB Diego | May 2018 | 5 | Suffolk |
| 18/048 | JB Diego | June 2018 | 5 | Suffolk |
| 18/065 | JB Diego | June 2018 | 5 | Fife |
| 18/113 | JB Diego | June 2018 | 5 | East Lothian |
| 18/036 | KWS Cochise | June 2018 | 6 | Cambridgeshire |
| 18/071 | KWS Gator | June 2018 | | Lincolnshire |
| 18/089 | KWS Gator | June 2018 | | Lincolnshire |
| 18/059 | KWS Silverstone | June 2018 | | Oxfordshire |
| 18/073 | KWS Silverstone | June 2018 | | Lincolnshire |
| 18/091 | KWS Silverstone | June 2018 | | Lincolnshire |
| 18/134 | KWS Siskin | July 2018 | 9 | Lincolnshire |
| 18/015 | KWS Target | May 2018 | | Fife |
| 18/119 | KWS Zyatt | June 2018 | 7 | Kent |
| 18/127 | KWS Zyatt | June 2018 | 7 | Herefordshire |
| 18/009 | Leeds | April 2018 | 6 | Lincolnshire |
| 18/037 | Leeds | June 2018 | 6 | Cambridgeshire |
| 18/034 | LG Jigsaw | May 2018 | | Lincolnshire |
| 18/105 | LG Jigsaw | June 2018 | | East Yorkshire |
| 18/110 | LG Jigsaw | June 2018 | | East Lothian |
| 18/124 | LG Jigsaw | June 2018 | | East Yorkshire |
| 18/025 | LG Rhythm | May 2018 | | Shropshire |
| 18/035 | LG Rhythm | May 2018 | | Lincolnshire |
| 18/042 | LG Rhythm | June 2018 | | East Yorkshire |
| 18/115 | LG Rhythm | June 2018 | | East Lothian |
| 18/014 | LG Rhythm | May 2018 | | East Yorkshire |
| 18/046 | Maris Dove | June 2018 | | Kent |
| 18/133 | Moro | July 2017 | | Cambridgeshire |
| 18/016 | Myriad | May 2018 | 4 | Fife |
| 18/029 | Myriad | May 2018 | 4 | Lincolnshire |
| 18/043 | Myriad | June 2018 | 4 | Herefordshire |

| Isolate Number | Host Variety | Date Sampled | RL Rating 2018/19 | Location |
|---|---|---|---|---|
| 18/053 | Myriad | June 2018 | 4 | Roxburghshire |
| 18/111 | Myriad | June 2018 | 4 | East Lothian |
| 18/002 | Reflection | February 2018 | | Norfolk |
| 18/005 | Reflection | April 2018 | | Cambridgeshire |
| 18/081 | Relay | June 2018 | | Lincolnshire |
| 18/095 | Relay | June 2018 | | Lincolnshire |
| 18/030 | Revelation | May 2018 | 9 | Lincolnshire |
| 18/049 | Revelation | May 2018 | 9 | Norfolk |
| 18/050 | RGT Gravity | June 2018 | 8 | Essex |
| 18/109 | RGT Gravity | June 2018 | 8 | East Yorkshire |
| 18/123 | RGT Gravity | June 2018 | 8 | East Yorkshire |
| 18/066 | RGT Universe | June 2018 | | Cambridgeshire |
| 18/112 | RGT Universe | June 2018 | | East Lothian |
| 18/020 | Robigus | May 2018 | | Fife |
| 18/079 | Robigus | June 2018 | | Lincolnshire |
| 18/094 | Robigus | June 2018 | | Lincolnshire |
| 18/132 | Robigus | July 2018 | | Lincolnshire |
| 18/008 | Shabras | April 2018 | 8 | Lincolnshire |
| 18/051 | Shabras | June 2018 | 8 | Essex |
| 18/104 | Shabras | June 2018 | 8 | Leicestershire |
| 18/107 | Shabras | June 2018 | 8 | East Yorkshire |
| 18/122 | Shabras | June 2018 | 8 | East Yorkshire |
| 18/130 | Shabras | June 2018 | 8 | Gloucestershire |
| 18/013 | Skyfall | May 2018 | 6 | Cambridgeshire |
| 18/031 | Skyfall | May 2018 | 6 | Suffolk |
| 18/056 | Skyfall | June 2018 | 6 | Warwickshire |
| 18/114 | Skyfall | June 2018 | 6 | East Lothian |
| 18/128 | Skyfall | June 2018 | 6 | Herefordshire |
| 18/039 | Solstice | June 2018 | | Lincolnshire |
| 18/082 | Solstice | June 2018 | | Lincolnshire |
| 18/098 | Solstice | June 2018 | | Lincolnshire |
| 18/011 | Spyder | May 2018 | 7 | Oxfordshire |
| 18/012 | Spyder | April 2018 | 7 | East Yorkshire |
| 18/058 | Spyder | June 2018 | 7 | Oxfordshire |
| 18/078 | Spyder | June 2018 | 7 | Lincolnshire |
| 18/086 | Spyder | June 2018 | 7 | Lincolnshire |
| 18/116 | Spyder | June 2018 | 7 | East Lothian |
| 18/129 | Spyder | June 2018 | 7 | Norfolk |
| 18/047 | Sterna | June 2018 | | Kent |
| 18/067 | Stigg | June 2018 | | Lincolnshire |
| 18/068 | Victo | June 2018 | | Lincolnshire |

| Isolate Number | Host Variety | Date Sampled | RL Rating 2018/19 | Location |
|---|---|---|---|---|
| 18/087 | Victo | June 2018 | | Lincolnshire |
| 18/063 | Viscount | June 2018 | 6 | Angus |
| 18/003 | Vuka/victo | March 2018 | | Cambridgeshire |
| 18/084 | Warrior | June 2018 | | Lincolnshire |
| 18/092 | Warrior | June 2018 | | Lincolnshire |
| 18/019 | Zulu | May 2018 | 5 | Fife |
| 18/026 | Zulu | May 2018 | 5 | Shropshire |
| 18/028 | Zulu | May 2018 | 5 | Lincolnshire |
| 18/033 | Zulu | May 2018 | 5 | Suffolk |
| 18/102 | Zulu | June 2018 | 5 | Essex |
| 18/117 | Zulu | June 2018 | 5 | East Lothian |
| 18/125 | Zulu | June 2018 | 5 | Herefordshire |

**2018 Wheat brown rust isolate register**

| Isolate Number | Host Variety | Date Sampled | RL Rating 2018/19 | Location |
|---|---|---|---|---|
| 18/026 | Bennington | June 2018 | 7 | Cambridgeshire |
| 18/030 | Buster | June 2018 | | Lincolnshire |
| 18/049 | Costello | June 2018 | 5 | Norfolk |
| 18/012 | Cougar | June 2018 | | Cambridgeshire |
| 18/024 | Crusoe | June 2018 | 3 | Cambridgeshire |
| 18/037 | Crusoe | June 2018 | 3 | Hampshire |
| 18/040 | Crusoe | June 2018 | 3 | Hampshire |
| 18/051 | Crusoe | June 2018 | 3 | Norfolk |
| 18/007 | Dunston | June 2018 | 6 | Lincolnshire |
| 18/032 | Dunston | June 2018 | 6 | Northamptonshire |
| 18/029 | Elicit | June 2018 | 7 | Cambridgeshire |
| 18/023 | Evolution | June 2018 | 7 | Cambridgeshire |
| 18/046 | Evolution | June 2018 | 7 | Lincolnshire |
| 18/015 | Freiston | June 2018 | 7 | Cambridgeshire |
| 18/010 | Graham | June 2018 | 6 | Lincolnshire |
| 18/011 | Graham | June 2018 | 6 | Cambridgeshire |
| 18/055 | Hereford | July 2018 | | Scottish Borders |
| 18/002 | Jaidor | February 2018 | | Cambridgeshire |
| 18/008 | KWS Barrel | June 2018 | 6 | Lincolnshire |
| 18/036 | KWS Barrel | June 2018 | 6 | Hampshire |
| 18/014 | KWS Firefly | June 2018 | | Hertfordshire |
| 18/048 | KWS Firefly | June 2018 | | Gloucestershire |
| 18/016 | KWS Kerrin | June 2018 | 7 | Cambridgeshire |
| 18/025 | KWS Lili | June 2018 | 4 | Cambridgeshire |
| 18/033 | KWS Lili | June 2018 | 4 | Essex |
| 18/052 | KWS Lili | July 2018 | 4 | Cambridgeshire |
| 18/005 | KWS Santiago | June 2018 | 5 | Lincolnshire |
| 18/041 | KWS Santiago | June 2018 | 5 | Hampshire |
| 18/001 | KWS Siskin | November 2017 | 5 | Warwickshire |
| 18/003 | KWS Siskin | February 2018 | 5 | Norfolk |
| 18/006 | KWS Siskin | June 2018 | 5 | Lincolnshire |
| 18/013 | KWS Siskin | June 2018 | 5 | Cambridgeshire |
| 18/027 | KWS Siskin | June 2018 | 5 | Cambridgeshire |
| 18/050 | KWS Siskin | June 2018 | 5 | Norfolk |
| 18/053 | KWS Siskin | July 2018 | 5 | Lincolnshire |
| 18/019 | KWS Trinity | June 2018 | 7 | Cambridgeshire |
| 18/044 | KWS Trinity | June 2018 | 7 | Lincolnshire |
| 18/038 | KWS Zyatt | June 2018 | 6 | Kent |
| 18/020 | LG Motown | June 2018 | 7 | Cambridgeshire |
| 18/045 | LG Motown | June 2018 | 7 | Lincolnshire |

| Isolate Number | Host Variety | Date Sampled | RL Rating 2018/19 | Location |
|---|---|---|---|---|
| 18/034 | LG Sundance | June 2018 | 6 | Hampshire |
| 18/009 | Moulton | June 2018 | 7 | Lincolnshire |
| 18/017 | Moulton | June 2018 | 7 | Cambridgeshire |
| 18/047 | Myriad | June 2018 | 5 | Roxburghshire |
| 18/018 | Revelation | June 2018 | 8 | Cambridgeshire |
| 18/039 | Revelation | June 2018 | 8 | Hampshire |
| 18/022 | RGT Illustrious | June 2018 | 6 | Cambridgeshire |
| 18/031 | RGT Universe | June 2018 | | Northamptonshire |
| 18/042 | Robigus | June 2018 | | Cambridgeshire |
| 18/043 | Robigus | June 2018 | | Cambridgeshire |
| 18/035 | Skyfall | June 2018 | 9 | Hampshire |
| 18/021 | Spyder | June 2018 | 7 | Cambridgeshire |
| 18/028 | SY Medea | June 2018 | | Cambridgeshire |
| 18/004 | Unknown | May 2018 | | Hertfordshire |
| 18/054 | Unknown | July 2018 | | Cambridgeshire |

**2018 Wheat powdery mildew isolate register**

| Isolate Number | Host Variety | Date Sampled | RL Rating 2018/19 | Location |
|---|---|---|---|---|
| 18/048 | AWCSW1 | June 2018 | | Cambridgeshire |
| 18/021 | Barrel | June 2018 | 6 | Lincolnshire |
| 18/041 | Basset | June 2018 | | East Lothian |
| 18/038 | Detroit | June 2018 | | East Lothian |
| 18/019 | Dunston | June 2018 | 5 | Lincolnshire |
| 18/028 | Dunston | June 2018 | 5 | East Northamptonshire |
| 18/040 | Dunston | June 2018 | 5 | East Lothian |
| 18/031 | Elation | June 2018 | 7 | East Lothian |
| 18/011 | Elicit | December 2017 | 6 | Cambridgeshire |
| 18/020 | Freiston | June 2018 | 6 | Lincolnshire |
| 18/029 | Freiston | June 2018 | 6 | Cambridgeshire |
| 18/042 | Freiston | June 2018 | 6 | East Lothian |
| 18/015 | Gleam | May 2018 | 6 | Shropshire |
| 18/043 | Gleam | June 2018 | 6 | East Lothian |
| 18/037 | Gravity | June 2018 | | East Lothian |
| 18/039 | Hardiwcke | June 2018 | 6 | East Lothian |
| 18/046 | Hardwicke | June 2018 | 6 | Shropshire |
| 18/032 | Jigsaw | June 2018 | | East Lothian |
| 18/010 | KWS Barrel | December 2017 | | Cambridgeshire |
| 18/009 | KWS Lili | December 2017 | 8 | Cambridgeshire |
| 18/018 | KWS Santiago | June 2018 | 6 | Lincolnshire |
| 18/001 | KWS Siskin | November 2017 | 9 | Warwickshire |
| 18/012 | KWS Siskin | February 2018 | 9 | Norfolk |
| 18/013 | KWS Siskin | January 2018 | 9 | Suffolk |
| 18/007 | KWS Trinity | December 2017 | 8 | Cambridgeshire |
| 18/035 | KWS W308 | June 2018 | | East Lothian |
| 18/006 | KWS Zyatt | December 2017 | 7 | Cambridgeshire |
| 18/014 | Leeds | April 2018 | 3 | East Yorkshire |
| 18/023 | Leeds | June 2018 | 3 | East Yorkshire |
| 18/027 | Leeds | June 2018 | 3 | Fife |
| 18/036 | Leeds | June 2018 | 3 | East Lothian |
| 18/026 | LG Rhythm | June 2018 | | Roxburghshire |
| 18/047 | LG Sundance | June 2018 | 7 | Roxburghshire |
| 18/034 | LG Rhythm | June 2018 | | East Lothian |
| 18/016 | LG Rhythm | May 2018 | | Shropshire |
| 18/022 | Moulton | June 2018 | 7 | Lincolnshire |
| 18/008 | RGT Illustrious | December 2017 | | Cambridgeshire |
| 18/033 | Sabertooth | June 2018 | | East Lothian |
| 18/030 | Shabras | June 2018 | 6 | East Lothian |
| 18/002 | Skyfall | November 2017 | 5 | Cambridgeshire |

| Isolate Number | Host Variety | Date Sampled | RL Rating 2018/19 | Location |
|---|---|---|---|---|
| 18/025 | Skyfall | June 2018 | | Lincolnshire |
| 18/024 | SY Medea | June 2018 | | Shropshire |
| 18/044 | SY115590 | June 2018 | | East Lothian |
| 18/045 | Viscount | June 2018 | 7 | Herefordshire |
| 18/017 | Zulu | May 2018 | 7 | Shropshire |

**2018 Barley powdery mildew isolate register**

| Isolate number | Host Variety | Date Sampled | RL Rating 2018/19 | Location |
|---|---|---|---|---|
| 18/004 | Amistar | Nov 2017 | | Cambridgeshire |
| 18/023 | Bazooka | Jun 2018 | 4 | Roxburghshire |
| 18/003 | Belmont | Nov 2017 | 6 | Cambridgeshire |
| 18/002 | Coref | Nov 2017 | 5 | Cambridgeshire |
| 18/001 | Craft | Nov 2017 | 6 | Cambridgeshire |
| 18/025 | Flagon | Jun 2018 | | Norfolk |
| 18/018 | KWS Cassia | May 2018 | 4 | East Yorkshire |
| 18/020 | KWS Creswell | Jun 2018 | 4 | Fife |
| 18/009 | KWS Infinity | Nov 2017 | 4 | Cambridgeshire |
| 18/027 | KWS Infinity | Jun 2018 | 4 | Aberdeenshire |
| 18/008 | KWS Orwell | Nov 2017 | 3 | Cambridgeshire |
| 18/021 | KWS Orwell | Jun 2018 | 3 | East Yorkshire |
| 18/022 | KWS Orwell | Jun 2018 | 3 | Herefordshire |
| 18/017 | KWS Orwell | May 2018 | 3 | East Yorkshire |
| 18/016 | KWS Tower | May 2018 | 5 | East Yorkshire |
| 18/010 | LG Mountain | Nov 2017 | | Cambridgeshire |
| 18/007 | SY Venture | Nov 2017 | 6 | Cambridgeshire |
| 18/013 | SY Venture | Apr 2018 | 6 | Kent |
| 18/005 | Unknown | Nov 2017 | | Cambridgeshire |
| 18/006 | Unknown | Nov 2017 | | Cambridgeshire |
| 18/011 | Unknown | Apr 2018 | | Cambridgeshire |
| 18/012 | Unknown | Apr 2018 | | Cambridgeshire |
| 18/014 | Unknown | May 2018 | | Cambridgeshire |
| 18/015 | Unknown | May 2018 | | Cambridgeshire |
| 18/019 | Unknown | Jun 2018 | | Cambridgeshire |
| 18/024 | Unknown | Jun 2018 | | Lincolnshire |
| 18/026 | Unknown | Jun 2018 | | Cambridgeshire |

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