



January 2016

United Kingdom Cereal Pathogen Virulence Survey 2015 Annual Report

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1. Abstract

The UKCPVS monitors the populations of the important cereal pathogens wheat yellow rust (*Puccinia striiformis* f.sp. *tritici*), wheat brown rust (*Puccinia triticina*), wheat powdery mildew (*Blumeria graminis* f.sp. *tritici*) and barley powdery mildew (*Blumeria graminis* f.sp. *hordei*).

Wheat Yellow Rust

Since the incursion of the Warrior population in 2011, the UK yellow rust population has been changing, with the old UK population now almost entirely replaced by the new Warrior group. Results from the tests on isolates found in 2014 show that there have been no new individual virulences identified, however there has been a subtle shift in the population, with the "Warrior 3" sub-group dominating. A subset of the isolates were tested on a wider range of varieties at the seedling and adult plant stages and one of the isolates (14/106) appeared to be virulent on a much wider range of varieties than other isolates. This was also apparent in the adult plant tests and further analysis of samples taken from this trial as well as the original isolates revealed that 14/106 was in fact an isolate of the Kranich race. This is the first report of the Kranich race in the UK since its discovery in Denmark and Sweden in 2011.

Wheat Brown Rust

The UKCPVS was interested in the higher than expected levels of disease which had been reported on the variety Crusoe in 2013 and 2014. Differential tests on isolates collected in 2014 showed a possible re-emergence of the Glasgow race, last seen in 2006. Adult plant tests were established to evaluate whether this change was responsible for the high levels of disease on Crusoe. However, a generally unfavourable season for brown rust in 2015 probably resulted in the test isolate failing to establish and increase, and the trial appeared to be contaminated with a late surge of natural infection.

Wheat Powdery Mildew

Only 13 samples were received by the UKCPVS, with additional samples being obtained from trap pots of a susceptible variety. The differential tests showed that virulence to all of the resistance genes under evaluation was found, except for *Pm17*. Virulence has been detected in the past for this gene. Virulence for the gene *Pm8* and the resistance gene(s) in Robigus were found at the highest levels in the last five years. The impact of this change is not clear at present as the isolates are only evaluated at the seedling stage.

Barley Powdery Mildew

Similar to the wheat powdery mildew, there were very few samples received by the UKCPVS of barley powdery mildew. From the isolates tested, there was little deviation in the virulence frequencies from previous years. There was however a marked increase in the detection of virulence for Porter, with an increase from 34% of samples in 2013 to 77% of samples in 2014. In addition to this change, virulence for KWS Meridian was detected for the first time. As with the wheat powdery mildew, the impact of these changes is unclear due to the current testing being limited to seedling stage only.

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 thrive. Warmer summers have also led to the presence of brown (leaf) rust at the end of the season which can be serious if left unchecked on susceptible cultivars. 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 is however subject to change and should be monitored as part of a virulence survey due to the ability of the pathogen to mutate and overcome some kinds of resistance. For this reason, the UK Cereal Pathogen Virulence Survey was established in 1967 following an unexpected outbreak of yellow rust on the previously resistant variety Rothwell Perdix.

2.1.2. Targets of the Survey and Pipeline for Pathotyping

2.1.2.1. Targets

Known originally as the Physiologic Race Survey of Cereal Pathogens, the survey was conducted by a group of organisations including NIAB. The list of target diseases was longer and included wheat yellow rust, wheat and barley mildew, barley brown rust, barley leaf scald (*Rhynchosporium*), barley net blotch, oat crown rust, oat leaf spot and oat mildew. Over time the list of target species has reduced but the principals still remain the same and in its 48th 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 populations of wheat yellow and brown rust and wheat and barley mildew. A close eye is also kept on 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 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. 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

Until very recently, changes in the pathogen populations were typically detected in only one or two locations at low levels. Depending on the prevalence of the host cultivar, the new races appeared in one year and then slowly increased until the following season where it was seen more widely. Eventually these new races would start to be more dispersed and therefore noted in virulence surveys of other European countries, such as France, Germany and Denmark. New races of wheat yellow rust for example have historically appeared in the UK on average every 3-4 years, with changes in the population appearing to be step wise mutations of current established isolates (Table 1).

Table 1: Key wheat yellow rust race changes in the UK

Year	Variety	Key Resistance Gene Combination
1988	Hornet	<i>Yr6, Yr9</i>
1994	Brigadier	<i>Yr9, Yr17</i>
1996	Madrigal	<i>Yr6, Yr9, Yr17</i>
2000	Robigus	<i>Yr9, Yr17, Yr32</i>
2008	Solstice	<i>Yr6, Yr9, Yr17, Yr32</i>
2011	Warrior	<i>Yr6, Yr7, Yr9, Yr17, Yr32, Spaldings Prolific</i>

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 *Yr7* and the variety Spaldings Prolific. It is important to note that virulence for *Yr7* had been seen before, but not in combination with virulence to *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 [1]. 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 [2, 3]. 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.

In addition to highlighting changes in the pathogen population, the UKCPVS also performs trials to assess the reaction of current UK Recommended List (RL) varieties to the newest isolates,

including those that are suspected to be of a new race. In the past varieties have been highly susceptible to new races, with catastrophic decreases in resistance ratings as so-called major resistance genes have been overcome. The Hornet race caused the RL yellow rust rating for Hornet drop from a 9 to a 2 in the space of a year, and a similar drop was seen for Brigadier (9 to 2). More recent race changes have seen more modest drops in ratings, for example Solstice changed from a 9 to a 4 in response to the Solstice race and Beluga from a 9 to a 5 and Claire from a 9 to a 6, both in response to the Warrior race. This suggests that some of the current varieties have other background resistance unaffected by the new races that reduce the effect of the breakdown. It is for this reason that it is difficult to predict the likely impact of a new race on different varieties and that a complete breakdown should never be assumed.

2.2. Aims and Objectives

The principal aim of the project is to detect new races of economically important diseases 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 wheat yellow rust and brown rust and wheat and barley powdery mildew. As detailed in 2.1.2.2, a subset of isolates will be characterised to identify any new races. The reactions of the current RL varieties and candidates will be assessed using the newest isolates at both the seedling and adult plant stages.

3. Materials and methods

3.1. Wheat Yellow and Brown Rust

3.1.1. Collection of samples and preparation of isolates

Infected wheat leaves were received from growers, agronomists and trials operators of RL trials. Spores from the infected samples were transferred on to plants of the universally susceptible varieties Victo (wheat yellow rust) and 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 plants for each isolate under test. 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 (AIT). A score of 0 - 2.3 indicates an avirulent reaction, 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 indicate a compatible reaction, and the isolate is virulent on that differential.

3.1.3. Characterisation of isolates using adult plant field 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. Susceptible "spreader" variety tussocks were sown in multiple tussocks through the trial and these were inoculated with the individual isolates in the spring using infected seedlings produced under controlled environment conditions. 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, 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 the universally susceptible varieties Cerco (wheat mildew) and Golden Promise (barley mildew) were sown in environmentally controlled conditions and given to NIAB staff living near arable areas to place in their gardens for up to 14 days, and then returned to the lab where individual pustules were harvested and maintained as normal.

3.2.2. Characterisation of Isolates using differential tests.

Seedlings of the differential set were inoculated with spores from the new isolates. The differentials used and the resistance genes they carry are listed in Table 14 and Table 16. Each differential was represented by 4 detached leaf sections, giving four replicates. This was to ensure the maximum amount of information is 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 2014, the UKCPVS received 130 samples of wheat yellow rust from 14 different counties across the UK, with the majority of samples being received from the South and East of England (Figure 1).



Figure 1: Map of the UK with the number of samples of wheat yellow rust received in 2014 from the different counties.

The full sample register is provided in Appendix 1. There were no reports of unexpected outbreaks of yellow rust and as such the number of samples received by the survey was lower than the

number received in 2013. In contrast to 2013, the distribution of samples received was much wider, with better coverage in the South and West of England. This change in sample distribution is the result of an effort to obtain more samples from these areas rather than any change in disease observations in a particular location. Samples were received from a wide range of varieties, ranging from RL ratings of 4 and the unclassified varieties such as Robigus and Oakley, through to the more resistant varieties rated 8 and above. As in previous years the survey was particularly interested in samples from varieties with a high RL rating as rust on these varieties could indicate a change in the pathogen population. The host varieties listed 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. Samples that were of note for the UKCPVS included those from the varieties KWS Trinity, Britannia, Relay, Scout, KWS Gator and Icon which all have RL ratings of 8 or above (2014/15 ratings).

4.1.2. Pathotyping of Isolates

Twenty five 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 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 average infection type (a.i.t.), to the component varieties are listed in Table 2. Isolates were classified as virulent if the a.i.t. score was 2.7 or above. Scores between 2.4 and 2.6 were considered borderline. Using these scores, it is 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 2014 using the differentials tested at the seedling stage. In addition, there were no new combinations of virulences detected. Both of these findings are in agreement with there being no reports of increased yellow rust on RL varieties in 2014. Although there were no new combinations of virulences detected, the population remains highly diverse. Since the introduction of the Warrior group of isolates in 2011, the population has shown much higher levels of diversity than previously found in the older UK populations [4-8]. This diversity has been demonstrated in 2014 with the identification of 14 different pathotypes from the 27 isolates tested. This is much higher than the levels found pre-Warrior, for example in 2009, where 12 pathotypes were detected from 42 isolates tested.

Table 2: Average Infection Type (AIT) scores for the 25 selected isolates against the UKCPVS differential set. Yellow shading indicates a compatible reaction, orange indicates a borderline reaction. Compatible interactions classify the isolate as virulent against a particular resistance gene or variety. Numbers next to the differential variety name indicate the known resistance genes carried by the variety. * = Missing data.

Isolate code	Host Variety	1	2	3a+	3a+	3b,4b	4,Su	5	6	2,6	2,6	7	7	6,7	7,17	8	9	9	10	15	9,17	17	17	17	24	2,25	25,Sd	27	27	32	32	32	Sp	Ro	So	Ti	Wa	St	Am				
		Chinese 166	Kalyansona	Vilmorin 23	Nord Desprez	Hybrid 46	Suwon Omar	Avocet Yr5	Avocet Yr6	Heines Kolben	Heines Peko	Lee	AV x Yr 7 NIL	Cadanza	Apache	Compair	Kavkaz x 4 fed	Clement	Moro	AVS x yr15	Brigadier	VPM 1	Rendezvous	AV x Yr17	Avocet Yr24	Heines VII	Strubes Dickkopf	Opata	Avocet Yr27	Carstens V	Talon	AV x Yr32	Spaldings Prolific	Robigus	Solstice	Timber	Warrior	KWS Sterling	Claire	Ambition	Crusoe	Vuka	
14/001	JB Diego	3.1	3.0	2.0	2.0	2.1	3.0	0.0	4.0	2.0	3.1	*	3.3	2.1	2.0	0.0	3.2	3.0	0.0	0.0	*	3.3	1.5	3.2	0.0	2.7	4.0	*	*	3.1	2.5	3.0	3.1	3.1	2.0	0.0	0.4	1.1	2.2	3.0	0.0	3.5	
14/007	KWS Kielder	4.0	4.0	3.0	3.0	2.0	3.0	0.0	3.5	2.0	3.0	3.0	4.0	3.0	3.0	0.0	3.0	3.0	0.0	0.0	*	2.0	0.2	3.5	0.0	0.0	3.5	*	*	4.0	2.3	3.0	3.0	3.0	3.0	0.0	2.1	0.1	2.6	0.0	0.0	3.5	
14/008	Hereward	3.0	3.0	3.5	3.2	3.0	4.0	0.0	4.0	2.0	3.0	2.5	4.0	3.0	2.8	0.0	3.0	2.2	0.0	0.0	*	4.0	3.0	3.5	0.0	3.5	3.0	*	*	3.0	3.0	3.0	3.0	4.0	3.0	0.0	0.0	2.0	3.0	0.5	0.0	3.0	
14/012	Timber	3.5	3.5	3.5	3.0	2.0	4.0	0.0	4.0	2.5	3.5	3.5	3.2	2.5	3.0	0.0	3.5	2.2	0.0	0.0	*	2.2	0.0	3.0	0.0	3.0	3.5	*	*	3.3	3.0	3.0	3.0	3.0	2.0	2.9	2.8	0.0	2.0	4.0	0.0	4.0	
14/013	Robigus	3.5	3.5	3.0	4.0	2.5	3.0	0.0	3.0	3.0	3.2	3.3	4.0	0.4	1.0	0.0	3.5	3.0	0.0	0.2	3.0	3.0	2.0	4.0	0.0	3.0	3.0	*	*	3.0	3.0	3.0	3.0	3.0	2.0	0.0	2.6	0.4	2.3	0.0	0.0	4.0	
14/016	Victo	3.0	3.1	3.1	3.2	2.0	3.0	0.0	3.1	3.0	3.1	3.5	3.0	3.0	2.6	0.0	2.5	3.0	0.0	0.0	3.1	2.5	0.0	3.0	0.0	3.0	3.0	*	*	3.0	3.0	2.2	3.0	3.0	3.0	0.0	2.9	0.0	2.0	0.0	0.0	3.5	
14/022	Spreader	3.0	3.0	3.0	3.0	2.0	3.0	0.0	3.0	2.0	3.0	3.0	3.1	3.0	2.0	0.0	3.0	3.0	0.0	0.0	*	2.2	0.2	3.0	0.0	2.0	3.0	*	*	2.2	2.0	3.0	3.0	3.0	2.1	0.5	2.0	0.2	2.5	1.3	0.0	3.5	
14/036	Claire	3.0	3.0	3.0	4.0	3.0	3.1	0.0	3.2	3.0	3.2	4.0	3.0	3.2	3.0	0.0	3.0	3.0	0.0	0.0	2.7	3.0	0.5	3.2	0.0	3.0	4.0	*	*	3.1	3.0	3.0	3.0	3.0	3.0	2.8	2.9	3.0	3.1	3.0	0.0	4.0	
14/044	Scout	3.0	3.0	3.0	3.0	2.0	3.5	0.0	4.0	2.5	3.1	3.0	4.0	3.0	3.0	0.0	4.0	2.1	0.0	0.0	3.0	3.0	0.3	3.0	0.0	3.0	3.0	*	*	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.3	1.3	3.0	0.0	0.0	3.5	
14/046	KWS Kielder	3.2	3.5	3.5	4.0	3.0	3.0	0.0	3.5	3.0	4.0	3.5	3.5	3.0	3.0	0.0	3.5	4.0	0.0	0.0	3.0	3.0	2.1	3.0	0.0	0.0	3.0	*	*	4.0	3.0	3.5	3.1	3.5	3.5	2.8	3.0	2.2	3.0	3.0	0.0	4.0	
14/056	Relay	3.5	3.5	3.5	4.0	2.0	3.0	0.0	4.0	3.0	3.5	3.5	3.5	3.0	3.0	0.0	4.0	3.2	0.0	0.0	2.2	3.0	1.3	4.0	0.0	3.0	4.0	*	*	3.4	3.0	3.0	3.0	4.0	3.2	0.2	2.5	2.0	3.0	0.0	0.0	3.5	
14/063	Cordiale	3.0	3.0	3.2	3.1	2.0	3.0	0.0	3.0	3.0	3.0	4.0	3.0	3.0	2.9	0.0	3.0	2.9	0.0	0.0	2.0	3.0	0.0	3.5	0.0	3.0	2.5	*	*	3.0	3.0	3.5	3.5	3.0	3.0	0.0	0.2	0.4	3.0	0.0	0.0	3.0	
14/072	Warrior	3.0	3.5	3.0	3.5	2.9	4.0	0.0	3.0	3.0	3.1	3.0	4.0	3.0	3.0	0.0	3.5	3.0	0.0	0.0	3.0	3.0	0.0	3.0	0.0	2.5	3.2	*	*	4.0	3.2	4.0	3.0	3.1	3.1	0.0	0.8	1.1	3.0	0.0	0.0	4.0	
14/083	Relay	4.0	4.0	3.0	4.0	3.0	3.0	0.0	3.0	4.0	3.5	4.0	4.0	2.5	3.0	0.0	4.0	3.0	0.0	0.0	3.0	3.0	0.7	3.1	0.0	3.0	3.5	*	*	4.0	3.0	3.0	3.0	4.0	3.5	1.9	2.7	2.0	2.7	0.0	0.0	4.0	
14/084	Relay	3.0	3.0	3.0	3.3	3.0	3.0	0.0	4.0	3.0	3.0	4.0	4.0	3.0	2.8	0.0	3.0	3.0	0.0	0.0	2.9	3.0	0.4	3.5	0.0	3.0	3.0	*	*	*	3.0	3.0	3.0	3.0	3.0	1.5	0.5	0.0	3.0	0.0	0.0	4.0	
14/091	Cougar	3.0	3.0	3.0	3.0	3.0	3.0	0.0	4.0	3.0	3.0	4.0	4.0	2.8	2.7	*	3.0	3.0	0.0	0.0	4.0	3.0	1.4	3.0	0.0	3.0	3.0	*	*	4.0	3.0	3.3	3.1	3.5	3.5	0.1	1.9	1.6	2.1	0.0	0.0	4.0	
14/103	KWS Lili	3.0	3.0	3.0	3.0	2.0	3.0	0.0	3.0	2.0	3.0	3.0	3.0	2.2	2.1	*	2.0	2.0	0.0	0.0	3.0	2.0	1.1	3.0	0.0	3.0	3.0	*	*	2.8	3.0	3.0	3.0	3.0	3.0	0.0	2.1	0.0	2.5	0.0	0.0	3.5	
14/105	Invicta	3.5	3.5	3.5	3.5	3.2	3.0	0.0	3.0	3.0	3.0	3.0	3.5	3.0	2.1	*	3.0	3.0	0.0	0.0	3.0	4.0	2.0	3.0	0.0	3.0	3.0	*	*	4.0	3.0	3.0	3.0	3.2	3.2	0.7	2.0	1.1	3.0	0.0	0.0	3.5	
14/106	Monterey	3.5	3.0	3.0	2.8	2.3	3.0	0.0	3.0	3.0	3.0	3.2	3.2	2.8	3.0	*	3.0	3.0	0.0	0.0	3.0	3.0	2.2	3.0	0.0	3.0	3.0	*	*	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.7	3.0	3.0	1.5	4.0	
14/108	KWSSantiago	3.1	3.1	3.1	3.2	3.0	3.0	0.0	3.1	3.0	3.1	1.0	2.5	0.0	0.0	*	3.0	3.0	0.0	0.0	3.0	2.9	2.8	3.0	0.0	3.0	3.0	*	*	3.2	3.0	3.0	0.6	3.0	3.0	0.0	0.8	0.0	1.7	0.0	0.0	4.0	

Isolate code	Host Variety	1	2	3a+	3a+	3b,4b	4,Su	5	6	2,6	2,6	7	7	6,7	7,17	8	9	9	10	15	9,17	17	17	17	24	2,25	25,Sd	27	27	32	32	32	Sp	Ro	So	Ti	Wa	St	Am			
		Chinese 166	Kalyansona	Vilmorin 23	Nord Desprez	Hybrid 46	Suwon Omar	Avocet Yr5	Avocet Yr6	Heines Kolben	Heines Peko	Lee	AV x Yr 7 NIL	Cadenza	Apache	Compair	Kavkaz x 4 fed	Clement	Moro	AVS x yr15	Brigadier	VPM 1	Rendezvous	AV x Yr17	Avocet Yr24	Heines VII	Strubes	Dickkopf	Opata	Avocet Yr27	Carstens V	Talon	Av x Yr32	Spaldings Prolific	Robigus	Solstice	Timber	Warrior	KWS Sterling	Claire	Ambition	Crusoe
14/117	KWS Cashel	3.5	3.5	4.0	3.5	3.0	3.0	0.0	4.0	3.0	3.0	4.0	4.0	3.0	3.0	*	3.0	3.0	0.0	0.0	3.0	3.0	2.0	3.0	0.0	3.0	3.0	*	*	3.0	3.0	3.5	3.0	3.0	3.0	0.4	0.3	0.1	2.5	0.0	0.0	3.0
14/118	KWSSantiago	3.0	3.0	3.0	3.0	3.0	2.9	0.0	3.0	3.0	3.0	1.8	2.2	0.0	0.0	*	3.0	3.0	0.0	0.0	3.0	3.0	2.9	3.0	0.0	3.0	3.0	*	*	3.0	3.0	3.0	0.0	3.0	3.0	0.0	0.8	0.1	2.0	0.4	0.0	4.0
14/119	Jorvik	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	2.1	*	3.0	3.0	0.0	0.0	3.0	2.1	1.5	3.0	0.0	3.0	3.0	*	*	3.0	2.5	3.0	3.0	3.0	3.0	0.0	2.0	0.2	3.0	0.0	0.0	3.5
14/120	Britannia	3.0	3.4	3.0	3.0	2.1	4.0	0.0	4.0	3.0	3.2	3.3	4.0	3.0	2.8	*	3.0	3.0	0.0	0.0	1.3	3.0	0.5	3.5	0.0	3.0	3.5	*	*	4.0	2.7	3.0	3.0	3.0	3.0	0.7	2.2	1.1	3.5	0.0	0.0	4.0
14/125	Icon	3.5	3.0	3.0	3.1	2.0	3.5	0.0	3.2	3.0	3.0	3.1	3.5	2.8	3.0	*	2.9	3.0	0.0	0.0	3.5	4.0	2.2	3.0	0.0	3.0	4.0	*	*	4.0	3.2	3.0	3.0	3.3	3.3	0.3	2.2	0.9	4.0	1.0	0.0	4.0
14/128	KWSSantiago	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	*	3.0	3.0	0.0	0.0	3.0	3.0	1.8	3.0	0.0	3.0	3.0	*	*	3.0	2.5	3.0	3.0	3.0	3.0	0.0	0.0	0.2	3.0	0.0	0.0	4.0
14/501	Crusoe	3.0	3.0	3.1	4.0	3.0	4.0	0.0	3.0	3.0	4.0	3.5	3.5	2.6	3.0	0.0	3.5	4.0	0.0	0.0	2.1	3.0	0.7	3.0	0.0	3.1	3.0	*	*	4.0	3.0	4.0	4.0	3.1	3.2	3.0	3.0	2.6	3.0	4.0	0.0	4.0

Table 3: Pathotypes of the 2014 wheat yellow rust isolates based on the differential test results in Table 2. Re = Rendezvous, Sp = Spaldings Prolific, Ro = Robigus, So = Solstice, Wa = Warrior, Am = Ambition, Ca = Cadenza, St = KWS Sterling. *Pathotype groups explained further in Table 5.

Isolate code	Host Variety	Pathotype Group*	Virulence Profile																								
			1	2	3	4	5	6	7	8	9	10	15	17	24	25	32	Re	Sp	Ro	So	Wa	Am	Ca	St	Ap	
14/001	JB Diego	Warrior 3	1	2		4		6	7		9			17		25	32		Sp	Ro				Am			
14/007	KWS Kielder	Warrior 3	1	2	3	4		6	7		9			17		(25)	32		Sp	Ro	So				Ca		Ap
14/008	Hereward	Warrior 4	1	2	3	4		6	7		9			17		25	32	Re	Sp	Ro	So				Ca		Ap
14/012	Timber	Warrior 1	1	2	3	4		6	7		9			17		25	32		Sp	Ro		Wa	Am	(Ca)			Ap
14/013	Robigus	Warrior 3	1	2	3	4		6	7		9			17		25	32		Sp	Ro		(Wa)					
14/016	Victo	Warrior 1	1	2	3	4		6	7		9			17		25	(32)		Sp	Ro	So	Wa			Ca		(Ap)
14/022	Spreader	Warrior 3	1	2	3	4		6	7		9			17		(25)	32		Sp	Ro					Ca		
14/036	Claire	Warrior 1	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So	Wa	Am	Ca	St		Ap
14/044	Scout	Warrior 3	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So				Ca		Ap
14/046	KWS Kielder	Warrior 1	1	2	3	4		6	7		9			17		(25)	32		Sp	Ro	So	Wa	Am	Ca			Ap
14/056	Relay	Warrior 3	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So	(Wa)			Ca		Ap
14/063	Cordiale	Warrior 3	1	2	3	4		6	7		9			17		(25)	32		Sp	Ro	So				Ca		Ap
14/072	Warrior	Warrior 3	1	2	3	4		6	7		9			17		(25)	32		Sp	Ro	So				Ca		Ap
14/083	Relay	Warrior 1	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So	Wa			(Ca)		Ap
14/084	Relay	Warrior 3	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So				Ca		Ap
14/091	Cougar	Warrior 3	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So				Ca		Ap
14/103	KWS Lili	Warrior 3	1	2	3	4		6	7					17		25	32		Sp	Ro	So						
14/105	Invicta	Warrior 3	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So				Ca		
14/106	Monterey	Warrior 1	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So	Wa	Am	Ca	St		Ap
14/108	KWS Santiago	Other	1	2	3	4		6	(7)		9			17		25	32	Re		Ro	So						
14/117	KWS Cashel	Warrior 3	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So				Ca		Ap
14/118	KWS Santiago	Other	1	2	3	4		6			9			17		25	32	Re		Ro	So						
14/119	Jorvik	Warrior 3	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So				Ca		
14/120	Britannia	Warrior 3	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So				Ca		Ap
14/125	Icon	Warrior 3	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So				Ca		Ap
14/128	KWS Santiago	Warrior 3	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So				Ca		Ap
14/501	Crusoe	Warrior 1	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So	Wa	Am	(Ca)	(St)		Ap

The frequency at which virulence for different resistance genes and varieties were detected showed some variation with previous years (Table 4). There was an increase in the frequency of detection of virulence to Spaldings Prolific. Since 2012, Spaldings Prolific has been used as the key identifier of the Warrior group of isolates and this increase in frequency of detection concurs with the finding that the older UK isolates are being replaced by the Warrior group [8]. There was a reduction in the virulence for *Yr25* in 2014, although at this stage it is difficult to interpret this change as it is only the second year that virulence for this gene has been assessed. There were also decreases in the virulence for the varieties Robigus, Solstice and KWS Sterling. Isolates virulent on these varieties were previously part of the older UK population, which has been largely displaced by the Warrior incursion. There have been isolates from the Warrior group that have displayed a similar pathotype to the older races such as the Solstice race, however genotypic analysis suggests that these isolates are still part of the Warrior group (Diane Saunders, *pers. comm.*). Virulence for Rendezvous, Warrior, Ambition, Cadenza and Claire has also reduced in frequency. Virulence for Rendezvous was generally found at high levels before the incursion of the Warrior group. Since the incursion, the frequency of detection has continued to fall, which suggests that the additional resistance gene(s) in Rendezvous, previously ineffective against the older UK races, is now effective once more to give limited protection. This was evident in 2014 adult plant trials where Rendezvous derivatives showed good levels of resistance to the Warrior isolates tested [4]. Categorising the isolates into different subgroups within the broader Warrior group based on some of these changes (Table 5) and comparing the frequency of detection of these subgroups across years (Table 6) suggests that the population has changed since the initial incursion. The frequency of the Warrior 1 group, which we would consider to include the original Warrior isolates, has reduced markedly since its detection in 2011. Conversely, the sub group Warrior 3, initially detected at relatively low levels, now dominates the isolates collected. Isolates in the other groups are detected at low levels. Our current working hypothesis is that isolates from all groups were present during the initial incursion and since then there has been a selection on the original population, with isolates that are best adapted to the UK climate and varieties becoming more dominant. Unfortunately we do not currently have a complete dataset for isolates collected in 2011 as some of these key differentials were not in use at that time. These isolates are being re-analysed in further work outside of the UKCPVS (Laura Bouvet, *pers. comm.*). Isolates categorised as “Other” would typically include isolates from the Solstice race that was part of the original UK population. The number of isolates collected that belong to this group has been steadily decreasing over the past three years, in agreement with others [8]. This displacement also includes the KWS Sterling race, first identified in 2011 as a suspected mutation of the Solstice race. It was characterised by the virulence profile: 1,2,3,4,6,7,9,17,32,Re,So,Wa,St. This pathotype has not been seen since 2011. It must be stressed though that this survey has only tested 27 isolates and this does not represent a thorough population study for the whole of the

Table 4: Frequency of detection of isolates carrying virulence to the different yellow rust resistance genes over the past five years.

* Indicates differential not tested in a particular year.

Virulence For Resistance Gene or Variety	Percentage of Isolates Identified with Virulence for Gene or Variety				
	2010	2011	2012	2013	2014
Yr1	100	100	100	100	100
Yr2	100	100	100	100	100
Yr3	100	100	97	100	96
Yr4	100	100	100	100	100
Yr5	0	0	0	0	0
Yr6	97	93	97	100	100
Yr7	9	63	97	92	93
Yr8	0	0	0	0	0
Yr9	100	100	100	100	96
Yr10	*	*	*	0	0
Yr15	0	0	0	0	0
Yr17	97	96	100	100	100
Yr24	*	*	*	0	0
Yr25	*	*	*	92	74
Yr32	100	96	90	100	96
Robigus	97	96	93	100	85
Solstice	97	96	93	100	85
Warrior	0	56	60	28	26
Spaldings Prolific	*	*	77	80	93
Rendezvous	91	63	27	48	11
Ambition	*	*	80	28	22
Apache	*	*	*	76	67
KWS Sterling	*	*	27	44	7
Cadenza	3	*	77	80	70
Claire	79	*	43	92	59
Crusoe	*	*	0	4	0
Total Number of Isolates	34	27	30	25	27

Table 5: Pathotype groups assigned to the wheat yellow rust isolates. “A” indicates an incompatible reaction (avirulence) and “V” indicates a compatible reaction (virulence)

Pathotype Group	Reaction on Differential		
	Spaldings Prolific	Warrior	Rendezvous
Warrior 1	V	V	A
Warrior 2	V	V	V
Warrior 3	V	A	A
Warrior 4	V	A	V
Other	A	A	V

Table 6: Pathotype group frequencies from 2012 to 2014

Pathotype Group	Frequency of Isolates Found (%)		
	2012	2013	2014
Warrior 1	60	20	26
Warrior 2	0	8	0
Warrior 3	13	32	63
Warrior 4	3	20	4
Other	23	20	7
Number of isolates	30	25	27

UK. The samples tested were also heavily biased according to host variety origin and will not fully represent every isolate in the UK.

4.1.3. Adult Plant Tests

To assess the impact of the most recent races of wheat yellow rust on varieties on the RL, two tests are carried out using a subset of five of the isolates tested in 4.1.2. The first test is a seedling test with each of the five isolates tested individually against seedlings of the RL varieties, candidate varieties, controls and a subset of the differential set. The second test evaluates adult plant resistance in individual trials for each of the isolates.

Isolates selected

Five isolates were selected for trial at seedling stage and adult plant stage and these were considered to be representative of the diversity of the isolates collected and pathotyped (Table 7). Three isolates from the Warrior 1 subgroup were selected, one from Warrior 3 and one classed as Other.

Seedling Tests

The five isolates were tested in seedling tests in the controlled environment rooms at NIAB in the summer of 2015. Results are combined with the adult plant test results (Table 8) and are sorted by the reaction on the adult plant trials. Twenty of the RL varieties and candidate varieties tested were resistant to all of the isolates tested, including well known resistant varieties such as Crusoe, Relay and KWS Gator. From the initial differential test results on these isolates, it was expected that varieties with Rendezvous in their pedigree would be susceptible to the isolate 14/108 at the seedling stage. This was confirmed, with the varieties Napier, Brigadier, KWS Santiago and Rendezvous all showing a compatible reaction with this isolate. Other varieties showing susceptibility to this isolate included Graham, Energise and Viscount. Warrior, RGT Conversion and Ambition all showed a very distinctive pattern, with susceptibility to the Warrior 1 isolates, and resistance to the other isolates, which agrees with expectations based on initial differential tests. With a very diverse population it can be difficult to identify patterns of response from the host varieties. There were some varieties that showed susceptibility to the Warrior isolates, but not to 14/108 (classed as "Other") such as Apache, Alchemy and Claire, all of which were affected by the change of race in 2011. Conversely there were varieties resistant to all of the Warrior isolates, but not the "other" isolate, in this experiment Dickens and KWS Trinity. Finally, there was one isolate that appeared to have additional uncharacterised virulences. The isolate 14/106, from Monterey displayed no obvious difference from other isolates in the preliminary differential tests, however in these tests it displayed virulence for many of the varieties tested. Some varieties were only susceptible to this isolate, such as Delphi, Revelation, KWS Sterling and Mosaic. Some of the varieties under evaluation were resistant to all of the isolates tested, however in previous years

these same varieties have been susceptible at the seedling stage. These varieties include KWS Gator, Britannia, Twister, Leeds, Zulu, Myriad, Icon, Relay, Invicta, Scout and KWS Croft. This "increase" in resistance at the seedling stage should be interpreted as the varieties being resistant to the five isolates under test and not the entire population. As discussed previously, the yellow rust population is very diverse and it is entirely possible that the five isolates chosen have by chance been avirulent on these varieties. Other isolates collected last year may have been virulent and so we would advise that these varieties are still monitored for yellow rust at the seedling stage.

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 2015. Assessments were made starting at growth stage 33 at the end of April through to growth stage 70 in the middle of June. The percentage of leaf area infected was assessed and the mean was taken of all assessments. The trials produced high levels of disease, with the susceptible controls Hornet and Robigus showing the highest levels of disease. Out of the 70 varieties tested, 29 showed no or trace levels of disease to all isolates. This included 18 RL varieties and 9 RL candidate varieties. The control varieties Cadenza and Mulika were also scored as highly resistant in these trials, however the visual symptoms on these two varieties were a high level of chlorotic striping without pustule formation. This gave the appearance of susceptibility, however the assessments made on these trials related to active yellow rust only and not host reactions. Susceptibility to all of the isolates tested was seen in KWS Kielder, Solstice, Gallant, the RL candidate variety Amplify and the control variety Hobbit. Moderate levels of disease were seen in Skyfall and Cubanita when challenged with all of the isolates tested. The remaining 32 varieties in the trials showed different levels of disease depending on the isolate used.

Resistance to Warrior isolates from Rendezvous confirmed in 2015 Trials

The varieties Rendezvous, Napier, Viscount and RGT Pembroke all showed low or moderate levels of disease when challenged with the Warrior isolates (14/12, 14/106, 14/501, 14/7), but much higher levels when challenged with the non-Warrior isolate 14/108. This result is in agreement with the virulence profile of the isolates, where virulence for Rendezvous at the seedling stage is only seen in the isolate 14/108. A similar result was seen in 2013, with KWS Santiago and Brigadier showing the same pattern. In the 2014 trials, both of these varieties show susceptibility to the non-Warrior isolate as we would expect, however they also show susceptibility to the isolate 14/106, the Warrior 1 isolate with additional virulence to KWS Sterling. This pattern is also seen for KWS Lili.

Table 7: Virulence profile of isolates selected for testing at adult plant stage in 2015. Re = Rendezvous, Sp = Spaldings Prolific, Ro = Robigus, So = Solstice, Wa = Warrior, Am = Ambition, Ca = Cadenza, St = KWS Sterling.

Isolate code	Host Variety	Pathotype Group	Virulence Profile																							
			1	2	3	4	5	6	7	8	9	10	15	17	24	25	32	Re	Sp	Ro	So	Wa	Am	Ca	St	Ap
14/007	KWS Kielder	Warrior 3	1	2	3	4		6	7		9			17		(25)	32		Sp	Ro	So			Ca		Ap
14/012	Timber	Warrior 1	1	2	3	4		6	7		9			17		25	32		Sp	Ro		Wa	Am	(Ca)		Ap
14/106	Monterey	Warrior 1	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So	Wa	Am	Ca	St	Ap
14/108	KWS Santiago	Other	1	2	3	4		6	(7)		9			17		25	32	Re		Ro	So					
14/501	Crusoe	Warrior 1	1	2	3	4		6	7		9			17		25	32		Sp	Ro	So	Wa	Am	(Ca)	(St)	Ap

Table 8: 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 eight assessments. Varieties are ordered in level of disease at adult plant stage for the isolates in order from left to right.

Variety	RL Rating 2015/16	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		14/012	14/106	14/501	14/007	14/108	14/012	14/106	14/501	14/007	14/108
Crusoe	9	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Costello	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KWS Crispin		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KWS Siskin		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scout	9	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Rendezvous		0.0	2.5	0.0	2.1	3.0	0.0	0.0	0.0	0.0	12.1
Sherlock		0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Icon	8	0.6	1.3	0.7	0.7	0.0	0.0	0.1	0.0	0.0	0.0
KWS Basset		1.3	3.0	2.4	1.0	3.0	0.0	0.1	0.0	0.0	0.0
Relay	9	0.2	0.0	0.1	0.2	1.6	0.0	0.1	0.0	0.0	0.0
Dickens	9	0.0	2.0	0.0	1.6	2.9	0.0	8.8	0.1	0.0	0.0
KWS Cashel	8	3.0	3.0	3.0	4.0	3.0	0.0	0.0	0.0	0.1	0.2
RGT Illustrious		0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.1
Mulika		3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
Delphi	8	0.9	3.1	1.9	2.2	0.5	0.0	0.0	0.1	0.0	0.0
KWS Gator	9	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.1	0.0	0.0
Zulu	9	0.1	2.0	0.0	1.0	2.0	0.0	0.1	0.0	0.0	0.0
KWS Trinity	9	0.1	1.5	0.0	0.0	3.0	0.0	0.1	0.1	0.2	0.5
KWS Silverstone		0.0	0.8	0.6	0.0	0.5	0.0	0.7	0.0	0.1	0.3
Cadenza		2.5	1.2	3.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0
RGT Marlborough		0.5	1.8	0.3	0.3	2.0	0.0	0.0	0.0	0.0	0.0
Cougar	8	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.1	1.9	1.0
Myriad	8	0.6	1.6	2.3	0.2	0.2	0.1	2.5	0.0	0.0	0.2
Revelation	9	0.0	3.0	0.0	0.0	2.1	0.1	0.0	0.0	0.0	0.0
JB Diego	8	1.4	1.5	0.8	2.8	0.7	0.1	1.7	1.6	0.5	0.5
KWS Croft	8	2.0	2.5	2.2	0.0	0.2	0.1	0.1	0.1	0.0	0.2
KWS Barrel		0.0	3.0	0.0	0.0	2.9	0.1	0.4	0.4	0.9	0.6

Variety	RL Rating 2015/16	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		14/012	14/106	14/501	14/007	14/108	14/012	14/106	14/501	14/007	14/108
Britannia	8	0.5	0.0	2.2	0.0	1.8	0.1	1.6	0.5	2.0	0.3
KWS Sterling		2.0	2.7	0.0	1.6	0.0	0.4	10.8	1.6	1.3	0.4
Invicta	8	0.4	2.0	2.1	2.2	0.0	0.5	2.5	1.0	0.0	0.5
Mosaic		0.1	3.0	0.3	2.1	0.3	0.7	0.8	0.8	1.2	0.9
Evolution	9	0.0	0.2	0.0	0.0	1.7	0.8	3.9	0.0	0.0	0.0
Napier		0.3	3.0	0.0	0.7	2.8	0.8	1.3	1.5	0.6	13.5
Spyder		1.5	3.0	2.0	2.7	3.0	1.4	16.6	0.5	0.1	0.0
Apache		3.0	3.5	3.0	3.0	0.0	1.5	10.5	3.1	0.3	0.0
Alchemy	7	3.0	3.0	3.0	3.0	1.7	1.6	3.7	9.8	0.1	0.4
Graham		0.6	3.0	3.0	3.0	3.0	1.8	16.0	1.4	0.2	0.5
Leeds	7	0.5	0.3	0.4	0.7	2.2	4.0	12.4	6.8	0.5	1.3
Brigadier		0.0	4.0	1.7	2.2	3.0	4.7	16.3	3.5	2.9	32.4
Energise		1.0	0.0	3.0	3.0	2.9	5.4	7.4	6.4	2.9	5.2
KWS Santiago	6	0.1	2.5	0.0	0.0	3.0	6.7	21.5	6.0	7.9	25.6
RGT Conversion	8	2.9	3.0	2.9	0.5	0.0	7.7	0.4	12.4	2.0	0.7
Compair		0.0	0.1	0.3	0.0	0.0	*	*	*	*	*
Kranich		2.0	3.0	3.0	0.0	0.0	8.9	16.9	14.8	0.0	0.0
Viscount	4	1.6	3.0	0.5	2.3	3.0	10.5	7.4	12.4	10.8	23.9
Butler		3.0	3.0	3.0	3.1	3.0	10.7	7.3	13.5	13.1	17.1
Monterey	7	0.0	2.5	1.1	0.2	0.3	11.1	27.1	15.6	1.1	3.2
Claire	6	3.0	2.8	3.0	3.0	1.9	12.1	12.4	14.5	0.4	1.4
Twister	6	0.4	1.5	1.0	0.7	0.9	12.3	21.9	15.7	5.8	3.6
Belgrade		1.0	2.9	2.2	1.1	2.5	12.8	33.1	9.1	1.3	2.7
RGT Pembroke		3.0	3.0	1.5	4.0	3.0	14.3	10.3	19.4	14.6	24.4
Grafton	6	2.8	2.0	3.0	3.0	0.0	15.2	7.5	11.0	17.8	16.8
Cubanita	6	3.0	3.0	3.0	2.7	1.5	15.2	15.4	19.7	15.1	15.1
Skyfall	6	1.2	0.5	1.7	2.8	0.0	15.4	13.1	18.8	13.6	13.9
Kws Lili	7	2.0	2.0	1.0	3.0	3.0	15.5	20.4	18.5	13.9	20.2
Warrior		3.0	3.0	2.7	1.4	0.0	17.3	34.8	11.2	1.4	0.2
Brock		3.0	4.0	3.0	4.0	0.0	18.4	17.2	22.9	19.7	21.5
Reflection	6	1.9	3.0	2.2	2.4	0.0	19.0	16.9	20.3	3.2	5.8

Variety	RL Rating 2015/16	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		14/012	14/106	14/501	14/007	14/108	14/012	14/106	14/501	14/007	14/108
Horatio	6	1.3	2.0	3.0	0.7	0.5	19.2	18.5	21.6	13.9	18.8
RGT Adventure		3.0	0.4	1.3	3.0	1.9	19.5	16.8	22.6	20.9	24.1
Hustler		2.9	4.0	3.0	3.0	4.0	21.9	21.3	17.2	17.8	21.8
Cordiale	5	3.5	3.5	3.0	3.0	0.0	23.0	17.5	23.6	26.2	26.1
Talon		2.5	3.5	3.0	2.5	3.0	25.3	50.5	35.9	14.3	19.8
Hobbit		1.2	3.0	3.0	3.0	3.0	25.4	24.4	27.6	26.3	32.7
Gallant	5	3.5	3.0	3.0	3.0	3.0	25.5	23.1	25.2	35.3	29.0
Amplify		3.0	3.0	3.0	4.0	1.7	26.1	21.4	28.4	23.9	30.3
Solstice	4	4.0	3.0	3.0	3.0	2.8	28.2	27.3	34.4	36.4	39.3
Kws Kielder	4	1.6	2.0	0.0	3.0	3.0	29.3	28.4	29.6	34.4	33.9
Hornet		3.0	3.0	3.0	3.0	3.0	42.1	44.8	46.5	43.1	46.6
Ambition		3.0	3.5	3.0	0.0	0.0	42.9	48.5	46.3	5.8	9.1
Robigus		3.0	3.0	3.0	3.0	3.0	47.9	50.4	50.9	46.4	48.6
Chinese 166		3.0	4.0	3.0	3.0	3.0					
Kalyansona		4.0	4.0	3.5	3.5	3.0					
Vilmorin 23		3.0	3.0	3.2	4.0	3.1					
Nord Desprez		3.3	3.0	3.5	4.0	3.0					
Hybrid 46		3.0	1.3	3.0	3.0	3.0					
Heines Kolben		3.0	3.0	3.0	3.0	3.0					
Heines Peko		3.1	3.0	3.5	3.0	3.0					
Lee		3.0	3.0	3.0	3.0	3.0					
Avocet Yr7 Nil		4.0	3.0	3.5	3.0	2.2					
Kavkaz 4 Fed		3.0	3.0	3.5	3.0	3.0					
Clement		3.0	3.0	3.5	3.5	3.0					
Avocet Yr15 Nil		0.0	0.0	0.0	0.0	0.0					
Vpm 1		3.0	3.0	3.0	3.0	3.0					
Avocet Yr17 Nil		3.0	3.0	3.0	3.1	3.0					
Carstens V		3.0	3.0	3.0	3.0	3.0					
Avocet Yr32 Nil		4.0	3.0	3.5	3.5	3.0					
Spaldings Prolific		3.0	2.4	3.0	3.0	2.0					
Avocet Yr5 Nil		0.0	0.0	0.0	0.0	0.0					

Variety	RL Rating 2015/16	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		14/012	14/106	14/501	14/007	14/108	14/012	14/106	14/501	14/007	14/108
Avocet Yr6 Nil		4.0	3.0	3.0	3.5	3.0					
Avocet Yr24 Nil		0.0	0.0	0.0	0.0	0.0					
Strubes Dickkopf		3.5	3.0	3.5	3.2	3.0					
Suwon Omar		3.5	0.5	3.0	3.1	3.0					
Stigg		0.0	0.0	0.0	0.0	0.0					
Moro		0.0	0.0	0.0	0.0	0.0					
Vuka		3.0	3.0	3.0	3.0	3.0					

* = Missing data

Varieties highlighted in green text are included as control varieties.

Colour coding: Seedling tests: Yellow indicates a compatible reaction, Orange indicates a borderline reaction. Adult plant tests: Green indicates resistant reaction, yellow indicates moderately resistant, orange indicates moderately susceptible and red indicates susceptible.

High levels of disease in one of the trials disagree with seedling test results

Noticeably higher levels of disease were seen in the trial inoculated with the isolate 14/106. This was not entirely unexpected as this isolate displayed virulence to a wider range of varieties at the seedling stage than the other isolates under investigation. There were however instances where moderate to high levels of disease were seen on varieties that showed resistance or low levels of disease at the seedling stage, for example, Dickens and Leeds. These discrepancies were also seen in some of the other trials and suggested that there was some natural infection in the trial as well as the infection caused by the inoculated isolates. To investigate these further, samples were taken from the trial and the isolates obtained were tested using a standard differential set. The pathotype of these isolates differed to the original pathotype. The new isolate had the pathotype: 1,2,3,6,7,8,9,17,25,32,Ro,Wa,Am,Ap. This was quite different to the original pathotype with avirulence for *Yr4*, Solstice and Spaldings Prolific all noted. Additional virulence was seen for *Yr8* which has not been recorded in the UK since 1977. These initial results would suggest that there was natural infection in the trial by a new race. To confirm this, stocks of the isolate 14/106 were tested again in a seedling differentia test by the UKCPVS and also by our collaborators at the Global Rust Reference Centre (GRRRC) to confirm the initial differential test results. The results from the GRRRC showed the same pathotype as the re-isolated samples from the trial and also supported the hypothesis that the isolate was in fact an isolate of the Kranich race (Hovmøller, Rodriguez Algaba and Jørgensen, *pers. comm.*). The Kranich race was first detected in 2011 in Denmark and Sweden and was identified by the pathotype 1,2,3,6,7,8,9,17,25,32 [8]. It has not been detected in the UK before now. When stocks of 14/106 were re-tested by the UKCPVS, the results were almost completely in agreement, with avirulence for *Yr4* and Spaldings Prolific both noted, however avirulence was also noted for *Yr8*. Taken together, there are two possible explanations. Firstly, given that avirulence for *Yr8* is consistently noted for different stocks of 14/106 by the UKCPVS but not for the re-isolated sample from the field trial, it is possible that there was a late season incursion into the trial and that the isolate 14/106 is not the Kranich race and an additional isolate infected the trial late in the season. The alternative possibility is that the isolate 14/106 is an isolate of the Kranich race, as suggested by the results from Denmark and the re-isolation results, and that tests on the 14/106 stocks by the UKCPVS are not in agreement for other reasons, for example testing under artificial light. This is the more likely explanation and further investigation is under way to establish the cause of this discrepancy.

Some susceptible varieties are showing higher than expected levels of disease

When comparing the trial results with results from previous years, some of the susceptible varieties and controls are conspicuous by their higher than expected levels of disease. Varieties such as KWS Kielder, Cordiale and Gallant all appear to be more susceptible this year. This may be due to the isolates under evaluation in these trials, however we cannot rule out the possibility of natural infection playing a part and further investigation of isolates from the other trials is under way.

Analysis of both datasets highlights varieties with adult plant resistance

There were a number of varieties that showed susceptibility at the seedling stage but were resistant under field conditions. They included Mosaic, KWS Basset, Revelation, JB Diego and KWS Barrel. These varieties were resistant to all of the isolates under test. It is not possible to predict durability based on these results and although durable resistance has been typified by adult plant resistance in the past we would recommend that caution is exercised and that no variety is assumed to be durably resistant, particularly in light of recent incursions. It is also important to note that these results only relate to five isolates. As seen in the differential tests, the wheat yellow rust population is diverse and it is entirely possible that varieties resistant to all isolates in these tests may be susceptible to other isolates currently found in the UK.

4.2. Wheat Brown Rust

4.2.1. Samples Received

In 2014, the UKCPVS received 73 samples of wheat brown rust from 9 different counties across the UK, with the majority of samples being received from the East of England (Figure 2). The full register is given in Appendix 2.



Figure 2: Map of the UK with the number of samples of wheat brown rust received in 2014 from the different counties.

The number of samples received was more modest than that for wheat yellow rust, but reflects the later emergence of this disease. As before, the host varieties have not been confirmed and the full register is supplied for information only. As in 2013 there were widespread reports of higher than expected levels of brown rust on the variety Crusoe. Therefore samples from this variety were of

particular interest to the survey. Other samples of interest included those from the varieties Cougar, Delphi, Dickens, Evolution, KWS Kielder, Revelation, Scout, Skyfall and Tuxedo, which all have RL ratings of 8 or above (2014/15 ratings).

4.2.2. Pathotyping of Isolates

Twenty five isolates were selected for further pathotyping using a differential set (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 average infection type (a.i.t.) to the component varieties. Isolates were classified as virulent if the a.i.t. score was 2.7 or above. Scores between 2.4 and 2.6 were considered borderline. Using these scores, it is possible to combine the scores for reactions to different resistance genes to infer a pathotype for each of the isolates (Table 10).

The results of these tests show that no new virulence for individual resistance genes was detected in the isolates collected using the limited set of differentials in use. When comparing the frequency of virulences detected over years it is clear that there has been a change in the population with marked increases and decreases in virulence for certain genes (Table 11). There was an increase in the frequency of detecting virulence for the genes *Lr1*, *Lr3a*, *Lr17b*, *Lr20*, *Lr26* and *Lr37*. There were also increases in detection of virulence for the varieties Dickens, Chronicle, Crusoe, KWS Sterling, Tuxedo and Revelation. There was a decrease in the detection of virulence for the genes *Lr24* and *Lr28*, which closely matches the reduction in acreage of varieties carrying these resistance genes (principally Warrior, Stigg and Robigus derivatives). This shift in the population is not unusual for the UK wheat brown rust population where historically there has been no single dominant race, rather a mixture of races that come and go according to the host varieties in use. When considering the pathotypes of the isolates it was clear that there was a core pathotype dominating in most of the isolates: virulence for *Lr1,3a,17b,20,26,37* with additional virulences for *Lr24* or *Lr28*, with 11 out of the 25 isolates carrying this core pathotype. This has been seen before in the UK as the Glasgow race and so it appears that the population has seen a re-emergence of a historic pathotype.

4.2.3. Adult Plant Tests

To establish whether the Glasgow race was responsible for the higher than expected levels of brown rust on the variety Crusoe, adult plant tests were carried out at NIAB in the summer of 2015. In addition to the adult plant trials in the field, a seedling test was also carried out using the selected isolates and all of the varieties from the RL.

Table 9: Average Infection Type (AIT) scores for the 25 selected isolates against the UKCPVS differential set. Yellow shading indicates a compatible reaction, orange indicates a borderline reaction. Compatible interactions classify the isolate as virulent against a particular resistance gene or variety. Numbers next to the differential variety name indicate the known resistance genes carried by the variety. I = no reaction. Th = Thatcher NIL.

Isolate Number	Host variety	1	1	3a	17b	20	20	20	24	24	24	26	26	28	28	28	28	37	APR	APR						APR		
		Th Lr1	Glasgow	Sterna	M Fundin	Th Lr20	Sappo	M Halberd	Th Lr24	Stigg	Warrior	Clement	Th Lr26	Robigus	Scout	Horatio	Leeds	Th Lr37	Alchemy	Cocoon	Tuxedo	Sterling	Crusoe	Cougar	Dickens	Revelation	Chronicle	Armada
14/001	JB Diego	0.0	0.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0
14/007	Beluga	I	3.0	2.0	0.2	3.0	2.0	3.0	3.0	0.8	3.0	1.5	2.5	i	1.0	2.0	1.0	2.0	2.5	3.0	1.0	2.8	2.8	2.0	3.0	2.3	1.0	2.3
14/009	Crusoe	3.0	3.0	2.5	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0
14/011	Energise	0.3	0.3	2.8	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
14/013	Jorvik	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
14/014	Soissons	I	2.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.3	3.0	1.0	i	i	0.0	i	2.5	3.0	3.0	0.0	1.0	2.8	0.0	0.5	1.5	0.0	3.0
14/019	KWS Trinity	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0
14/020	Delphi	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	3.0	0.0	0.5	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0
14/022	Alchemy	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	3.0	3.0	2.5	3.0	3.0	3.0	3.0	3.0	3.0	2.5	3.0	3.0	3.0	3.0
14/025	Revelation	3.0	3.0	3.0	3.0	3.0	3.0	3.0	1.0	3.0	3.0	3.0	3.0	i	3.0	3.0	2.5	3.0	3.0	3.0	3.0	3.0	3.0	1.0	3.0	3.0	3.0	3.0
14/030	Myriad	0.0	0.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.5	0.0	3.0	2.8	3.0	3.0	3.0	3.0	0.3	3.0	3.0	3.0	3.0
14/031	Conquerer	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	2.8	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0
14/033	Grafton	3.0	3.0	2.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	2.0	3.0	2.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0
14/039	Rye	3.0	3.0	3.0	3.0	3.0	3.0	3.0	1.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0
14/040	KWS lili	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.5	0.0	0.0	3.0	3.0	0.0	0.0	1.0	0.0	3.0	2.0	3.0	3.0	3.0	3.0	0.5	3.0	3.0	3.0	3.0
14/041	Crusoe	3.0	2.5	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	2.5	0.0	0.0	0.0	0.0	2.5	2.5	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0
14/043	Warrior	0.3	0.0	3.0	2.5	3.0	3.0	3.0	0.5	0.3	0.3	3.0	2.0	0.3	0.8	0.0	0.0	2.5	2.5	3.0	2.5	2.5	3.0	0.0	3.0	2.5	2.5	2.5
14/051	Evolution	3.0	2.0	2.0	2.0	2.0	1.8	2.5	0.0	0.0	0.0	2.0	3.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	2.5	2.5	2.5	0.0	3.0	3.0	3.0	3.0
14/052	KWS Cashel	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0
14/053	Skyfall	3.0	3.0	2.5	2.8	3.0	3.0	3.0	0.0	0.0	0.0	3.0	2.5	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	2.5	3.0	0.0	3.0	3.0	3.0	3.0
14/054	KWS Tempo	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0
14/502	Relay	0.0	0.0	2.5	3.0	2.5	3.0	3.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	3.0	2.0	3.0	2.5	3.0	3.0	0.0	3.0	3.0	2.5	2.5
14/503	Scout	3.0	0.0	3.0	3.0	3.0	3.0	3.0	0.0	0.3	0.3	3.0	3.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.8	3.0	3.0	2.5
14/504	Dickens	3.0	0.3	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	3.0	2.0	0.0	0.0	0.0	0.0	2.0	2.0	3.0	3.0	3.0	3.0	0.0	2.0	3.0	2.5	2.0
14/505	Tuxedo	3.0	3.0	3.0	2.5	3.0	3.0	3.0	0.0	0.0	0.0	2.0	3.0	0.5	0.0	0.0	0.0	3.0	3.0	1.0	1.0	2.5	2.5	0.0	2.5	2.5	2.3	2.5

Table 10: Pathotypes of the 2014 wheat brown rust isolates based on the differential test results in Table 9. Al = Alchemy, Co = Cocoon, Tu = Tuxedo, St = KWS Sterling, Cr = Crusoe, Cou = Cougar, Di = Dickens, Re = Revelation, Ch = Chronicle.

Isolate Number	Host variety	Pathotype	Virulence Profile																
			1	3a	17b	20	24	26	28	37	Al	Co	Tu	St	Cr	Cou	Di	Re	Ch
14/001	JB Diego	3a, 17b, 20, 26, 37		3a	17b	20		26		37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/007	Beluga	1, 20, 24	1			20	24	(26)			(Al)	Co		St	Cr		Di		
14/009	Crusoe	1, 17b, 20, 26, 37	1	(3a)	17b	20		26		37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/011	Energise	3a, 17b, 20, 26, 28, 37		3a	17b	20		26	28	37	Al	Co	Tu	St	Cr	Cou	Di	Re	Ch
14/013	Jorvik	1, 3a, 17b, 20, 26, 28, 37	1	3a	17b	20		26	28	37	Al	Co	Tu	St	Cr	Cou	Di	Re	Ch
14/014	Soissons	3a, 17b, 20, 26		3a	17b	20		26		(37)	Al	Co			Cr				
14/019	KWS Trinity	1, 3a, 17b, 20, 26, 37	1	3a	17b	20		26		37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/020	Delphi	1, 3a, 17b, 20, 26, 37	1	3a	17b	20		26		37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/022	Alchemy	1, 3a, 17b, 20, 24, 26, 37	1	3a	17b	20	24	26	(28)	37	Al	Co	Tu	St	Cr	(Cou)	Di	Re	Ch
14/025	Revelation	1, 3a, 17b, 20, 24, 26, 37	1	3a	17b	20	24	26	(28)	37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/030	Myriad	3a, 17b, 20, 26, 37		3a	17b	20		26		37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/031	Conquerer	1, 3a, 17b, 20, 26, 37	1	3a	17b	20		26		37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/033	Grafton	1, 17b, 20, 24, 26, 37	1		17b	20	24	26	(28)	37		Co	Tu	St	Cr		Di	Re	Ch
14/039	Rye	1, 3a, 17b, 20, 24, 26, 37	1	3a	17b	20	24	26		37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/040	KWS lili	1, 3a, 17b, 20, 26, 37	1	3a	17b	20		26		37		Co	Tu	St	Cr		Di	Re	Ch
14/041	Crusoe	1, 3a, 17b, 20, 26	1	3a	17b	20		26		(37)	(Al)	Co	Tu	St	Cr		Di	Re	Ch
14/043	Warrior	3a, 20, 26		3a	(17b)	20		26		(37)	(Al)	Co	(Tu)	(St)	Cr		Di	(Re)	(Ch)
14/051	Evolution	1, 26, 37	1			(20)		26		37	Al	Co	(Tu)	(St)	(Cr)		Di	Re	Ch
14/052	KWS Cashel	1, 3a, 17b, 20, 26, 37	1	3a	17b	20		26		37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/053	Skyfall	1, 17b, 20, 26, 37	1	(3a)	17b	20		26		37	Al	Co	Tu	(St)	Cr		Di	Re	Ch
14/054	KWS Tempo	1, 3a, 17b, 20, 26, 37	1	3a	17b	20		26		37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/502	Relay	17b, 20, 26, 37		(3a)	17b	20		26		37		Co	(Tu)	St	Cr		Di	Re	(Ch)
14/503	Scout	1, 3a, 17b, 20, 26, 28, 37	1	3a	17b	20		26	28	37		Co	Tu	St	Cr	Cou	Di	Re	Ch
14/504	Dickens	1, 3a, 17b, 20, 26	1	3a	17b	20		26				Co	Tu	St	Cr			Re	(Ch)
14/505	Tuxedo	1, 3a, 20, 26, 37	1	3a	(17b)	20		26		37	Al			(St)	(Cr)		(Di)	(Re)	

Table 11: Virulence frequencies of key resistance genes from 2005-2014.

Virulence for Differential	Postulated Resistance Gene	Year									
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Glasgow	<i>Lr1</i>		32	17	19	18	0	10	7	40	72
Thatcher x <i>Lr1</i>	<i>Lr1</i>	28	32	13	14	18	0	10	7	24	60
Sterna	<i>Lr3a</i>	56	68	8	14	0	90	0	7	24	76
Fundin	<i>Lr17b</i> , APR	100	100	100	86	91	70	86	89	76	84
Sappo	<i>Lr20</i>	13	28	8	5	0	0	14	19	24	92
Halberd	<i>Lr20</i>	13	24	8	10	9	0	10	22	12	96
Thatcher x <i>Lr20</i>	<i>Lr20</i>								7	4	92
Thatcher x <i>Lr24</i>	<i>Lr24</i>								37	16	8
Stigg	<i>Lr24</i>							24	41	24	16
Warrior	<i>Lr24</i>						0	5	44	28	20
Clement	<i>Lr26</i>	69	44	21	24	0	70	5	11	44	88
Thatcher x <i>Lr26</i>	<i>Lr26</i>	69	44	17	33	0	40	5	11	28	76
Robigus	<i>Lr28</i> , Robigus		32	30	10	18	0	52	59	48	12
Scout	<i>Lr28</i> , Robigus				14	18	0	43	59	44	24
Horatio	<i>Lr28</i> , Robigus							38	56	44	24
Leeds	<i>Lr28</i> , Robigus								48	44	12
Thatcher x <i>Lr37</i>	<i>Lr37</i> , APR		100	30	91	27	100	91	59	56	80
Alchemy	Claire		100	58	100	100	100	91	85	68	68
Chronicle									67	64	76
Cocoon									74	68	96
Cougar									33	28	12
Crusoe									67	48	92
Dickens									33	28	88
KWS Sterling									33	44	80
Revelation									82	52	84
Tuxedo									59	48	76
Armada		100	100	100	100	100	100	100	100	72	76
No. isolates		32	25	24	21	11	10	21	27	25	25

Table 12: Virulence profile of isolates selected for testing at adult plant stage in 2015. Al = Alchemy, Co = Cocoon, Tu = Tuxedo, St = KWS Sterling, Cr = Crusoe, Cou = Cougar, Di = Dickens, Re = Revelation, Ch = Chronicle.

Isolate code	Host Variety	Pathotype Group	Virulence Profile																
			1	3a	17b	20	24	26	28	37	Al	Co	Tu	St	Cr	Cou	Di	Re	Ch
14/001	JB Diego	3a, 17b, 20, 26, 37		3a	17b	20		26		37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/011	Energise	3a, 17b, 20, 26, 28, 37		3a	17b	20		26	28	37	Al	Co	Tu	St	Cr	Cou	Di	Re	Ch
14/013	Jorvik	1, 3a, 17b, 20, 26, 28, 37	1	3a	17b	20		26	28	37	Al	Co	Tu	St	Cr	Cou	Di	Re	Ch
14/019	KWS Trinity	1, 3a, 17b, 20, 26, 37	1	3a	17b	20		26		37	Al	Co	Tu	St	Cr		Di	Re	Ch
14/022	Alchemy	1, 3a, 17b, 20, 24, 26, 37	1	3a	17b	20	24	26	(28)	37	Al	Co	Tu	St	Cr	(Cou)	Di	Re	Ch

Isolates selected

Five isolates were selected for these tests (Table 12) and these isolates were considered to be representative of the diversity of the isolates collected and pathotyped. All of the isolates selected are similar to the Glasgow pathotype, however they each have slightly different virulence profiles. The isolate 14/19 is the core Glasgow race, 14/01 is avirulent on *Lr1*, 14/11 is avirulent on *Lr1* but virulent on *Lr28* (the Robigus resistance), 14/13 is the Glasgow race with additional virulence for *Lr28* and similarly 14/22 is the Glasgow race with additional virulence for *Lr24* (the Stigg and Warrior resistance gene).

Seedling Tests

The five isolates were tested in seedling tests in the controlled environment rooms at NIAB in the summer of 2015. Results are combined with the adult plant test results (Table 13) and are sorted by the reaction on the adult plant trials. Twenty three of the varieties and differential lines were resistant to all of the isolates tested. From the initial differential test results on these isolates, it was expected that varieties such as Warrior, Glasgow and Robigus would be susceptible to some of the isolates. Unfortunately the tests carried out in the summer of 2015 did not agree with the original differential tests carried out in winter 2014. For example, the isolates 14/13, 14/19 and 14/22 are all virulent on *Lr1* in the original differential tests, but in these seedling tests both Glasgow and the Thatcher *Lr1* NIL are resistant to all of these isolates. There are two possible explanations for this. Brown rust resistance genes are known to be difficult to handle under controlled environment conditions, with variable expression of symptoms reported by other researchers (H. Goyeau, *pers. comm.*). To investigate this further we plan to test some of the isolates collected in 2015 in parallel experiments in both the growth room and in glasshouse units. The second explanation could be that the isolate has been altered in the process of multiplication. Wheat brown rust takes more rounds of multiplication in the growth rooms to obtain enough spores to test. Further method improvements are currently under investigation to improve efficiency and thereby reduce the number of rounds of multiplication required. This disagreement between the differential test results and these seedling tests was not universal across all of the genes, for example there was perfect agreement for the genes *Lr3a* and *Lr37*. Taken together, the results presented here indicate a minimum level of susceptibility for the RL varieties under test. For example, varieties currently listed as resistant to all isolates may be susceptible to one of the isolates that was previously virulent on *Lr1* but due to the reasons discussed above susceptibility may not be evident in the current tests. There was one result of note from the RL varieties however, Myriad has been resistant at the seedling stage against all isolates in the past two years of testing, however it was susceptible to two of the isolates (14/22 and 14/01). This could suggest that 14/22 and 14/01 are part of a new race that was not evident until these tests on a wider

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 three assessments.

Variety	RL Rating 2015/16	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		14/01	14/11	14/13	14/19	14/22	14/01	14/11	14/13	14/19	14/22
Revelation	8	2.8	2.0	3.0	3.0	3.0	0.2	17.9	1.1	16.7	3.9
Maris Fundin		2.8	0.0	3.0	3.0	3.0	0.2	3.2	5.4	40.3	27.2
KWS Target		0.0	0.0	2.8	0.0	0.0	0.9	0.7	18.7	1.5	4.7
Skyfall	8	3.0	0.0	3.0	3.0	3.0	1.0	2.9	1.9	14.2	4.3
Maris Huntsman		2.8	2.8	3.0	3.0	3.0	1.0	12.2	2.2	10.7	2.2
Cordiale	4	3.0	3.0	3.0	2.5	3.0	1.0	15.5	33.7	5.2	1.0
Gamin		2.8	3.0	3.0	3.0	3.0	1.1	4.7	2.0	2.0	*
Evolution	8	2.0	2.8	3.0	3.0	2.0	1.1	5.0	1.7	*	*
Reaper		2.5	2.8	3.0	3.0	2.5	1.3	27.7	14.9	2.1	9.0
Britannia	5	0.0	0.0	0.0	0.0	0.0	1.4	7.8	3.4	*	*
Crusoe	4	2.8	2.8	2.8	3.0	2.8	1.4	34.1	22.5	2.0	*
Grafton	4	2.8	3.0	3.0	3.0	3.0	1.5	1.9	18.2	0.2	0.7
RGT Adventure		2.0	1.0	3.0	3.0	2.5	1.6	17.0	*	35.0	10.5
Cougar	9	0.0	0.0	0.0	0.0	0.0	2.0	*	0.0	3.7	0.1
RGT Pembroke		0.0	0.0	0.0	0.0	0.0	2.1	*	9.4	12.7	2.7
Armada		2.8	3.0	3.0	3.0	3.0	2.1	2.2	7.0	2.3	1.7
Avalon		2.8	3.0	3.0	3.0	2.5	2.2	4.0	*	*	0.7
Consort		3.0	3.0	3.0	3.0	3.0	2.2	22.3	37.5	38.3	20.0
Claire	5	3.0	3.0	3.0	0.0	3.0	2.2	19.8	2.7	35.5	*
Horatio	6	0.0	0.2	0.0	0.0	0.0	2.5	17.3	9.7	5.7	20.2
RGT Illustrious		2.0	2.0	3.0	3.0	2.5	2.8	17.4	3.5	11.8	1.3
Costello	7	2.5	2.0	3.0	3.0	2.8	2.9	1.3	7.5	3.4	6.0
Solstice	5	3.0	3.0	3.0	0.0	3.0	2.9	1.4	*	8.7	4.0
RGT Marlborough		0.0	0.0	0.0	0.6	0.0	2.9	4.1	0.0	3.3	3.2
KWS Siskin		2.0	2.5	2.8	2.0	3.0	3.4	42.5	2.2	4.0	3.9

Variety	RL Rating 2015/16	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		14/01	14/11	14/13	14/19	14/22	14/01	14/11	14/13	14/19	14/22
Energise		0.2	0.0	0.0	0.0	0.0	3.7	0.2	7.8	*	1.6
RGT Conversion	6	0.0	0.0	0.0	0.0	0.0	3.7	5.3	1.5	*	4.5
KWS Santiago	6	2.8	0.5	3.0	3.0	3.0	3.8	3.5	13.3	*	5.2
KWS Barrel		2.0	2.0	3.0	2.0	3.0	3.9	31.8	3.4	9.5	4.0
Maris Ranger		1.0	1.0	1.0	1.0	1.0	4.0	3.0	*	8.7	1.4
KWS Croft	6	0.0	0.0	0.0	0.0	0.0	4.0	22.7	8.0	6.5	2.0
Delphi	7	3.0	3.0	3.0	3.0	3.0	4.5	3.5	8.2	15.5	1.4
KWS Sterling		2.5	2.0	2.8	3.0	2.5	4.5	2.7	4.7	3.5	4.7
Scout	7	0.0	2.0	0.0	0.0	0.0	4.5	9.2	2.9	9.0	*
Mosaic		2.5	3.0	3.0	3.0	3.0	4.7	8.8	23.3	4.5	11.5
KWS Cashel	9	3.0	2.3	3.0	3.0	3.0	4.9	0.4	0.1	10.5	1.2
Glasgow		0.0	0.0	*	0.0	0.0	5.0	6.2	*	0.0	3.2
Myriad	5	3.0	0.0	0.2	0.3	3.0	5.0	1.4	3.3	4.3	2.2
KWS Kielder	8	3.0	2.5	2.5	3.0	3.0	5.0	14.8	*	7.5	7.7
Buster		*	*	*	*	0.8	5.0	27.8	41.2	0.0	*
Maris Halberd		2.8	0.0	3.0	3.0	3.0	5.2	5.0	*	*	3.4
Cubanita	5	2.8	3.0	3.0	2.8	3.0	5.5	11.3	4.7	1.2	0.7
Alchemy	4	3.0	3.0	3.0	3.0	3.0	5.7	20.5	2.1	15.0	*
Gallant	6	3.0	3.0	3.0	3.0	3.0	5.7	30.0	*	10.7	1.9
Robigus		0.0	0.0	0.0	0.0	0.0	6.5	25.5	*	5.0	0.0
Stigg		0.0	0.0	0.0	0.0	0.3	7.0	3.5	1.2	5.3	1.2
Sappo		0.0	2.5	3.0	3.0	3.0	7.7	1.7	*	5.5	*
KWS Trinity	8	2.0	2.8	3.0	3.0	3.0	8.0	13.0	3.8	*	2.3
KWS Basset		2.8	3.0	3.0	2.5	3.0	8.4	21.7	9.5	*	17.8
Leeds	4	0.0	0.0	0.0	0.0	0.0	9.3	28.7	5.9	*	13.8
Belgrade		3.0	2.8	3.0	3.0	2.5	9.5	36.0	4.5	2.5	2.7
JB Diego	5	2.8	2.8	3.0	3.0	3.0	10.0	2.2	6.7	1.2	*
Sterna		3.0	3.0	2.8	3.0	3.0	10.4	20.5	0.2	5.0	3.7
KWS Silverstone		2.5	2.5	3.0	0.0	0.0	11.0	2.3	0.7	19.2	2.6
KWS Crispin		2.0	0.0	2.5	3.0	2.5	12.5	12.2	3.3	0.4	*

Variety	RL Rating 2015/16	Seedling (Average Infection Type)					Adult Plant (% leaf area infected)				
		14/01	14/11	14/13	14/19	14/22	14/01	14/11	14/13	14/19	14/22
Butler		2.5	2.3	2.3	3.0	3.0	12.5	36.0	6.9	7.2	*
Graham		2.5	3.0	3.0	3.0	3.0	12.7	0.4	3.2	2.4	*
Invicta	6	0.0	0.0	0.0	0.0	0.0	12.8	4.2	4.6	*	16.7
Twister	4	0.0	0.0	0.0	0.0	0.0	14.7	30.0	20.8	9.9	*
Tuxedo		2.8	2.3	3.0	3.0	3.0	14.7	1.7	10.3	5.8	2.0
KWS Gator	3	2.0	1.0	3.0	3.0	3.0	16.0	1.2	30.5	*	*
Icon	5	0.0	0.0	0.0	0.0	0.0	16.3	0.5	3.9	1.7	2.1
Viscount	7	0.0	0.0	0.0	0.0	0.0	16.5	37.5	1.2	17.3	3.4
Monterey	4	0.0	0.0	0.0	0.0	0.0	17.0	18.3	7.2	11.2	6.0
Soissons		3.0	3.0	3.0	3.0	3.0	17.5	14.8	35.2	0.5	*
Dickens	8	3.0	3.0	3.0	3.0	3.0	17.6	2.5	2.3	5.5	*
Amplify		3.0	3.0	2.8	3.0	3.0	17.9	6.4	*	2.3	3.7
Reflection	9	0.0	0.0	0.0	0.0	0.0	18.2	17.9	0.0	17.2	3.0
Mascot		3.0	2.8	3.0	3.0	2.5	18.2	35.0	5.3	5.2	8.7
KWS Lili	5	2.8	2.8	1.5	3.0	2.5	18.7	5.3	19.3	3.0	2.4
Sherlock		0.0	0.0	0.0	3.0	2.5	20.2	18.0	0.0	1.7	*
Relay	8	2.8	2.8	2.0	3.0	3.0	20.3	2.1	2.5	*	8.8
Zulu	4	2.8	2.8	2.5	3.0	3.0	23.8	17.8	3.7	5.7	2.3
Spyder		2.8	2.0	3.0	3.0	2.5	26.1	4.7	2.1	2.0	1.4
Warrior		0.0	0.0	0.0	0.0	0.3	44.3	0.2	26.3	2.0	0.7
Clement		2.8	2.5	2.5	3.0	3.0					
Thatcher Lr1 NIL		0.0	0.0	0.0	1.0	0.0					
Thatcher Lr20 NIL		3.0	3.0	2.8	3.0	3.0					
Thatcher Lr24 NIL		0.0	0.0	0.0	0.0	0.0					
Thatcher Lr26 NIL		3.0	2.8	2.8	3.0	3.0					
Thatcher Lr37 NIL		2.8	3.0	3.0	3.0	3.0					

* = Missing data

Varieties highlighted in green text are included as control varieties.

Colour coding: Seedling tests: Yellow indicates a compatible reaction, Orange indicates a borderline reaction. Adult plant tests: Green indicates resistant reaction, yellow indicates moderately resistant, orange indicates moderately susceptible and red indicates susceptible.

range of varieties was carried out. Further work is needed to compare the reaction of Myriad with older Glasgow races to establish if the new Glasgow race is indeed an old race re-emerging or a slightly different variant.

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 2015. The disease was slow to develop in these trials due to the cool overcast weather conditions experienced. Assessments were made starting at growth stage 65 in the middle of June through to growth stage 83 at the end of July, although usable data was only obtained between 25th June and 9th July. Prior to the 25th June disease levels were too low to be useful in the analysis (below 5%). Some of the assessments were omitted from the final assessments as the plants were senescing or had become too heavily infected with other diseases to be reliable. Where this has happened the data for that particular variety-isolate combination are recorded as missing. Although the trial was late in developing disease, high levels of disease were seen on some of the susceptible controls, such as Buster. It is noticeable that Buster is not universally susceptible to all of the isolates tested and the other universal susceptible variety, Armada, is much cleaner than expected. Some of the other control varieties are showing disease levels that disagree with expectations based on the initial differential test. For example, Warrior should only be susceptible to 14/22 but shows susceptibility to 14/01 and 14/13 and resistance to 14/22. There are also examples of varieties which are resistant at the seedling stage, such as Robigus, which show high levels of disease at the adult plant stage. Taken together, this evidence suggests that the initial inoculation failed to progress due to unfavourable environmental conditions, and the trials were naturally infected at a later point in the season. This was confirmed when an infected sample from the 14/11 trial was tested. The infected sample had a virulence profile of 1, 3a, 20, which is very different to the expected profile of virulence to *Lr3a*, 17b, 20, 26, 28, 37.

Although the trials are complicated by the incursion of natural isolates the results are still of use to highlight any new varietal susceptibilities. The varieties KWS Kielder, Horatio, Reflection, Relay, Revelation, Viscount and Dickens have all shown the highest amount of disease in these trials in the years of inclusion in the adult plant tests. Other varieties such as Cubanita and Energise have less disease than previous years which could reflect a change in the brown rust population, but most likely it indicates an escape due to low disease pressure. Interestingly, although we suspect the trials are mainly naturally infected, both Cordiale and Cubanita (a Cordiale derivative) show susceptibility to the isolate(s) in the 14/13 trial. Further investigations are underway to establish the causal isolate.

4.3. Wheat Powdery Mildew

4.3.1. Samples Received

As with previous years, 2014 was not reported to be a bad mildew year for wheat and as such the survey only received 13 samples. These samples came from 10 different varieties and 4 counties. Further samples were obtained from trap pots of the variety Cerco which are used when sample numbers are low.

4.3.2. Pathotyping of Isolates

From the 112 samples, 27 were chosen for further characterisation using the detached leaf method detailed in section 3. Results from the assays were converted into a binary code for ease of interpretation (Table 14) and were compared to virulence frequencies from the past five years of testing (Table 15).

Virulence was seen for all of the differentials tested, with the exception of Amigo, which carries the gene *Pm17*. This is in agreement with data for previous years, which shows that virulence for this gene was last detected in 2010. Changes in frequency of detection were seen for most of the resistance genes tested, however most were within the expected boundaries, as evidenced by the variation seen over the past five years. Virulence for the genes *Pm8* and the resistance gene(s) in Robigus were found at the highest levels in the last five years. There were however no reports of 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 are not tested 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.

Table 14: Pathotype results for the wheat powdery mildew detached seedling tests. Average infection types have been converted into a binary factor, where 1 = a compatible reaction (virulent), highlighted yellow and 0 = an incompatible reaction (avirulent). Differential varieties are listed along with the known resistance genes carried by these lines.

Isolate Number	Host Variety		<i>Pm2</i>	<i>Pm3b</i>	<i>Pm4b</i>	<i>Pm5</i>	<i>Pm6</i>	<i>Mld</i>	<i>Pm8</i>	<i>Pm2,MITa2</i>	<i>Pm5,MITa2</i>		<i>Pm3d</i>	<i>Pm5, MISi2</i>		<i>MIAx</i>	<i>Pm17</i>	<i>MISh</i>				
		Cerco	Galahad	Chul	Armada	Flanders	Brimstone	Maris dove	Clement	Brock	Mercia	Tonic	Broom	Sicco	Wembley	Axona	Amigo	Shamrock	Robigus	Warrior	Stigg	Crusoe
14.30.AW	Cerco	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0
14.44.AW	Cerco	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0
14.12.7	Armada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
14.4.2	Conquerer	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
14.3.1	Beluga	0	1	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0
14.2.1	Cougar	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	1
14.8.3	KWS Santiago	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0
14.10.3	JB Diego	1	1	0	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0
14.75.A	Cerco	1	0	0	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	1	1	1
14.2.2	Cerco	1	1	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
14.86.A	Cerco	0	0	0	1	1	1	1	0	1	1	0	0	0	0	0	0	0	1	0	0	1
14.18.EC	Cerco	0	0	0	1	1	1	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0
14.6.3	Britannia	1	1	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
14/96/AH	Cerco	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0
14/16/SC	Cerco	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1
14/8/1	KWS Santiago	0	1	0	1	1	1	0	1	1	1	0	0	1	1	0	0	0	1	0	0	0
14/11/02	Solstice	0	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	0	1
14/21/RB	Cerco	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0	1	0	0	1
14/14/6	Cerco	1	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1
14/5/2	Evolution	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	0	1

Isolate Number	Host Variety																					
		Cerco	Galahad	Chul	Armada	Flanders	Brimstone	Maris dove	Clement	Brock	Mercia	Tonic	Broom	Sicco	Wembley	Axona	Amigo	Shamrock	Robigus	Warrior	Stigg	Crusoe
14/12/10	Armada	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	0	0	1	
14.7.2	Claire	1	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	
14.10.4	JB Diego	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	
14.4.1	KWS Santiago	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
14.8.2	Conquerer	1	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	
Number of Isolates		17	18	5	21	19	20	11	15	22	20	6	5	2	2	3	0	1	16	2	2	9
Frequency		68	72	20	84	76	80	44	60	88	80	24	20	8	8	12	0	4	64	8	8	36

Table 15: Virulence frequencies of key wheat powdery mildew resistance genes over the past five years of testing. * = Not tested.

Differential	Known Genes	Virulence Frequency by Year					
		2009	2010	2011	2012	2013	2014
Cerco		93	29	*	72	80	68
Galahad	<i>Pm2</i>	76	41	*	74	77	72
Chul	<i>Pm3b</i>	8	4	*	2	11	20
Armada	<i>Pm4b</i>	86	46	*	77	74	84
Flanders	<i>Pm5</i>	77	37	*	67	43	76
Brimstone	<i>Pm6</i>	71	33	*	74	80	80
Maris dove	<i>Mld</i>	49	7	*	72	94	44
Clement	<i>Pm8</i>	17	33	*	44	46	60
Brock	<i>Pm2, MITa2</i>	75	64	*	86	89	88
Mercia	<i>Pm5, MITa2</i>	62	43	*	67	77	80
Tonic	<i>MITo</i>	15	12	*	33	26	24
Broom	<i>Pm3d</i>	17	18	*	42	26	20
Sicco	<i>Pm5, MISi2</i>	9	1	*	2	3	8
Wembley	<i>MISo</i>	2	1	*	2	9	8
Axona	<i>MIAx</i>	12	7	*	30	17	12
Amigo	<i>Pm17</i>	4	0	*	0	0	0
Shamrock	<i>MISh</i>	0	0	*	0	0	4
Robigus	<i>MIRo</i>	26	16	*	28	51	64
Warrior		13	0	*	5	6	8
Stigg		*	0	*	5	6	8
Crusoe		*	*	*	47	40	36
Total Number of Isolates Tested		138	76	0	43	35	25

4.4. Barley Powdery Mildew

4.4.1. Samples Received

Like the wheat powdery mildew, low levels of barley powdery mildew were observed in 2014 and as a result only 21 samples were received from growers, trial operators and agronomists. To provide further samples, trap pots of the susceptible variety Golden Promise were stationed around the Cambridge area to collect further isolates.

4.4.2. Pathotyping of Isolates

From the 40 samples received and collected, 26 were chosen for further characterisation using the detached leaf method detailed in section 3. Results from the assays were converted into a binary code for ease of interpretation (Table 16) and were compared to virulence frequencies from the past five years of testing (Table 17). Virulence for some of the genes under test was detected in every sample tested, for example, *Mlh*, *Mlra* and *Mlg*. For the remaining genes, there were minor deviations from the virulence frequencies in 2013 which is not unusual in this particular population. Some of the frequencies were slightly higher than expected, for example, virulence for Porter increased from 34% to 77% of the samples tested. Virulence was also detected for KWS Meridian for the first time. As with the wheat powdery mildew, no adult plant tests are conducted with these isolates and the full impact of any change in the population will not become evident until the following seasons. Any reports of unusual sightings of barley powdery mildew are always welcomed by the UKCPVS, even if it is not possible to provide a sample.

Table 16: Pathotype results for the wheat powdery mildew detached seedling tests. Average infection types have been converted into a binary factor, where 1 = a compatible reaction (virulent), highlighted yellow and 0 = an incompatible reaction (avirulent). Differential varieties are listed along with the known resistance factors and resistance genes carried by these lines.

Isolate Code	Host Variety	0	Mlh	Mlra	Mlg	Mlg,MI(CP)	Mla6	MLa	Mla12	Mlk1	Mla7	MlAb	Mla7,MIAb	Mla1	Mla9	mlo 11	mlo?	Mla13	Mla3	Van				
		Golden Promise 0	1a	1b	2a	2a,2b	3	4	5	6a	6b	6c	6b,6c	7	8	9	9	10	11	Van				
		Golden Promise	W.37/136	W.41/145	Goldfoil	Zephyr	Midas	Lofa	Hassan	H.1063	Porter	Lotta	Triumph	Tyra	Roland	Apex	Riviera	Digger	Ricardo	Vanessa	Optic	NFC Tipple	Propino	KWS Meridian
14/3/1	Volume	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0
14/12/1	breeding line	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0
14/1/9	Cassata	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0
14/2/1	KWS Tower	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	1	1	1	1	1	0
14/9/1	KWS Cassia	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0
14/40/AH	Golden Promise	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
14/1/5	Cassata	1	1	1	1	1	1	0	0	0	1	1	1	1	0	0	0	0	1	1	0	0	0	0
14/2/4	KWS Tower	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0
14/03/2	Volume	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
14/01/2	Cassata	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	1	1	0	0	0
14/25/AH	Golden Promise	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
14/4/1	Golden Promise	1	1	1	1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
14/11/1	Golden Promise	1	1	1	1	1	1	1	1	0	0	1	0	0	0	1	0	0	1	0	0	1	1	0
14/11/2	Golden Promise	1	1	1	1	1	1	1	1	0	0	1	0	0	0	1	0	0	1	0	0	1	1	0
14/11/5	Golden Promise	1	1	1	1	0	1	1	1	1	1	1	0	1	0	0	0	0	1	1	1	1	1	0
14/15/3	Golden Promise	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0
14/13/1	Golden Promise	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	1	1	1	0	1	1	0

Isolate Code	Host Variety	Golden Promise	0	1a	1b	2a	2a,2b	3	4	5	6a	6b	6c	6b,6c	7	8	9	9	10	11	Van				
		0	0	Mlh	Mira	Mlg	Mlg,MI(CP)	Mla6	MlLa	Mla12	Mlk1	Mla7	MIAb	Mla7,MIAb	Mla1	Mla9	mlo 11	mlo?	Mla13	Mla3	Van				
		Golden Promise	W.37/136	W.41/145	Goldfoil	Zephyr	Midas	Lofa	Hassan	H.1063	Porter	Lotta	Triumph	Tyra	Roland	Apex	Riviera	Digger	Ricardo	Vanessa	Optic	NFC Tipple	Propino	KWS Meridian	
14/39/AH	Golden Promise	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	1	1	0	1	1	0	
14/27/AH	Golden Promise	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	1	1	1	1	0	
14/6/1	Golden Promise	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	1	1	1	0	1	1	0
14/7/1	Golden Promise	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0	0	0	0	1	0	1	1	1	
14/14/2	Golden Promise	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	1	1	1	1	1	0
14/21/1	Golden Promise	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0
14/16/2	Golden Promise	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0	0	0	0	1	1	0	0	0	0
14/35/AH	Golden Promise	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	1	1	1	1	1	0
14/18/1	Golden Promise	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	0	1	1	0
Number of Isolates		26	26	26	26	25	25	23	24	9	20	20	4	9	0	3	0	3	16	21	7	14	14	1	
Frequency		100	100	100	100	96	96	88	92	35	77	77	15	35	0	12	0	12	62	81	27	54	54	4	

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

Differential	Resistance Factors	Known Genes	Virulence Frequency by Year					
			2009	2010	2011	2012	2013	2014
Golden Promise	0	0	99	*	81	100	93	100
W.37/136	1a	Mlh	89	*	81	100	100	100
W.41/145	1b	Mlra	43	*	69	81	100	100
Goldfoil	2a	Mlg	93	*	84	96	83	100
Zephyr	2a,2b	Mlg,MI(CP)	86	*	76	100	76	96
Midas	3	Mla6	68	*	70	89	83	96
Lofa	4	MILa	89	*	83	85	48	88
Hassan	5	Mla12	90	*	87	96	76	92
H.1063	6a	Mlk1	15	*	29	7	45	35
Porter	6b	Mla7	56	*	48	52	34	77
Ark Royal	6a,6b	Mlk1,Mla7	41	*	*	*	0	*
Lotta	6c	MIAb	56	*	58	33	14	77
Triumph	6b,6c	Mla7,MIAb	32	*	35	19	3	15
Tyra	7	Mla1	47	*	42	56	34	35
Roland	8	Mla9	7	*	4	7	0	0
Apex	9	mlo 11	0	*	1	4	0	12
Riviera	9?	mlo 11	0	*	0	4	0	0
Digger	10	Mla13	23	*	5	4	7	12
Ricardo	11	Mla3	5	*	35	22	17	62
Vanessa	Van	Van	81	*	80	89	86	81
Optic			63	*	35	48	10	27
NFC Tipple			32	*	45	30	14	54
Propino			33	*	34	30	14	54
KWS Meridian			*	*	*	0	0	4
Total Number of Isolates			111	0	113	27	29	26

5. References

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6. Appendix 1: Sample Register

2014 Wheat Yellow Rust UKCPVS Sample Register

Isolate Number	Host Variety	Date Received	RL Rating 2014/15	Location
14/109	Beluga	Jun-14	5.3	Oxfordshire
14/045	Belvoir	May-14	7.1	Lincolnshire
14/120	Britannia	Jun-14	9.0	Norfolk
14/011	Claire	Jan-14	5.4	Northamptonshire
14/014	Claire	Jan-14	5.4	Lincolnshire
14/031	Claire	Apr-14	5.4	Herefordshire
14/036	Claire	May-14	5.4	North Yorkshire
14/053	Claire	May-14	5.4	Kent
14/073	Claire	May-14	5.4	Hampshire
14/080	Claire	May-14	5.4	Herefordshire
14/024	Cocoon	Mar-14	7.7	Essex
14/070	Cocoon	May-14	7.7	Oxfordshire
14/115	Conqueror	Jun-14	5.9	Oxfordshire
14/055	Cordiale	May-14	5.5	Kent
14/063	Cordiale	May-14	5.5	Norfolk
14/074	Cordiale	May-14	5.5	Hampshire
14/078	Cordiale	May-14	5.5	Herefordshire
14/090	Cordiale	Jun-14	5.5	Norfolk
14/122	Cordiale	Jun-14	5.5	East Lothian
14/091	Cougar	Jun-14	8.2	Norfolk
14/094	Cougar	Jun-14	8.2	Oxfordshire
14/104	Cougar	Jun-14	8.2	Oxfordshire
14/501	Crusoe	May-14	8.6	Cambridgeshire
14/079	Delphi	May-14	8.7	Herefordshire
14/127	Energise	Jun-14	8.0	East Lothian
14/028	Evolution	Apr-14	8.7	Essex
14/003	Gallant	Dec-13	4.9	Oxfordshire
14/069	Gallant	May-14	4.9	Cambridgeshire
14/113	Grafton	Jun-14	6.2	Oxfordshire
14/066	Granary	May-14	5.6	Kent
14/008	Hereward	Dec-13		Cambridgeshire
14/025	Horatio	Mar-14	5.9	Kent
14/114	Horatio	Jun-14	5.9	Oxfordshire
14/125	Icon	Jun-14	8.7	East Lothian
14/101	Invicta	Jun-14	7.7	Norfolk
14/105	Invicta	Jun-14	7.7	Oxfordshire
14/001	JB Diego	Nov-13	7.7	Lincolnshire
14/004	JB Diego	Dec-13	7.7	Cambridgeshire
14/005	JB Diego	Dec-13	7.7	Cambridgeshire
14/099	JB Diego	Jun-14	7.7	Norfolk
14/124	JB Diego	Jun-14	7.7	East Lothian
14/119	Jorvik	Jun-14	9.0	Norfolk
14/102	Kranich	Jun-14		Norfolk

Isolate Number	Host Variety	Date Received	RL Rating 2014/15	Location
14/088	KWS Cashel	Jun-14	8.6	Norfolk
14/098	KWS Cashel	Jun-14	8.6	Norfolk
14/117	KWS Cashel	Jun-14	8.6	Norfolk
14/067	KWS Gator	May-14	8.8	Norfolk
14/007	KWS Kielder	Dec-13	3.8	Oxfordshire
14/029	KWS Kielder	Apr-14	3.8	North Yorkshire
14/046	KWS Kielder	May-14	3.8	Shropshire
14/111	KWS Kielder	Jun-14	3.8	Oxfordshire
14/126	KWS Kielder	Jun-14	3.8	East Lothian
14/103	KWS Lili	Jun-14	7.0	Hertfordshire
14/009	KWS Santiago	Dec-13	4.4	Oxfordshire
14/096	KWS Santiago	Jun-14	4.4	Oxfordshire
14/108	KWS Santiago	Jun-14	4.4	Oxfordshire
14/118	KWS Santiago	Jun-14	4.4	Norfolk
14/128	KWS Santiago	Jun-14	4.4	Angus
14/054	KWS Sterling	May-14		Kent
14/075	KWS Sterling	May-14		Hampshire
14/021	KWS Target	Mar-14	8.0	Cambridgeshire
14/116	KWS Trinity	Jun-14	9.0	Norfolk
14/106	Monterey	Jun-14	7.4	Oxfordshire
14/100	Myriad	Jun-14	8.4	Norfolk
14/015	Oakley	Jan-14		Lincolnshire
14/019	Oakley	Feb-14		Hampshire
14/034	Oakley	May-14		North Yorkshire
14/041	Oakley	May-14		Lincolnshire
14/050	Oakley	May-14		Kent
14/059	Oakley	May-14		Hertfordshire
14/065	Oakley	May-14		Norfolk
14/089	Panacea	Jun-14		Norfolk
14/092	Panacea	Jun-14		Oxfordshire
14/121	Panacea	Jun-14		Hampshire
14/020	Panorama	Mar-14	8.0	Cambridgeshire
14/093	Panorama	Jun-14	8.0	Oxfordshire
14/110	Panorama	Jun-14	8.0	Oxfordshire
14/123	Panorama	Jun-14	8.0	East Lothian
14/056	Relay	May-14	8.9	Kent
14/076	Relay	May-14	8.9	Hampshire
14/083	Relay	May-14	8.9	Herefordshire
14/084	Relay	May-14	8.9	North Yorkshire
14/130	RGT Scrummage	Jun-14		Angus
14/013	Robigus	Jan-14		Lincolnshire
14/037	Robigus	May-14		North Yorkshire
14/039	Robigus	May-14		Lincolnshire
14/057	Robigus	May-14		Kent
14/062	Robigus	May-14		Norfolk
14/010	Scout	Dec-13	8.8	Oxfordshire

Isolate Number	Host Variety	Date Received	RL Rating 2014/15	Location
14/044	Scout	May-14	8.8	Hertfordshire
14/112	Skyfall	Jun-14	6.2	Oxfordshire
14/002	Solstice	Nov-13	4.0	Oxfordshire
14/006	Solstice	Dec-13	4.0	Oxfordshire
14/017	Solstice	Jan-14	4.0	Lincolnshire
14/030	Solstice	Apr-14	4.0	North Yorkshire
14/035	Solstice	May-14	4.0	North Yorkshire
14/040	Solstice	May-14	4.0	Lincolnshire
14/047	Solstice	May-14	4.0	Dorset
14/051	Solstice	May-14	4.0	Kent
14/064	Solstice	May-14	4.0	Norfolk
14/068	Solstice	May-14	4.0	Hampshire
14/095	Solstice	Jun-14	4.0	Oxfordshire
14/097	Solstice	Jun-14	4.0	Norfolk
14/129	Solstice	Jun-14	4.0	Angus
14/022	Spreader	Mar-14		Cambridgeshire
14/023	Spreader	Mar-14		Cambridgeshire
14/012	Timber	Jan-14		Lincolnshire
14/032	Timber	Apr-14		Herefordshire
14/038	Timber	May-14		North Yorkshire
14/043	Timber	May-14		Lincolnshire
14/058	Timber	May-14		Kent
14/061	Timber	May-14		Norfolk
14/077	Timber	May-14		Hampshire
14/081	Timber	May-14		Herefordshire
14/048	Unknown	May-14		Cambridgeshire
14/085	Unknown	Jun-14		Cambridgeshire
14/086	Unknown	Jun-14		Kent
14/087	Unknown	Jun-14		Cambridgeshire
14/016	Victo	Jan-14		Lincolnshire
14/018	Victo	Feb-14		Hampshire
14/026	Victo	Apr-14		Norfolk
14/027	Victo	Apr-14		Herefordshire
14/033	Victo	May-14		North Yorkshire
14/042	Victo	May-14		Lincolnshire
14/049	Victo	May-14		Kent
14/071	Victo	May-14		Hampshire
14/107	Viscount	Jun-14	4.6	Oxfordshire
14/601	Vuka			
14/602	Vuka			
14/603	Vuka			
14/052	Warrior	May-14		Kent
14/060	Warrior	May-14		Norfolk
14/072	Warrior	May-14		Hampshire
14/082	Warrior	May-14		Herefordshire

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Isolate Number	Host Variety	Date Received	RL Rating	Location
14/022	Alchemy	Jun-14	4	Cambridgeshire
14/007	Beluga	Jun-14	3	Cambridgeshire
14/023	Beluga	Jun-14	3	Cambridgeshire
14/010	Britannia	Jun-14	4	Hertfordshire
14/034	Claire	Jun-14	5	Norfolk
14/031	Conquerer	Jun-14	7	Lincolnshire
14/016	Conqueror	Jun-14	7	Shropshire
14/015	Cordiale	Jun-14	3	Norfolk
14/017	Cougar	Jun-14	9	Norfolk
14/003	Crusoe	Jun-14	6	Cambridgeshire
14/004	Crusoe	Jun-14	6	Cambridgeshire
14/009	Crusoe	Jun-14	6	Hertfordshire
14/018	Crusoe	Jun-14	6	Shropshire
14/027	Crusoe	Jun-14	6	Cambridgeshire
14/028	Crusoe	Jun-14	6	Lincolnshire
14/035	Crusoe	Jun-14	6	Norfolk
14/041	Crusoe	Jul-14	6	Kent
14/056	Crusoe	Jul-14	6	Yorkshire
14/020	Delphi	Jun-14	8	Cambridgeshire
14/037	Delphi	Jun-14	8	Norfolk
14/501	Delphi	Jul-14	8	Cambridgeshire
14/026	Dickens	Jun-14	8	Cambridgeshire
14/061	Dickens	Jul-14	8	Yorkshire
14/504	Dickens	Jul-14	9	Cambridgeshire
14/011	Energise	Jun-14	4	Hertfordshire
14/051	Evolution	Jul-14	9	Cambridgeshire
14/065	Evolution	Jul-14	9	Yorkshire
14/033	Grafton	Jun-14	4	Lincolnshire
14/064	Grafton	Jul-14	4	Yorkshire
14/001	JB Diego	Dec-13	5	Cambridgeshire
14/063	JB Diego	Jul-14	5	Yorkshire
14/013	Jorvik	Jun-14	5	Hertfordshire
14/029	Jorvik	Jun-14	5	Lincolnshire
14/052	KWS Cashel	Jul-14	9	Cambridgeshire
14/002	KWS Gator	Jun-14	3	Cambridgeshire
14/005	KWS Gator	Jun-14	3	Cambridgeshire
14/048	KWS Kielder	Jul-14	8	Cambridgeshire
14/012	KWS Lili	Jun-14	6	Hertfordshire
14/032	KWS Lili	Jun-14	6	Lincolnshire
14/040	KWS Lili	Jun-14	6	Hampshire
14/008	KWS Tempo	Jun-14	8	Cambridgeshire
14/054	KWS Tempo	Jul-14	9	Cambridgeshire
14/019	KWS Trinity	Jun-14	9	Norfolk
14/055	KWS Trinity	Jul-14	9	Cambridgeshire

Isolate Number	Host Variety	Date Received	RL Rating	Location
14/058	KWS Trinity	Jul-14	9	Yorkshire
14/068	Leeds	Jul-14		
14/030	Myriad	Jun-14	4	Lincolnshire
14/057	Panorama	Jul-14	5	Yorkshire
14/050	Relay	Jul-14	8	Cambridgeshire
14/062	Relay	Jul-14	8	Yorkshire
14/502	Relay	Jul-14	8	Cambridgeshire
14/025	Revelation	Jun-14	9	Cambridgeshire
14/049	Ruskin	Jul-14	9	Cambridgeshire
14/059	Ruskin	Jul-14	9	Yorkshire
14/039	Rye	Jun-14		Cambridgeshire
14/024	Scout	Jun-14	7	Cambridgeshire
14/060	Scout	Jul-14	7	Yorkshire
14/503	Scout	Jul-14	8	Cambridgeshire
14/053	Skyfall	Jul-14	8	Cambridgeshire
14/014	Soissons	Jun-14	4	Cambridgeshire
14/038	Timber	Jun-14		Norfolk
14/505	Tuxedo	Jul-14	8	Cambridgeshire
14/021	Viscount	Jun-14	7	Cambridgeshire
14/036	Warrior	Jun-14		Norfolk
14/043	Warrior	Jul-14		Yorkshire
14/047		Jul-14		Cambridgeshire
14/066		Jul-14		Lincolnshire
14/067		Jul-14		Essex

2014 Wheat Powdery Mildew Sample Register

Isolate Number	Host Variety	Date received	RL Rating 2014/2015	Location
WM14012	Armada	Jul-14		Cambridgeshire
WM14003	Beluga	Apr-14	3	Cambridgeshire
WM14009	Beluga	Jun-14	3	Angus
WM14006	Britannia	Apr-14		Cambridgeshire
WM14014	Cerco	Sep-14		Cambridgeshire
WM14015	Cerco	Sep-14		Cambridgeshire
WM14016	Cerco	Sep-14		Cambridgeshire
WM14019	Cerco	Sep-14		Cambridgeshire
WM14020	Cerco	Sep-14		Cambridgeshire
WM14021	Cerco	Sep-14		Cambridgeshire
WM14022	Cerco	Sep-14		Cambridgeshire
WM14023	Cerco	Sep-14		Cambridgeshire
WM14024	Cerco	Sep-14		Cambridgeshire
WM14025	Cerco	Sep-14		Cambridgeshire
WM14026	Cerco	Sep-14		Cambridgeshire
WM14027	Cerco	Sep-14		Cambridgeshire
WM14028	Cerco	Sep-14		Cambridgeshire
WM14029	Cerco	Sep-14		Cambridgeshire
WM14030	Cerco	Sep-14		Cambridgeshire
WM14031	Cerco	Sep-14		Cambridgeshire
WM14032	Cerco	Sep-14		Cambridgeshire
WM14033	Cerco	Sep-14		Cambridgeshire
WM14034	Cerco	Sep-14		Cambridgeshire
WM14035	Cerco	Sep-14		Cambridgeshire
WM14036	Cerco	Sep-14		Cambridgeshire
WM14038	Cerco	Sep-14		Cambridgeshire
WM14039	Cerco	Sep-14		Cambridgeshire
WM14040	Cerco	Sep-14		Cambridgeshire
WM14041	Cerco	Sep-14		Cambridgeshire
WM14042	Cerco	Sep-14		Cambridgeshire
WM14043	Cerco	Sep-14		Cambridgeshire
WM14044	Cerco	Sep-14		Cambridgeshire
WM14045	Cerco	Sep-14		Cambridgeshire
WM14046	Cerco	Sep-14		Cambridgeshire
WM14047	Cerco	Sep-14		Cambridgeshire
WM14048	Cerco	Sep-14		Cambridgeshire
WM14049	Cerco	Sep-14		Cambridgeshire
WM14050	Cerco	Sep-14		Cambridgeshire
WM14051	Cerco	Sep-14		Cambridgeshire
WM14052	Cerco	Sep-14		Cambridgeshire
WM14053	Cerco	Sep-14		Cambridgeshire
WM14054	Cerco	Sep-14		Cambridgeshire
WM14055	Cerco	Sep-14		Cambridgeshire
WM14056	Cerco	Sep-14		Cambridgeshire
WM14057	Cerco	Sep-14		Cambridgeshire

Isolate Number	Host Variety	Date received	RL Rating 2014/2015	Location
WM14058	Cerco	Sep-14		Cambridgeshire
WM14059	Cerco	Sep-14		Cambridgeshire
WM14060	Cerco	Sep-14		Cambridgeshire
WM14061	Cerco	Sep-14		Cambridgeshire
WM14062	Cerco	Sep-14		Cambridgeshire
WM14063	Cerco	Sep-14		Cambridgeshire
WM14064	Cerco	Sep-14		Cambridgeshire
WM14065	Cerco	Sep-14		Cambridgeshire
WM14066	Cerco	Sep-14		Cambridgeshire
WM14067	Cerco	Sep-14		Cambridgeshire
WM14068	Cerco	Sep-14		Cambridgeshire
WM14069	Cerco	Sep-14		Cambridgeshire
WM14070	Cerco	Sep-14		Cambridgeshire
WM14071	Cerco	Sep-14		Cambridgeshire
WM14072	Cerco	Sep-14		Cambridgeshire
WM14073	Cerco	Sep-14		Cambridgeshire
WM14074	Cerco	Sep-14		Cambridgeshire
WM14075	Cerco	Sep-14		Cambridgeshire
WM14076	Cerco	Sep-14		Cambridgeshire
WM14077	Cerco	Sep-14		Cambridgeshire
WM14078	Cerco	Sep-14		Cambridgeshire
WM14079	Cerco	Sep-14		Cambridgeshire
WM14080	Cerco	Sep-14		Cambridgeshire
WM14081	Cerco	Sep-14		Cambridgeshire
WM14082	Cerco	Sep-14		Cambridgeshire
WM14083	Cerco	Sep-14		Cambridgeshire
WM14084	Cerco	Sep-14		Cambridgeshire
WM14085	Cerco	Sep-14		Cambridgeshire
WM14086	Cerco	Sep-14		Cambridgeshire
WM14087	Cerco	Sep-14		Cambridgeshire
WM14088	Cerco	Sep-14		Cambridgeshire
WM14089	Cerco	Sep-14		Cambridgeshire
WM14090	Cerco	Sep-14		Cambridgeshire
WM14091	Cerco	Sep-14		Cambridgeshire
WM14092	Cerco	Sep-14		Cambridgeshire
WM14093	Cerco	Sep-14		Cambridgeshire
WM14094	Cerco	Sep-14		Cambridgeshire
WM14095	Cerco	Sep-14		Cambridgeshire
WM14096	Cerco	Sep-14		Cambridgeshire
WM14097	Cerco	Sep-14		Cambridgeshire
WM14098	Cerco	Sep-14		Cambridgeshire
WM14099	Cerco	Sep-14		Cambridgeshire
WM14100	Cerco	Sep-14		Cambridgeshire
WM14101	Cerco	Sep-14		Cambridgeshire
WM14102	Cerco	Sep-14		Cambridgeshire
WM14103	Cerco	Sep-14		Cambridgeshire

Isolate Number	Host Variety	Date received	RL Rating 2014/2015	Location
WM14104	Cerco	Sep-14		Cambridgeshire
WM14105	Cerco	Sep-14		Cambridgeshire
WM14106	Cerco	Sep-14		Cambridgeshire
WM14107	Cerco	Sep-14		Cambridgeshire
WM14108	Cerco	Sep-14		Cambridgeshire
WM14109	Cerco	Sep-14		Cambridgeshire
WM14110	Cerco	Sep-14		Cambridgeshire
WM14111	Cerco	Sep-14		Cambridgeshire
WM14112	Cerco	Sep-14		Cambridgeshire
WM14113	Cerco	Sep-14		Cambridgeshire
WM14017	Cerco	Sep-14		Cambridgeshire
WM14018	Cerco	Sep-14		Cambridgeshire
WM14007	Claire	Jun-14	4	Cambridgeshire
WM14004	Conquerer	Apr-14	3	Cambridgeshire
WM14013	Conquerer	Jul-14	3	South Yorkshire
WM14002	Cougar	Apr-14	6	Cambridgeshire
WM14005	Evolution	Apr-14	6	Cambridgeshire
WM14001	JB Diego	Dec-13	6	Cambridgeshire
WM14010	JB Diego	Jun-14	6	Angus
WM14008	KWS Santiago	Jun-14	4	Angus
WM14011	Solstice	Jun-14	4	Angus

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Isolate Number	Host Variety	Date Received	RL Rating 2014/15	Location
BM14/004	Archer	Mar-14	7	Cheshire
BM14/011	Breeding Line	Jun-14		Cambridgeshire
BM14/012	Breeding Line	Jun-14		Cambridgeshire
BM14/013	Breeding Line	Jun-14		Cambridgeshire
BM14/021	California	Jun-14	6	Belfast
BM14/001	Cassata	Nov-13	4	Hampshire
BM14/017	Cassata	Jun-14	4	Belfast
BM14/015	Catriona	Jun-14		Cambridgeshire
BM14/014	Cindy	Jun-14		Cambridgeshire
BM14/006	Discard	May-14		Cambridgeshire
BM14/020	Florentine	Jun-14	6	Belfast
BM14/022	Golden Promise	Sep-14		Cambridgeshire
BM14/023	Golden Promise	Sep-14		Cambridgeshire
BM14/024	Golden Promise	Sep-14		Cambridgeshire
BM14/025	Golden Promise	Sep-14		Cambridgeshire
BM14/026	Golden Promise	Sep-14		Cambridgeshire
BM14/027	Golden Promise	Sep-14		Cambridgeshire
BM14/028	Golden Promise	Sep-14		Cambridgeshire
BM14/029	Golden Promise	Sep-14		Cambridgeshire
BM14/030	Golden Promise	Sep-14		Cambridgeshire
BM14/031	Golden Promise	Sep-14		Cambridgeshire
BM14/032	Golden Promise	Sep-14		Cambridgeshire
BM14/033	Golden Promise	Sep-14		Cambridgeshire
BM14/034	Golden Promise	Sep-14		Cambridgeshire
BM14/035	Golden Promise	Sep-14		Cambridgeshire
BM14/036	Golden Promise	Sep-14		Cambridgeshire
BM14/037	Golden Promise	Sep-14		Cambridgeshire
BM14/038	Golden Promise	Sep-14		Cambridgeshire
BM14/039	Golden Promise	Sep-14		Cambridgeshire
BM14/040	Golden Promise	Sep-14		Cambridgeshire
BM14/041	Golden Promise	Sep-14		Cambridgeshire
BM14/009	KWS Cassia	May-14		Cambridgeshire
BM14/018	KWS Cassia	Jun-14	4	Belfast
BM14/002	KWS Tower	Mar-14	5	Cambridgeshire
BM14/008	KWS Tower	May-14	5	Cambridgeshire
BM14/016	Makof	Jun-14		Cambridgeshire
BM14/010	Retriever	May-14	6	Cambridgeshire
BM14/019	Saffron	Jun-14	3	Belfast
BM14/007	Scarlett	May-14		Cambridgeshire
BM14/003	Volume	Mar-14	5	Cheshire