

September 2013



UK Cereal Pathogen Virulence Survey Brown rust of wheat – 2012 Annual Report

R A Bayles

NIAB, Huntingdon Road, Cambridge CB3 0LE

While the Agriculture and Horticulture Development Board, operating through its HGCA division, seeks to ensure that the information contained within this document is accurate at the time of printing, no warranty is given in respect thereof and, to the maximum extent permitted by law, the Agriculture and Horticulture Development Board accepts no liability for loss, damage or injury howsoever caused (including that caused by negligence) or suffered directly or indirectly in relation to information and opinions contained in or omitted from this document.

Reference herein to trade names and proprietary products without stating that they are protected does not imply that they may be regarded as unprotected and thus free for general use. No endorsement of named products is intended, nor is any criticism implied of other alternative, but unnamed, products.

HGCA is the cereals and oilseeds division of the Agriculture and Horticulture Development Board.



Key points

Virulence for the cultivars Timber, Stigg and Warrior, first detected in 2011, was identified in nearly half of 2012 isolates. These cultivars are believed to carry the *Lr24* resistance. Virulence for the Robigus group of cultivars, carrying *Lr28*, remained at around 50%.

Introduction

There was a moderate incidence of brown rust in wheat in 2012.

2012 isolates: seedling virulence tests

Methods

27 isolates were tested from 13 different wheat cultivars (Table 1). Seven isolates came from Stigg and five from Warrior. Both of these cultivars had been highly resistant until 2011, when isolates with corresponding virulence were first reported. The greatest number of isolates came from samples collected in the East Midlands and East Anglia (Table 2).

Table 1. Cultivars from which brown rust isolates were tested

Cultivar	1–9 Resistance rating*	No. of isolates tested
Stigg	9	7
Warrior	8	5
Timber	(9)	2
Gravitas	7	1
KWS Target	5	1
Leeds	8	1
Monterey	6	1
SY Epsom	6	1
Alchemy	5	2
Beluga	4	2
Cordiale	3	1
Crusoe	7	1
Unknown		1
Stigg	9	7
Warrior	8	5
Timber	(9)	2
Total		27

*HGCA Recommended Lists 2012/13: ratings based on data available before 2012 season

Table 2. Locations from which brown rust isolates were tested

Region	County	No. of isolates tested
East Anglia	Cambridgeshire	3
	Bedfordshire	6
	Norfolk	1
East Midlands	Lincolnshire	11
	Rutland	1
West Midlands	Warwickshire	1
South East	Kent	1
South West	Devon	2
North	Yorkshire	1
Total		27

Isolates were tested for virulence on seedlings of three sets of wheat lines:

1. the standard WBR differential cultivars
2. selected 'Thatcher' Near Isogenic Lines (NILS) carrying different *Lr* resistance genes
3. current UK cultivars with known or unknown resistance genes (Table 3)

Results

Seedling virulence frequencies are shown in Table 4.

Virulence for Timber, Stigg and Warrior, all believed to carry *Lr24*, increased to 40–50%, having been first detected in 2011. *Lr24* virulence was identified only in isolates derived from cultivars with the corresponding *Lr24* resistance.

Virulence for Robigus and other cultivars carrying *Lr28* was detected in just over 50% of isolates, a level very similar to that recorded in 2011. This virulence was identified in isolates from cultivars carrying both corresponding and non-corresponding resistance, indicating that it is becoming widely established in the brown rust population.

Virulence for WBR /*Lr26*, *Lr1*/Glasgow, WBR3/WBR4/*Lr20* and WBR7 all remained at low levels.

All of the additional cultivars included in virulence tests because of their high adult plant resistance ratings of 8 or 9 were found to be susceptible to at least a proportion of isolates at the seedling stage.

Table 3. Differential cultivars used in 2012 seedling virulence tests

Differential cultivar	WBR factor	Lr gene
<u>Standard WBR cultivars</u>		
Clement	WBR 1	<i>Lr26</i>
Fundin	WBR 2	<i>Lr17b</i>
Sappo	WBR 3	<i>Lr20</i>
Halberd	WBR 4	<i>Lr20</i>
Sterna	WBR 7	<i>Lr3a</i>
Armada	WBR 0	
<u>Thatcher near isogenic lines</u>		
Thatcher x <i>Lr1</i>		<i>Lr1</i>
Thatcher x <i>Lr20</i>		<i>Lr20</i>
Thatcher x <i>Lr24</i>		<i>Lr24</i>
Thatcher x <i>Lr26</i>		<i>Lr26</i>
Thatcher x <i>Lr37</i>		<i>Lr37</i>
<u>Additional cultivars</u>		
Alchemy	'Claire'	
Glasgow		<i>Lr1</i>
Robigus	'Rob'	<i>Lr28</i>
Scout	? 'Rob'	
Horatio	? 'Rob'	
Gravitas	? 'Rob'	
Invicta	? 'Rob'	
Timber	'Timber'	<i>Lr24</i>
Stigg (9)	? 'Timber'	
Warrior (8)	? 'Timber'	
Chronicle (9)		
Cocoon (9)		
Cougar (9)		
Crusoe (7)		
Dickens (9)		
KWS Sterling (8)		
Leeds (8)		
Revelation (9)		
Tuxedo (9)		

Table 4. Virulence frequencies 2003–2012

		03	05	06	07	08	09	10	11	12
<u>WBR cvs</u>										
Clement	WBR 1	73	69	44	21	24	0	70	5	11
Fundin	WBR 2*	73	100	100	100	86	91	70	86	89
Sappo	WBR 3	0	13	28	8	5	0	0	14	19
Halberd	WBR 4	0	13	24	8	10	9	0	10	22
Sterna	WBR 7	68	56	68	8	14	0	90	0	7
Armada	WBR 0	100	100	100	100	100	100	100	100	100
<u>Thatcher NILs</u>										
Thatcher x <i>Lr1</i>	<i>Lr1</i>	0	28	32	13	14	18	0	10	7
Thatcher x <i>Lr20</i>	<i>Lr20</i>									7
Thatcher x <i>Lr24</i>	<i>Lr24</i>									37
Thatcher x <i>Lr26</i>	<i>Lr26</i>	73	69	44	17	33	0	40	5	11
Thatcher x <i>Lr37</i>	<i>Lr37</i> *			100	30	91	27	100	91	59
<u>Additional cultivars</u>										
Alchemy	R 'Claire'			100	58	100	100	100	91	85
Glasgow	<i>Lr1</i>			32	17	19	18	0	10	7
Robigus	'Rob'			32	30	10	18	0	52	59
Scout	? 'Rob'					14	18	0	43	59
Horatio	? 'Rob'								38	56
Gravitas	? 'Rob'								57	44
Invicta	? 'Rob'								57	44
Timber	<i>Lr24</i>				0	0	0	0	19	48
Stigg	? <i>Lr24</i>								24	41
Warrior	? <i>Lr24</i>							0	5	44
Chronicle										67
Cocoon										74
Cougar										33
Crusoe										67
Dickens										33
KWS Sterling										33
Leeds										48
Revelation										82
Tuxedo										59
No. of isolates		22	32	25	24	21	11	10	21	27

* = resistances expressed at adult plant stage, not detectable at seedling stage

2011 isolates: adult plant tests

Methods

Four isolates from the 2011 survey (Table 5) were tested on a set of 52 cultivars in adult plant tests in field isolation nurseries.

Table 5. Isolates tested on adult plants in 2012 (virulence / avirulence for resistances detectable at the seedling stage).

Code	Cultivar	Virulent on	Avirulent on
11/15	Stigg	<i>Lr24</i> , Timber, Stigg, (Warrior)	<i>Lr1</i> , <i>Lr3a/R7</i> , <i>Lr20/R3,R4</i> , <i>Lr26/R1</i> , Robigus
11/126	Stigg	<i>Lr24</i> , Timber, Stigg, (Warrior)	<i>Lr1</i> , <i>Lr3a/R7</i> , <i>Lr20/R3,R4</i> , <i>Lr26/R1</i> , Robigus
11/110	Viscount	Robigus	<i>Lr1</i> , <i>Lr3a/R7</i> , <i>Lr20/R3,R4</i> , <i>Lr24</i> , <i>Lr26/R1</i> , Timber, Stigg, Warrior
11/98	Horatio	Robigus	<i>Lr1</i> , <i>Lr3a/R7</i> , <i>Lr20/R3,R4</i> , <i>Lr24</i> , <i>Lr26/R1</i> , Timber, Stigg, Warrior

Results and discussion

Adult plant results in Table 6 are mean leaf area infection values for four assessments made at approximately 7-day intervals between GS45 and GS68 (1 June–28 June).

Unfortunately, the nurseries suffered predation during the late winter / early spring. Although most plots recovered to an acceptable degree, a number were so severely damaged that they had to be regarded as missing. In addition, a few varieties became heavily infected with yellow rust and could not therefore be assessed for brown rust infection. Missing data, whether due to predation or yellow rust contamination, is indicated in Table 6 as 'xx'.

Levels of brown rust infection in the nurseries were generally low, compared with most seasons. Despite this, infection did build up to severe levels in some of the most susceptible cultivars, including Buster, KWS Solo, KWS Gator, Beluga, Chilton, Stigg and Warrior, indicating that conditions were conducive for disease development and inoculation had been successful.

Of note were the lower than expected levels of infection on some well-known susceptible cultivars with ratings of 3 or 4, which are more usually susceptible across the board to all isolates; examples of these included Cordiale, Grafton, JB Diego, Duxford, Panorama, Gallant, Kingdom and KWS Santiago. This suggests that these cultivars may carry specific resistances which were not matched by corresponding virulence in the isolates tested here.

Infection on Claire and Alchemy was also at a relatively low level, indicating that, with the possible exception of isolate 11/15, virulence for the 'Claire' adult plant resistance was absent. Virulence for the adult plant resistance *Lr37* was also absent, along with virulence for *Lr1*, *Lr3a*, *Lr14a* and *Lr20*.

Moving on to the group of cultivars believed to carry the 'Robigus' resistance (*Lr28*), there was confirmation that isolates 11/110 and 11/98 carried the corresponding virulence. This was demonstrated most clearly in the reactions of the more susceptible cultivars, in particular KWS Target and Monterey.

Isolates 11/15 and 11/126, both derived from the cultivar Stigg, were virulent on adult plants of the Thatcher *Lr24* differential, Timber, Stigg and Warrior, reflecting the virulence detected at the seedling stage. This provides further confirmation that Stigg and Warrior carry the resistance *Lr24*. Contrary to expectations from seedling virulence phenotypes, the nursery inoculated with 11/110 showed high levels of infection on some *Lr24* cultivars. The most likely explanation is contamination by incoming inoculum, either from nearby inoculated nurseries or from natural sources. The extreme adult plant susceptibility of Stigg puts it at particularly high risk of infection from outside sources.

Table 6. Adult Plant Tests: % leaf area infected with brown rust (mean of 4 assessments)

Variety	Resistance Rating*	R factors	11/15 Stigg	11/126 Stigg	11/110 Viscount	11/98 Horatio
Buster			36.50	17.75	16.13	11.13
Armada		0	5.38	3.50	6.75	4.63
KWS Solo	3		15.13	19.25	12.13	6.50
Avalon		WBR9	11.63	6.25	5.88	3.48
Consort		Lr10,Lr13	12.63	8.75	xx	6.40
Gamin		WBR6	3.88	1.63	2.18	2.13
Maris Fundin		WBR2	9.25	2.88	4.25	4.33
Maris Huntsman		Lr13	5.63	1.88	xx	3.25
Solstice	4	Lr13	5.38	xx	3.30	4.28
Cordiale	3	?	6.50	2.08	2.50	2.73
Grafton	3	?	2.95	0.45	1.75	0.80
KWS Gator	3	?	10.25	2.68	10.25	10.38
Beluga	4	?	16.38	4.88	10.88	5.60
JB Diego	4	?	6.63	3.08	xx	1.88
Chilton	4	?	11.00	5.58	4.63	5.25
Claire	5	Claire	4.38	1.65	2.13	0.75
Alchemy	5	Claire	8.63	3.00	2.75	3.00
Mascot		Lr37	0.90	0.05	0.00	0.13
Reaper		Lr37	0.75	0.15	0.75	0.00
Soissons		Lr14a	0.05	0.00	0.00	0.00
Maris Halberd		Lr20	0.00	0.00	0.38	0.00
Sappo		Lr20	0.03	0.03	1.43	0.63
Sterna		Lr3a	0.00	0.00	xx	0.00
Glasgow		Lr1	xx	0.05	0.00	0.03
KWS Sterling	7		0.00	0.00	0.00	0.03
Denman	5		0.00	0.03	0.00	0.50
Duxford	4	?	2.13	1.00	0.08	0.03
Panorama	4	?	2.58	0.38	0.43	0.05
Gallant	4	?	1.05	0.20	0.43	0.18
Conqueror	5	?	1.33	0.10	0.28	0.05
Kingdom	4	?	0.48	0.08	0.33	0.25
KWS Podium	7		0.00	0.00	0.00	0.00
KWS Santiago	4		2.03	0.03	0.03	0.05
Tuxedo	7		0.00	0.00	0.00	0.18
Relay	5		0.03	0.00	0.00	0.00
Crusoe	7		0.00	0.05	0.00	0.50
Delphi	7		0.38	0.05	0.08	0.05
Robigus		Rob	xx	3.63	5.53	xx
Scout	9	Rob	0.00	0.03	0.03	0.08
Viscount	8	Rob	0.00	0.00	2.93	0.40
Invicta	7	Rob	0.00	0.00	1.00	0.98
KWS Target	5	Rob?	0.45	1.15	13.45	11.33
SY Epson	6	Rob?	0.45	0.10	3.50	2.78
Horatio	6	Rob?	0.18	0.73	4.00	4.20
Monterey	6	Rob?	0.75	0.45	10.88	6.00
Gravitas	9	Rob?	0.93	0.23	xx	1.80
Thatcher <i>Lr24</i>		<i>Lr24</i>	5.33	1.37	3.00	0.03
Timber		<i>Lr24</i>	6.75	4.25	0.80	0.03
Stigg	9		33.50	21.88	38.75	6.38
Warrior	8		28.00	18.13	6.10	1.50
KWS Saxtead	8		0.00	0.00	0.00	0.03
Maris Ranger		WBR8	0.00	0.00	0.00	0.00

* = 1-9 rating for resistance to brown rust on HGCA RL for 2012/13. Data collected before 2012 season.
xx = missing data

September 2013



UK Cereal Pathogen Virulence Survey

Yellow rust of wheat – 2012 Annual Report

A J Hubbard and R A Bayles

NIAB, Huntingdon Road, Cambridge CB3 0LE

While the Agriculture and Horticulture Development Board, operating through its HGCA division, seeks to ensure that the information contained within this document is accurate at the time of printing, no warranty is given in respect thereof and, to the maximum extent permitted by law, the Agriculture and Horticulture Development Board accepts no liability for loss, damage or injury howsoever caused (including that caused by negligence) or suffered directly or indirectly in relation to information and opinions contained in or omitted from this document.

Reference herein to trade names and proprietary products without stating that they are protected does not imply that they may be regarded as unprotected and thus free for general use. No endorsement of named products is intended, nor is any criticism implied of other alternative, but unnamed, products.

HGCA is the cereals and oilseeds division of the Agriculture and Horticulture Development Board.



Key points

Virulence for adult plants of Warrior was confirmed in field tests of isolates collected in 2011. Isolates of the 'Warrior race' also overcame the adult plant resistance of Claire and related cultivars, which has remained effective in the UK since the variety first entered national list trials in 1997. Virulence for KWS Sterling was confirmed at the adult plant stage.

Introduction

Yellow rust was widespread in farm crops and variety trials in 2012 and a greater than average number of samples were received by the UKCPVS.

2012 isolates: seedling virulence tests

Methods

28 isolates were selected for virulence testing on the basis of the cultivar and location from which they originated.

Isolates tested came from 16 different wheat cultivars (Table 1). 11 were from highly resistant cultivars with a rating of 9 on the HGCA Recommended List. Another 11 were from cultivars rated 8 and five from cultivars rated 7.

Table 1. Cultivars from which wheat yellow rust isolates were tested

Cultivar	1–9 Resistance rating*	No. of isolates tested
Beluga	9	2
Claire	9	4
Cougar	9	1
Leeds	9	2
Stigg	9	1
Torphins	9	1
Warrior	8	3
Invicta	8	1
JB Diego	8	3
KWS Yaris	8	1
KWS Kielder	8	2
KWS Rowan	8	1
Cordiale	7	2
Denman	7	1
Gravitas	7	2
Shamrock	*	1
Total		28

*HGCA Recommended Lists 2012/13: ratings based on data available before 2012 season

Most isolates were from the eastern parts of England, in a band running from Kent in the south to Lincolnshire in the north (Table 2). However, there were also isolates from the South West, the West Midlands and Yorkshire.

Table 2. Locations from which wheat yellow rust isolates were tested

Region	County	No. of isolates tested
East Anglia	Cambridgeshire	4
	Norfolk	1
East Midlands	Lincolnshire	6
	Leicestershire	4
South East	Kent	6
	Essex	2
South West	Somerset	3
West Midlands	Oxford	1
North	Yorkshire	1
Total		28

Virulence tests were carried out on seedlings of the differential cultivars listed in Table 3, using the methods described by Priestley, Bayles and Thomas, 1984. Additional cultivars, of particular relevance to UK breeding, were added to the core differential set.

Table 3. Differential cultivars used in 2012 seedling virulence tests

Differential cultivar	WYR factor	Gene designation
<u>Core set</u>		
Chinese 166	WYR1	Yr1
Kalyansona	WYR2	Yr2
Vilmorin 23	WYR3	Yr3+
Nord Desprez	WYR3	Yr3+
Hybrid 46	WYR4	Yr4
Heines Kolben	WYR2,6	Yr2, Yr6
Heines Peko	WYR2,6	Yr2, Yr6
Lee	WYR7	Yr7
Avocet x Yr7	WYR7	Yr7
Compair	WYR8	Yr8
Kavkaz x 4 Fed	WYR9	Yr9
Clement	WYR9	Yr9
Avocet xYr15	WYR15	Yr15
VPM 1	WYR17	Yr17
Rendezvous	WYR17	Yr17
Avocet x Yr32	WYR32	Yr32
Carstens V	WYR32	Yr32
Talon	WYR32	Yr32
Spaldings Prolific	WYR Sp	YrSp
<u>Additional cultivars*</u>		
Robigus	WYR 'Rob'	
Solstice (4)	WYR 'Sol'	
Timber	WYR 'Tim'	
Cadenza	WYR6,7+APR	
Warrior	WYR 'Warrior'	
Ambition	WYR 'Ambition'	
Cougar (9)		
Crusoe (9)		
KWS Sterling (9)		
Leeds (9)		
Stigg (9)		
Torphins (9)		
JB Diego (8)		
KWS Kielder (8)		
KWS Rowan (8)		
KWS Yaris (8)		
Weaver (8)		

* resistance ratings in brackets are based on data prior to 2012 season

Results and discussion

Virulence frequency data for 2012, together with data from 2002-2012, are shown in Table 4.

Table 4. Virulence frequencies (%) from 2002 to 2012

Virulence for	02	03	04	05	06	07	08	09	10	11	12
WYR1	97	100	100	100	*	*	100	100	100	100	100
WYR2	97	100	100	100	*	*	100	100	100	100	100
WYR3	97	100	93	100	*	*	91	99	100	100	100
WYR4	63	86	50	87	100	100	81	98	100	100	100
WYR6	31	50	42	10	19	4	19	90	98	95	100
WYR7	3	36	4	8	11	4	0	0	24	65	100
WYR8	0	0	0	0	0	0	0	0	0	0	0
WYR9	88	93	100	95	100	94	93	93	99	98	100
WYR15	0	0	0	0	0	0	0	0	0	0	0
WYR17	88	93	85	97	100	88	83	87	97	96	100
WYR32	73	64	38	85	89	92	79	94	95	98	100
Spaldings Prolific 'Sp'	0	7	0	0	*	*	*	*	*	*	79
Robigus 'Rob'			31	79	89	84	81	81	100	100	100
Solstice 'Sol'							10	69	98	96	100
Timber 'Tim'					7	0	5	2	0	48	75
Warrior 'War'									3 [†]	52	61
Ambition 'Amb'											79
Cadenza R6,7,+									3 [†]	48	79
Cougar											0
Crusoe											0
KWS Sterling											29
Leeds											89
Stigg											0
Torphins											32
JB Diego											82
KWS Kielder											96
KWS Rowan											100
KWS Yaris											100
Weaver											89
No. isolates	36	14	48	39	27	25	21	42	40	27	28

[†] not confirmed in subsequent tests

* differential not included in tests

All 2012 isolates were virulent on *Yr1,2,3,4,6,7,9,17,32* and on cultivars Robigus and Solstice.

Virulence for Warrior was detected in 61% of isolates, with virulence for Spaldings Prolific (re-introduced as a differential after a break of six years), Timber and Cadenza in around 75% to 79% of isolates.

No virulence was detected for the differential cultivars for *Yr8* or *Yr15* nor for the cultivars Cougar, Crusoe or Stigg.

29% of isolates were virulent on KWS Sterling.

The most common pathotype was virulent on *Yr1,2,3,4,6,7,9,17,32,Sp,Rob,Sol,Tim War*. This pathotype has been widely referred to as the 'Warrior race'. A variant of this type carried additional virulence for KWS Sterling.

A second, less frequent, pathotype was similar to the earlier 'Solstice type', but with additional virulence for *Yr7* i.e virulence for *Yr1,2,3,4,6,7,9,17,32, Rob,Sol*.

It was notable that whereas 'Solstice' type isolates were virulent on both of the differentials used for *Yr17*, VPM and Rendezvous, 'Warrior' types were virulent on VPM1 but consistently avirulent on Rendezvous. It appears that Rendezvous may carry an additional, unidentified, specific resistance, which is not matched by the Warrior pathotype, but has been matched by previous UK pathotypes carrying virulence for *Yr17*, including the 'Solstice' type.

2011 isolates: adult plant tests

Methods

Five isolates (Table 5) were tested on a set of 51 cultivars in adult plant tests in field isolation nurseries. Seedling tests of the same isolates and cultivars were carried out under standard controlled environment conditions.

Table 5. Isolates tested on adult plants in 2012

Code	Year	Location	Cultivar	Virulence at seedling stage
11/08	2011	Lincolnshire	Warrior	1,2,3,4,6,7,9,17,32,Sp,Rob,Sol,Tim,War
11/13	2011	Lincolnshire	Warrior	1,2,3,4,6,7,9,17,32,Sp,Rob,Sol,Tim,War,Ste [†]
11/75	2011	Cambridgeshire	Torch	1,2,3,4,6,7,9,17,32,Sp,Rob,Sol,Tim,War
11/128	2011	Bedfordshire	Panorama	1,2,3,4,6,7,9,17,32,Sp,Rob,Sol,Tim,War
11/140	2011	Bedfordshire	KWS Sterling	1,2,3,4,6,7,9,17,32, Rob,Sol,Ste [†]

[†] KWS Sterling

Results and discussion

The results of adult plant tests are presented in Table 6, with corresponding seedling reactions in Table 7. In Table 6, percentage infection levels are expressed as the mean of eight assessments made at regular intervals between 4 May (GS36) and 22 June (GS 72).

Four isolates (11/08, 11/13, 11/75 and 11/128) were virulent on Warrior at the seedling stage and fell within the 'Warrior race' category. These gave slight to moderate levels of infection on adult

plants of Warrior. The first two isolates, which had been collected from Warrior itself, gave clearly higher levels of infection on adult plants on Warrior than the second two, collected from other cultivars.

Perhaps an even more significant attribute of these four isolates is that they produced moderate to high levels of infection on Claire, Alchemy and Beluga, all previously rated at '9' for resistance. This is the first firm evidence that the adult plant resistance of Claire and related cultivars has now been overcome in the UK.

Isolate 11/140, collected from KWS Sterling, was the only isolate to infect this cultivar at the adult plant stage. It also gave moderate to high levels of infection on the cultivar Apache, which has been used for some years as a source of adult plant resistance in breeding programmes in France. 11/140 was avirulent on adult plants of Claire, together with Alchemy, Gallant, Duxford, Beluga and Denman, despite being virulent on seedlings of these varieties.

Stigg and Crusoe maintained their resistance at seedling and adult plant stages to all isolates. Cultivars listed from Scout to Cadenza in the tables continued to be resistant at the adult plant stage, despite susceptibility to some isolates as seedlings.

Table 6. Adult Plant Tests. % leaf area infected with yellow rust (mean 8 assessments)

Variety	R Factors	11/8	11/13	11/75	11/128	11/140
Stigg	R	0.0	0.0	0.0	0.0	0.0
Crusoe	R	0.0	0.2	0.1	0.1	0.0
Scout	?+APR	0.0	0.0	0.0	0.0	0.0
Panorama	?+APR	0.3	0.3	0.1	0.1	0.0
Cocoon	?+APR	0.4	0.6	0.9	0.1	0.0
JB Diego	?+APR	1.4	0.0	0.0	0.0	0.0
Invicta	?+APR	0.7	0.4	0.1	0.4	0.1
KWS Target	?+APR	0.3	0.4	1.5	0.3	0.3
Tuxedo	?+APR	0.0	0.0	0.0	0.0	0.0
Apostle	?+APR	0.0	0.0	0.0	0.0	0.0
Relay	?+APR	0.0	0.0	0.0	0.0	0.0
KWS Gator	?+APR	0.0	0.1	0.0	0.0	0.0
Cadenza	6,7,+APR	0.2	0.0	0.1	0.0	0.0
KWS Saxtead	?	0.0	0.0	0.0	0.0	1.3
Delphi	?	0.0	0.0	0.0	0.0	0.0
Alchemy	?	8.4	7.9	12.2	4.6	0.0
Gallant	?	11.8	11.9	11.9	11.9	1.3
Duxford	?	10.1	16.2	15.1	8.5	2.3
Beluga	?	16.9	15.4	14.5	14.6	3.5
Denman	?	15.4	17.0	15.6	15.9	2.5
Claire	?	14.8	18.2	16.8	13.8	0.1
Horatio	?	14.8	22.6	15.4	14.4	0.0
Kingdom	?	2.5	4.0	1.7	1.6	0.1
KWS Solo	?	5.0	4.9	2.7	1.6	0.1
SY Epson	?	7.7	7.3	9.6	2.6	0.1
Monterey	?	18.1	17.3	10.9	8.5	0.2
Warrior	?	13.9	6.7	2.3	1.0	0.0
Gravitas	?	17.6	19.4	17.6	16.4	3.8
Timber	?	22.9	23.9	27.2	29.3	13.0
KWS Sterling	?	0.1	0.6	0.8	0.0	16.9
Apache	7,17+APR	4.5	4.1	3.6	1.6	25.9
Grafton	7+	3.1	2.4	4.7	2.6	3.6
Cordiale	7+	9.3	11.6	12.0	7.7	8.7
Brock	7+	13.0	12.5	10.1	5.5	14.6
KWS Podium	?Rob	7.1	9.3	5.5	3.6	7.9
Conqueror	?Rob+	6.3	9.5	5.9	10.9	15.2
Talon	32	21.3	28.9	23.1	21.0	9.4
KWS Santiago	?	11.5	10.3	11.1	15.0	12.9
Viscount	?Sol	18.5	13.3	10.6	17.4	19.9
Solstice	Sol	11.0	22.9	15.4	16.4	19.2
Robigus	Rob	35.4	34.8	26.2	28.9	31.3
Oakley	6+	30.0	34.5	38.6	30.0	37.4
Torch	?	51.1	52.7	48.9	51.5	44.0
Brigadier	9,17	19.5	18.1	17.1	19.5	36.3
Slejpner	9	22.1	20.0	20.9	24.4	31.0
Hornet	6,9	32.7	32.1	33.7	29.5	22.3
Mascot	6,17	11.4	12.6	8.9	14.8	13.9
Napier	6,9,17	3.8	7.9	3.2	7.5	12.5
Hobbit	14	11.7	9.4	9.3	12.8	14.1
Chilton	?	11.4	10.0	10.9	10.6	7.7
Hustler	13	9.1	1.7	4.1	12.1	19.0

Highlighting indicates compatible variety x isolate interactions based on infection levels

Table 7. Seedling reactions to isolates used in adult plant tests (AIT[†])

Variety	R Factors	11/8	11/13	11/75	11/128	11/140
Stigg	R	0.0	0.0	0.0	0.0	0.0
Crusoe	R	0.7	0.0	0.0	0.4	0.7
Scout	?+APR	3.0	3.0	3.2	3.0	3.0
Panorama	?+APR	3.0	3.0	3.0	3.0	3.5
Cocoon	?+APR	3.0	3.2	3.0	4.0	3.0
JB Diego	?+APR	3.0	3.3	4.0	3.2	3.0
Invicta	?+APR	3.2	3.1	4.0	3.5	4.0
KWS Target	?+APR	4.0	3.2	3.0	3.3	2.8
Tuxedo	?+APR	0.0	0.2	0.4	3.0	2.9
Apostle	?+APR	1.1	1.5	1.2	2.1	3.0
Relay	?+APR	2.7	0.3	0.0	2.8	3.0
KWS Gator	?+APR	0.0	2.6	3.0	2.8	3.0
Cadenza	6,7,+APR	3.0	2.3	3.0	2.6	3.0
KWS Saxtead	?	*	*	*	*	*
Delphi	?	*	*	*	*	*
Alchemy	?	3.2	3.5	3.5	4.0	3.5
Gallant	?	4.0	3.0	3.5	3.1	3.0
Duxford	?	3.2	3.1	3.0	3.2	2.9
Beluga	?	3.0	3.1	3.0	3.0	4.0
Denman	?	4.0	4.0	4.0	4.0	4.0
Claire	?	3.2	3.2	3.0	3.0	3.2
Horatio	?	3.5	3.5	4.0	3.0	3.5
Kingdom	?	*	*	*	*	*
KWS Solo	?	*	*	*	*	*
SY Epson	?	*	*	*	*	*
Monterey	?	*	*	*	*	*
Warrior	?	3.1	2.9	3.1	3.0	2.2
Gravitas	?	3.0	3.0	2.9	3.0	0.2
Timber	?	3.2	3.1	3.0	3.0	1.4
KWS Sterling	?	2.1	2.9	2.3	0.0	3.0
Apache	7,17+APR	3.0	2.9	3.5	1.2	3.5
Grafton	7+	3.0	3.0	3.0	2.3	3.0
Cordiale	7+	3.2	3.0	3.0	3.0	3.5
Brock	7+	3.5	3.5	3.0	2.9	3.5
KWS Podium	?Rob	3.0	3.5	3.0	3.5	3.1
Conqueror	?Rob+	4.0	3.2	3.5	4.0	4.0
Talon	32	3.0	3.1	3.1	4.0	4.0
KWS Santiago	?	2.0	2.7	1.1	3.1	4.0
Viscount	?Sol	1.6	1.0	0.4	3.0	4.0
Solstice	Sol	3.2	4.0	3.2	4.0	4.0
Robigus	Rob	3.0	4.0	4.0	4.0	4.0
Oakley	6+	3.3	4.0	3.0	4.0	4.0
Torch	?	3.0	3.2	4.0	3.0	0.0
Brigadier	9,17	*	*	*	*	*
Slejpner	9	*	*	*	*	*
Hornet	6,9	*	*	*	*	*
Mascot	6,17	*	*	*	*	*
Napier	6,9,17	*	*	*	*	*
Hobbit	14	*	*	*	*	*
Chilton	?	*	*	*	*	*
Hustler	13	*	*	*	*	*

[†] 0,1,2 = resistant (green shading) 3,4 = susceptible (yellow shading) *Variety not included

Reference

Priestley R H, Bayles R A and Thomas J E (1984). Identification of specific resistances against *Puccinia striiformis* (Yellow Rust) in winter wheat varieties. 1. Establishment of a set of type varieties for adult plant tests. *Journal of the National Institute of Agricultural Botany*, **16**, 469-476.