UKCPVS 2013 ANNUAL REPORT

BROWN RUST OF WHEAT

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Virulence for the cultivars Timber, Stigg and Warrior, first detected in 2011, was identified in around 30% of the 2013 isolates. These cultivars are believed to carry the *Lr24* resistance. Virulence for the Robigus group of cultivars, carrying *Lr28*, was identified in 45% of the isolates.

INTRODUCTION

There was a moderate incidence of brown rust in wheat in 2013.

2013 ISOLATES: SEEDLING VIRULENCE TESTS

METHODS

25 isolates were tested from 23 different wheat cultivars (Table 1). These included a wide range of cultivars from the Recommended List and several cultivars no longer in trials. The greatest number of isolates came from samples collected in Cambridgeshire (Table 2) with a further 3 tested from Lincolnshire and 1 from Hampshire and 1 from Dorset.

Table 1: Cultivars from which brown rust isolates were tested.

Cultivar	1-9 Resistance rating*	No. of isolates tested
Warrior		1
Beluga	4	1
Viscount	7	1
Scout	8	1
Torch		1
KWS Dali		1
KWS Croft		1
Stigg		2
Timber		1
Crusoe	6	1
Mascot		1

Robigus		2
Conqueror	6	1
Icebreaker		1
Icon		1
Invicta	6	1
KWS Rowan		1
Leeds	5	1
Panacea		1
Revelation	9	1
Denman	5	1
Claire	5	1
Glasgow		1
TOTAL		**25**

*****HGCA Recommended Lists 2013/2014

Table 2: Locations from which brown rust isolates were tested.

Region	County	No. of isolates tested
East Anglia	Cambridgeshire	20
East Midlands	Lincolnshire	3
South East	Hampshire	1
South West	Dorset	1
TOTAL		**25**

Isolates were tested for virulence on seedlings of three sets of wheat lines (Table 3):

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: Differential cultivars used in 2013 seedling virulence tests.

Differential cultivar	WBR factor	*Lr* gene
Standard WBR cultivars		
Clement	WBR1	*Lr26*
Fundin	WBR2	*Lr17b*
Sappo	WBR3	*Lr20*
Halberd	WBR4	*Lr20*
Sterna	WBR7	*Lr3a*
Armada	WBR0	
Thatcher near isogenic lines		
Thatcher x *Lr1*		*Lr1*
Thatcher x *Lr20*		*Lr20*
Thatcher x *Lr24*		*Lr24*
Thatcher x *Lr26*		*Lr26*
Thatcher x *Lr37*		*Lr37*
Additional cultivars		
Alchemy	“Claire”	
Glasgow		*Lr1*
Robigus	“Rob”	*Lr28*
Scout	? “Rob”	
Horatio	? “Rob”	
Timber	“Timber”	*Lr24*
Stigg	?”Timber”	
Warrior	?”Timber”	
Chronicle		
Cocoon (9)		
Cougar (9)		
Crusoe (6)		
Dickens (9)		
KWS Sterling (8)		
Leeds (5)		
Revelation (9)		
Tuxedo (8)		

RESULTS

Seedling virulence frequencies are shown in Table 4, along with data from 2003 – 2012.

Virulence for Timber, Stigg and Warrior, all believed to carry *Lr24*, decreased from 44% in 2012 to less than 30% in 2013.

Virulence for Robigus and other cultivars carrying *Lr28* decreased from 58% in 2012 to 45%. The 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 WBR3/WBR4/*Lr20* and WBR7 remained at low levels.

Virulence for WBR1/*Lr26* and *Lr1*/Glasgow increased by 2-5 fold from 2012.

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 4. Virulence frequencies (%) 2003-2013.

Virulence for		03	05	06	07	08	09	10	11	12	**13**
WBR cultivars											
Clement	WBR1	73	69	44	21	24	0	70	5	11	**44**
Fundin	WBR2*	73	100	100	100	86	91	70	86	89	**76**
Sappo	WBR3	0	13	28	8	5	0	0	14	19	**24**
Halberd	WBR4	0	13	24	8	10	9	0	10	22	**12**
Sterna	WBR7	68	56	68	8	14	0	90	0	7	**24**
Armada	WBR0	100	100	100	100	100	100	100	100	100	**72**
Thatcher NILs											
Thatcher x *Lr1*	*Lr1*	0	28	32	13	14	18	0	10	7	**24**
Thatcher x *Lr20*	*Lr20*									7	**4**
Thatcher x *Lr24*	*Lr24*									37	**16**
Thatcher x *Lr26*	*Lr26*	73	69	44	17	33	0	40	5	11	**28**
Thatcher x *Lr37*	*Lr37**			100	30	91	27	100	91	59	**56**
Additional cultivars											
Alchemy	"Claire"*			100	58	100	100	100	91	85	**68**
Glasgow	*Lr1*			32	17	19	18	0	10	7	**40**
Robigus	"Rob"			32	30	10	18	0	52	59	**48**
Scout	? "Rob"					14	18	0	43	59	**44**
Horatio	? "Rob"								38	56	**44**
Timber	*Lr24*				0	0	0	0	19	48	**28**
Stigg	? *Lr24*								24	41	**24**
Warrior	? *Lr24*							0	5	44	**28**
Chronicle										67	**64**
Cocoon										74	**68**
Cougar										33	**28**
Crusoe										67	**48**
Dickens										33	**28**
KWS Sterling										33	**44**
Leeds										48	**44**
Revelation										82	**52**
Tuxedo										59	**48**
No. of isolates		22	32	25	24	21	11	10	21	27	**25**

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

2012 ISOLATES: ADULT PLANT TESTS

METHODS

Five isolates from the 2012 survey (Table 5) were tested on a set of 75 cultivars in adult plant tests in field isolation nurseries.

Table 5. Isolates tested on adult plants in 2013 (virulence / avirulence for resistances detectable at the seedling stage).

Code	Cultivar	Virulent on	Avirulent on
12/07	Stigg	*Lr17b*/R2, *L24*, *Lr37*, Timber, Stigg, Warrior, Alchemy/Claire	*Lr26*/R1, *L20*/R3, R4, *Lr3a*/R7, *Lr1*, *Lr26*, *Lr28*, Robigus, *Lr20*
12/08	Crusoe	*Lr26*/R1, *Lr17b*/R2, *Lr20*/R4, *Lr3a*/R7, *Lr1*, *Lr28*, *Lr37*, Alchemy/Claire	*Lr20*/R3, *Lr24*, Timber, Stigg, Warrior, Robigus, *Lr20*
12/09	Leeds	*Lr17b*/R2, *Lr26*, *Lr37*, Robigus, Alchemy/Claire	*Lr26*/R1, *Lr20*/R3, R4, *Lr3a*/R7, *Lr1*, *Lr24*, *Lr28*, Timber, Stigg, Warrior, *Lr20*
12/10	KWS Target	*Lr17b*/R2, *Lr37*, Robigus, Alchemy/Claire	*Lr26*/R1, *Lr20*/R3, R4, *Lr3a*/R7, *Lr1*, *Lr24*, *Lr26*, *Lr28*, Timber, Stigg, Warrior, *Lr20*
12/14	Warrior	*Lr17b*/R2, *Lr20*/R3, R4, *Lr24*, *Lr37*, Timber, Stigg, Warrior, Robigus, *Lr20*, Alchemy/Claire	*Lr26*/R1,*Lr3a*/R7, *Lr1*, *Lr28*

RESULTS AND DISCUSSION

Adult plant results in Table 6 are mean leaf area infection values for four assessments made between GS65 and GS77 (1st July – 16th July).

Levels of brown rust infection in the nurseries were generally low. Infection did however build up to significant levels in some of the most susceptible cultivars, including Buster, Beluga, KWS Gator, Chilton, Stigg and Warrior, indicating that conditions were conducive for disease development and inoculation had been successful. Yellow rust contamination was observed late in the season.

Lower than expected levels of infection were recorded on some well-known susceptible cultivars with ratings of 3 or 4 which are usually susceptible to all isolates; examples of these included Alchemy, Cordiale, Duxford, Gallant, Grafton and JB Diego. This suggests that

these cultivars may carry specific resistances which were not matched by corresponding virulences in the isolates tested.

Infection on Claire and Alchemy was also at a relatively low level, suggesting that virulence for the "Claire" adult plant resistance was absent in the isolates. Virulence for the adult plant resistance *Lr3a* was also absent.

Virulence for the group of cultivars believed to carry the "Robigus" resistance (*Lr28*) was represented in the nurseries in isolates 12/09 and 12/10. This was most apparent in the reactions of the more susceptible cultivars, in particular KWS Target, Gravitas and Monterey.

Isolate 12/07, derived from cultivar Stigg, was virulent on adult plants of Timber, Stigg and Warrior, reflecting the virulence detected at the seedling stage. The isolate was also shown to be virulent on seedlings of the Thatcher *Lr24* differential and provides further confirmation that Stigg and Warrior carry the resistance *Lr24*.

The virulences detected in isolate 12/08, derived from cultivar Crusoe, at the seedling stage were also represented in adult plants. It gave very high levels on adult plants of this variety, none of the other isolates infected Crusoe at adult plant stage

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

			12/08	12/07	12/09	12/10	12/14
VARIETY	**Resistance Rating***	**R factors**	**Crusoe**	**Stigg**	**Leeds**	**KWS Target**	**Warrior**
ARMADA		0	8.29	4.56	5.54	6.64	5.06
ALCHEMY	4	Claire	2.41	4.10	2.19	2.84	2.03
CLAIRE	5	Claire	1.84	3.80	1.53	0.94	0.33
GLASGOW		Lr1	12.33	0.13	0.17	0.60	0.06
CONSORT		Lr10, Lr13	15.00	4.94	3.33	6.67	2.40
SOLSTICE	4	Lr13	18.17	4.31	6.17	6.55	14.24
MARIS HUNTSMAN		Lr13	4.00	0.60	0.39	0.75	0.17
SOISSONS		Lr14a	6.67	2.28	0.10	0.10	0.10
SAPPO		Lr20	8.03	2.44	0.08	0.20	4.39
MARIS HALBERD		Lr20	2.08	0.03	0.02	0.10	0.13
TIMBER		Lr24	0.26	10.58	0.09	0.13	3.08
REAPER		Lr37	20.17	1.00	0.10	0.90	0.20
MASCOT		Lr37	12.14	0.10	0.46	0.07	0.08
STERNA		Lr3a	0.68	0.10	0.10	0.13	0.06
ROBIGUS		Rob	0.01	0.13	10.81	17.00	0.24
VISCOUNT	7	Rob	0.08	0.09	1.76	4.70	0.15
INVICTA	6	Rob	0.08	0.09	1.27	2.81	0.16
SCOUT	8	Rob	0.04	0.08	0.59	1.18	0.09
GRAVITAS	5	Rob?	0.41	0.14	9.41	5.77	0.10
KWS TARGET	4	Rob?	0.13	0.10	9.14	9.75	4.16
MONTEREY	5	Rob?	0.18	0.09	5.48	6.60	0.15
MARIS FUNDIN		WBR2	14.20	5.14	2.00	6.17	6.00
GAMIN		WBR6	2.44	1.17	0.47	1.79	1.27
MARIS RANGER		WBR8	0.08	0.03	0.03	0.04	0.07
AVALON		WBR9	18.14	3.91	14.89	8.33	25.75
BUSTER			37.43	21.50	17.57	12.00	12.00
STIGG			0.15	21.13	0.08	0.09	1.95
BELUGA	4		5.86	12.44	6.74	4.84	1.90
TORCH			0.04	10.06	0.06	0.11	3.33
WARRIOR			0.66	8.13	0.11	4.08	6.88
FUGUE	4		4.88	5.51	6.83	2.29	3.00
KWS GATOR	3		11.50	4.89	5.57	5.30	6.31
CUBANITA	5		5.85	2.50	1.13	3.11	1.67
CHILTON	4		7.48	2.43	3.33	4.71	2.60
WEAVER			14.59	2.39	0.71	0.50	0.20
CORDIALE	3		9.71	2.21	0.80	1.87	0.48
RW41094	5		2.03	1.79	2.66	4.57	1.26
ZULU	4		1.30	1.56	3.76	2.49	0.99
KWS W199	3		14.17	1.25	4.71	4.40	3.65
PANORAMA	5		1.77	1.13	0.28	4.11	1.58

*****= 1-9 rating for resistance to brown rust on HGCA RL for 2013/2014. Data collected before 2013 season.

Table 6 (continued). Adult plant tests: % leaf area infected with brown rust (mean of 4 assessments).

			12/08	12/07	12/09	12/10	12/14
VARIETY	**Resistance Rating***	**R factors**	**Crusoe**	**Stigg**	**Leeds**	**KWS Target**	**Warrior**
KWS CROFT	6		0.14	0.15	1.39	3.19	0.10
CONQUEROR	6		7.38	0.13	0.11	0.10	0.20
CRUSOE	6		39.29	0.13	0.09	0.11	0.06
RW41057	5		0.06	0.11	2.82	6.06	0.09
TUXEDO	8		8.04	0.11	0.09	0.09	0.05
DELPHI	7		12.38	0.10	0.09	0.13	0.03
KWS ROWAN			0.11	0.10	0.73	3.03	0.13
RW41097	5		0.08	0.10	0.41	0.61	0.10
DICKENS	9		3.69	0.09	0.04	0.06	0.01
DENMAN	5		8.71	0.08	0.69	0.14	0.05
KWS KIELDER	7		4.59	0.08	0.04	0.06	0.03
KWS STERLING	8		6.61	0.08	0.08	0.14	0.03
KWS W196	6		0.31	0.08	3.30	4.33	0.10
KWS PODIUM	7		0.06	0.06	0.24	0.64	0.10
EVOLUTION	8		2.50	0.05	0.05	0.06	0.03
KWS W204	8		4.64	0.05	0.03	0.08	0.04
RW41079	8		5.05	0.05	0.08	0.08	0.03
COCOON	9		1.39	0.04	0.09	0.08	0.00
REVELATION	9		1.65	0.04	0.03	0.06	0.01
COUGAR	9		0.01	0.00	0.00	0.00	0.00

*****= 1-9 rating for resistance to brown rust on HGCA RL for 2013/2014. Data collected before 2013 season.

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MILDEW OF BARLEY

A J HUBBARD

2013 was a poor year for barley mildew and the UKCPVS received a total of 37 infected leaf samples from just three different UK Counties.

2013 ISOLATES: SEEDLING VIRULENCE TESTS

METHODS

29 isolates were pathotyped in 2013 seedling tests and were selected for testing based on their host cultivar and the location from which they originated. Table 1 and Table 2.

Isolates were inoculated onto detached leaf segments of differential cultivars. Reaction types were assessed according to the method of Moseman *et al* (1965).

The standard set of differential cultivars, together with additional cultivars of UK relevance are shown in Table 3.

Table 1. Cultivars from which barley mildew isolates were tested.

Cultivar	1-9 Resistance rating *	No. of Isolates tested
Harlequin	7†	1
Flagon	6	2
Florentine	6	1
Winsome	6	1
Volume	6	2
Cavalier	5†	1
Escadre	5	1
KWS Joy	5	1
Mezmaar	5	1
Cassata	4	1
KWS Cassia	4	1
KWS Glacier	4	1
Fentara	4†	2
Saffron	3	2
MH07JB50		1
unknown		10
TOTAL		**29**

*HGCA Recommended List 2013/14: ratings based on data available before 2013 season
†HGCA 2013/2014 Candidate rating

Table 2. Locations from which barley mildew isolates were tested**.**

Region	County	No. of isolates tested
East Anglia	Cambridgeshire	15
East Midlands	Lincolnshire	11
Yorkshire	North Yorkshire	3
TOTAL		**29**

Table 3. Differential cultivars used in 2013 seedling virulence tests.

Differential Cultivar	BMR	Resistance genes
W.37/136	1a	*Mlh*
W.41/145	1b	*Mlra*
Goldfoil	2a	*Mlg*
Zephyr	2a,2b	*Mlg,Ml(CP)*
Midas	3	*Mla6*
Lofa	4	*MlLa*
Hassan	5	*Mla12*
H.1063	6a	*Mlk1*
Porter	6b	*Mla7*
Lotta	6c	*MlAb*
Triumph	6b,6c	*Mla7,MlAb*
Tyra	7	*Mla1*
Roland	8	*Mla9*
Apex	9	*mlo 11*
Riviera	9?	*mlo 11?*
Digger	10	*Mla13*
Ricardo	11	*Mla3*
Vanessa	Van	*Van*
Optic	Optic	
NFC Tipple	NFC Tipple	
Propino	Propino	
KWS Meridian (rating of 8)	KWS Meridian	

RESULTS AND DISCUSSION

Virulence frequency data for 2013, together with data from 2009 - 2012, are shown in Table 4.

The 2013 Barley mildew survey showed that virulence frequencies followed the same overall pattern to previous years with the odd exception.

Virulence for the most commonly used mildew resistances *Mlh, Mlra, Mlg, MI(CP),Mla6, Mla12 remained* at very high levels in 2013 isolates.

Virulence detected for *Mlk1* has risen from 7% in 2012 to 45% in 2013 but this figure is more similar to 2009 (26%) and 2011 (33%).

Virulence for *MlLa, Mla7, MlAb* and Optic has dropped in the current population.

Virulence for the additional cultivar NFC Tipple dropped from 37% in 2012 to 14% in 2013 tests.

The *Mlo11* resistance carried by the cultivars Rivera and Apex remains effective.

No virulence was detected for the additional cultivar KWS Meridian which has a rating of 8 on the 2013/14 HGCA recommended list.

Table 4. Virulence frequencies (%) from 2009 to 2013.

Virulence for	2009	2011	2012	**2013**
Mlh	96	91	100	**100**
Mlra	75	84	89	**100**
Mlg	99	97	96	**93**
Mlg,Ml(CP)	95	87	100	**83**
Mla6	77	85	100	**90**
MlLa	95	93	93	**55**
Mla12	97	96	96	**90**
Mlk1	26	33	7	**45**
Mla7	74	66	67	**48**
MlAb	74	71	44	**17**
Mla7,MlAb	49	42	26	**7**
Mla1	61	52	56	**34**
Mla9	10	6	7	**0**
mlo 11	0	3	4	**3**
mlo11?	0	0	7	**0**
Mla13	29	9	7	**7**
Mla3	19	50	37	**34**
Van	90	90	89	**86**
Optic	76	60	48	**10**
NFC Tipple	35	56	37	**14**
Propino	34	50	33	**21**
KWS Meridian			0	**0**
No. tested	111	113	27	**29**

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MILDEW OF WHEAT

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The virulence composition of the mildew population has remained very stable. Virulence corresponding to widely used winter wheat resistances remained high, while virulence corresponding to resistances from spring wheat backgrounds remained at moderate levels. Virulence detected for Robigus increased in 2013. Virulence for Stigg, Warrior and Timber remained at very low levels.

2013 ISOLATES: SEEDLING VIRULENCE TESTS

METHODS

35 single pustule isolates were tested in 2013. These comprised of 32 isolates taken from samples sent in to the UKCPVS and 3 isolates taken from mobile trap nurseries comprised of the universally susceptible variety Cerco.
The host variety and location of the original leaf samples are shown in Tables 1 -3.

Isolates were inoculated onto detached leaf segments of differential cultivars. Reaction types were assessed according to the method of Moseman *et al* (1965).

The standard set of differential cultivars, together with additional cultivars of UK relevance are shown in Table 4.

Table 1. Cultivars from which leaf sample isolates were tested.

Cultivar	1-9 rating*	No. of isolates tested
Relay	6	2
JB Diego	5	2
KWS Santiago	5	2
Scout	5	2
Claire	4	2
KWS Cashel	9†	1
Skyfall	7†	4
Icebreaker	5†	1
Oakley		1
Duxford		1
Torch		1
Consort		2
Altigo		1

Arrezzo	1
Audace	3
Talent	1
Recital	1
Unknown	4
Cerco trap nurseries	3
TOTAL	**35**

*HGCA Recommended List 2013/14: ratings based on data available before 2013 season
†HGCA 2013/14 candidate rating

Table 2. Locations from which 2013 leaf sample isolates were tested.

Region	County	No. of isolates
East Anglia	Cambridgeshire	11
East Midlands	Lincolnshire	7
West Midlands	Shropshire	8
Yorkshire	North Yorkshire	6
TOTAL		32

Table 3. Locations from which 2013 mobile trap nursery isolates were tested.

Region	County	No. of isolates
East Anglia	Suffolk	2
	Cambridgeshire	1
TOTAL		3

Table 4. Differential cultivars used to determine virulence factors.

Differential cultivar	Resistance Factors (European Codes)	Resistance genes
Standard set		
Galahad	Pm2	*Pm2*
Chul	Pm3b	*Pm3b*
Armada	Pm4b	*Pm4b*
Flanders	Pm5	*Pm5*
Brimstone	Pm6	*Pm6*
Maris Dove	Mld	*Mld*
Clement	Pm8	*Pm8*
Brock	Pm2, MITa2	*Pm2, MITa2*
Mercia	Pm5, MITa2	*Pm5, MITa2*
Tonic	MITo	*Pm3d*+?
Broom	Pm3d	*Pm3d*
Sicco	Pm5, MISi2	*Pm5, MISi2*
Wembley	MISo	*MISo*
Axona	MIAx	*MIAx*
Amigo	Pm17	*Pm17*
Shamrock	MISh	?
Additional cultivars		
Robigus	MIRo	
Timber	MITi	
Warrior		
Stigg		
Crusoe		

RESULTS AND DISCUSSION

Virulence frequency data obtained from the seedling tests for 2013, together with data from 1999-2012, are shown in Table 5.

Overall, the virulence composition of the UK mildew population appears to have remained relatively stable over the past 14 years.

Virulence for *Pm2, Pm4b, Pm5, Pm6, Pm8* and *MlTa* remained at high frequencies, demonstrating that they are largely ineffective against the current mildew population. These resistances have been used extensively in UK winter wheat breeding over many years.

14% of isolates tested carried virulence for *Pm3b* which is an increase from 0% in 2012 but brings it more in line with results recorded in 2005-2010.

Virulence for resistances derived from spring wheat, such as *MlAx*, *MlTo* and *Pm3d*, remained at intermediate levels, in the range 23-34%.

Virulence for Robigus increased from 33% in 2011 and 2012 to 51% in 2013.

Virulence for the resistances of cultivars Stigg and Warrior were again detected at very low levels. The patterns of interactions of these cultivars with the isolates were similar to that of Timber, suggesting that they have a resistance in common.

The virulence frequency of 43% recorded for Crusoe, remained at a similar level to 2012 results.

No virulence was detected for *Pm17* and Shamrock which continues the trend seen in preceeding years.

Table 5. Virulence frequencies (%) 1999 – 2013.

	Frequency of virulence (%)											
Virulence for	1999	2000	2001	2002	2003	2004	2005	2006	2008	2010	2012	2013
Pm2	100	100	100	99	100	100	99	100	95	78	93	**91**
Pm3b	2	1	4	6	7	4	25	10	8	10	0	**14**
Pm4b	99	99	100	100	100	100	97	99	97	75	93	**83**
Pm5	91	88	90	89	92	90	92	95	92	71	83	**54**
Pm6	100	99	100	100	100	99	97	98	84	87	93	**83**
Pm8	99	97	98	98	94	98	90	98	62	74	93	**94**
Mld	6	12	25	24	18	18	30	31	23	20	57	**49**
Pm2, MITa2									89	99	97	**94**
Pm5, MITa2	97	96	95	99	96	97	97	98	80	67	83	**83**
MITo	16	5	24	20	20	20	27	36	24	22	43	**34**
Pm3d	15	8	24	27	20	21	30	37	25	26	47	**31**
Pm5, MlSi2	20	8	8	15	6	6	20	9	11	1	7	**6**
MlSo	6	4	6	11	4	4	16	10	5	3	3	**9**
MlAx	1	1	10	8	8	9	13	23	16	15	37	**23**
Pm17	22	2	9	13	4	6	11	9	6	0	0	**0**
MISh	3	0	4	16	8	1	5	1	0	6	0	**0**
Additional cultivars												
Robigus										33	33	**51**
Timber								7	16	1	7	**6**
Warrior										0	7	**6**
Stigg										0	7	**9**
Crusoe											57	**43**
No. of isolates tested	187	148	286	15	209	376	219	160	110	69	30	**35**

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UKCPVS 2013 ANNUAL REPORT

YELLOW RUST OF WHEAT

A J HUBBARD and R A BAYLES

The 2013 UK yellow rust pathogen population remains dominated by strains of the Warrior race first detected in 2011.
Isolates of the 'Warrior race' are capable of overcoming the adult plant resistance of Claire and related varieties.

INTRODUCTION

Yellow rust was widespread in farm crops and variety trials in 2013 and a good number of samples were received by the UKCPVS. Epidemics were seen early in the season and affected a range of RL varieties.

2013 ISOLATES: SEEDLING VIRULENCE TESTS

METHODS

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

Isolates tested came from 18 different winter wheat cultivars and two spring wheat cultivars (Table 1). Eight of these were from highly resistant cultivars with a rating of 9 or 8 on the HGCA Recommended List.

Isolates were selected for testing from a wide geographical spread.

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

Cultivar	1-9 Resistance rating*	No. of isolates tested
Crusoe	9	1
Cocoon	8	1
Invicta	8	1
JB Diego	8	3
KWS Evoke	8†	1
KWS Sterling	8	1
Chilton	7	1
KWS Podium	7	1
Cordiale	6	2
Cubanita	6†	1
Horatio	6	1
Claire	6	1
Gallant	5	1
KWS Santiago	5	2
Denman	4	1
KWS Kielder	4	1
Solstice	4	2
KWS Rowan		1
Mulika (Spr)	9	1
Paragon (Spr)	9	1
TOTAL		**25**

*HGCA Recommended List 2013/14: ratings based on data available before 2013 season
†HGCA 2013/14 Candidate rating

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

Region	County	No. of isolates tested
East Anglia	Cambridgeshire	4
	Norfolk	3
East Midlands	Lincolnshire	4
South East	Essex	4
South	Hampshire	2
West Midlands	Oxfordshire	1

	Gloucestershire	1
	Herefordshire	1
	Warwickshire	1
South West	Dorset	1
Yorkshire	North Yorkshire	3
TOTAL		**25**

Table 3. Differential cultivars used in 2013 seedling virulence tests.

Differential cultivar	WYR factor	Gene designation
Core set		
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 Yr17	WYR17	*Yr17*
Carstens V	WYR32	*Yr32*
Talon	WYR32	*Yr32*
Avocet x Yr32	WYR32	*Yr32*
Spaldings Prolific	WYR Sp	*YrSp*
Additional cultivars		
Robigus	WYR‘Rob’	
Solstice	WYR ‘Sol’	
Timber	WYR ‘Tim’	
Warrior	WYR ‘Warrior’	
KWS Sterling	WYR ‘Ster’	
Cadenza	WYR6,7+APR	
Claire	WYR Claire	
Stigg		
Crusoe		

Ambition	WYR 'Ambition'	
Heines VII	WYR2,25+	*Yr2,Yr25+*
Suwon Omar	WYR Su	*YrSu*
Avocet Yr5	WYR5	*Yr5*
Avocet Yr6	WYR6	*Yr6*
Moro	WYR10	*Yr10*
Opata	WYR27+	*Yr27+*
Strubes Dickkopf	WYR Sd,Yr25	*YrSd,25+*
Avocet Yr24	WYR24	*Yr24*
Apache	WYR7,17	*Yr7,17*

RESULTS AND DISCUSSION

Virulence frequency data for 2013, together with data from 2002-2012, are shown in Table 4.

For 2013 seedling virulence tests a range of differentials, taken from the European standard differential set, were added to bring the results in line with Europe. Several of these are older differentials which were included in historic UKCPVS seedling tests but in recent years had been omitted to allow for more current UK varieties to be added.

Virulence for the main differential factors remained at very high levels similar to previous years and all the 2013 isolates tested carried virulence for Yr 1,2,3,4,6,7,9,17,32,Rob,Sol. All isolates were also virulent on the differentials Suwon Omar (YrSu), Avocet Yr 6 (Yr6) and Strubes Dickkopf (YrSd,25).

Rendezvous previously used as a Yr17 differential was not infected in all tests unlike the other two Yr17 differentials included and this has again highlighted the likelihood of an additional specific resistance(s) within Rendezvous first observed in 2012 tests.

Ambition and Apache are European cultivars included for international interest and to further our research into the strains present in the UK.

No virulence was found for WYR8, WYR15, WYR5, WYR10, WYR24 nor for the additional cultivar Stigg.

Table 4. Virulence frequencies (%) from 2002 to 2013.

Virulence for	02	03	04	05	06	07	08	09	10	11	12	**13**
WYR1	97	100	100	100	*	*	100	100	100	100	100	**100**
WYR2	97	100	100	100	*	*	100	100	100	100	100	**100**
WYR3	97	100	93	100	*	*	91	99	100	100	100	**100**
WYR4	63	86	50	87	100	100	81	98	100	100	100	**100**
WYR6	31	50	42	10	19	4	19	90	98	95	100	**100**
WYR7	3	36	4	8	11	4	0	0	24	65	100	**90**
WYR8	0	0	0	0	0	0	0	0	0	0	0	**0**
WYR9	88	93	100	95	100	94	93	93	99	98	100	**100**
WYR15	0	0	0	0	0	0	0	0	0	0	0	**0**
WYR17	88	93	85	97	100	88	83	87	97	96	100	**100**
WYR32	73	64	38	85	89	92	79	94	95	98	100	**100**
Spaldings Prolific ‘Sp’	0	7	0	0	*	*	*	*	*	*	79	**80**
Robigus ‘Rob’			31	79	89	84	81	81	100	100	100	**100**
Solstice ‘Sol’							10	69	98	96	100	**100**
Timber ‘Tim’					7	0	5	2	0	48	75	**28**
Warrior ‘War’									3	52	61	**28**
KWS Sterling ‘Ster’											29	**50**
Cadenza									3	48	79	**80**
Claire				23	0	4	14	43	83	93	*	**92**
Stigg											0	**0**
Crusoe											0	**4**
Ambition ‘Amb’											79	**28**
Heines VII												**92**
Suwon Omar												**100**
Avocet Yr5												**0**
Avocet Yr6												**100**
Moro												**0**
Avocet Yr24												**0**
Strubes Dickkopf												**100**
Apache												**76**
Rendezvous											25	**52**
No. isolates	36	14	48	39	27	25	21	42	40	27	28	**25**

2012 ISOLATES: ADULT PLANT TESTS

METHODS

Six isolates (Table 5) were tested on a set of 71 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 2013.

Isolate Location	Cultivar	Virulence at seedling stage
12/16	Beluga	1,2,3,4,6,7,9,17,32, Rob, Sols, Sp, Tim, Cad, Warr
12/59	Gravitas	1,2,3,4,6,7,9,17,32, Rob, Sols, Sp, Tim, Cad, Warr
12/75	JB Diego	1,2,3,4,6,7,9,17,32, Rob, Sols
12/83	Claire	1,2,3,4,6,7,9,17,32, Rob, Sols, Sp, Tim, Cad
12/85	Invicta	1,2,3,4,6,7,9,17,32, Rob, Sols
12/86	Claire	1,2,3,4,6,7,9,17,32, Rob, Sols, Sp, Tim, Cad, Warr

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 6 assessments made at regular intervals between 30 May (GS34) and 4 July (GS68).

It was clear from the seedling tests and adult plant reactions that isolates 12/75 and 12/85 were typical solstice type isolates and the other four isolates exhibited characteristics similar to Warrior and Warrior type isolates.

12/75 and 12/85 showed elevated levels of infection on a group of varieties which included Viscount, KWS Santiago and Brigadier.

Solstice was infected at fairly high levels in all six trials but isolate 12/85 gave the highest infection out of the six isolates.

Warrior was infected at varying levels in the four Warrior type isolate beds and recorded higher levels of infection against the isolates 12/86 and 12/59.

The isolate 12/59 originally collected from plants of Gravitas gave the highest levels on adult plants of this variety.

Torch was the variety to show the highest recorded overall levels of infection and was infected in all six trials.

Cadenza did show chlorotic stripes without pustules at adult plant stage and this reaction was thought to be a resistant reaction and was recorded as zero.

Thirteen of the cultivars showed very good resistance to all isolates at the adult plant stage: KWS Gator, KWS Cashel, Crusoe, Scout, Delphi, Relay, Evolution, Revelation, Zulu, JB Diego, Icon, Tuxedo and Solace.

Table 6. Adult Plant Tests. % plot infected with yellow rust (mean 6 assessments).

VARIETY	12/16 Beluga	12/59 Gravitas	12/75 JBDiego	12/83 Claire	12/85 Invicta	12/86 Claire
CLAIRE	18.4	27.2	11.7	10.8	0.5	16.1
SOLSTICE	20.6	20.0	14.3	22.7	30.3	21.4
CORDIALE	7.6	16.7	4.8	4.4	3.8	13.7
ALCHEMY	4.9	13.3	0.4	12.6	0.1	11.7
DUXFORD	21.3	28.0	5.6	19.6	13.3	22.7
JB DIEGO	0.9	0.1	1.3	0.0	0.5	0.0
GALLANT	14.6	23.4	9.7	11.3	4.2	20.1
SCOUT	0.0	0.0	0.0	0.0	0.0	0.0
PANORAMA	1.8	1.5	0.5	1.7	6.4	1.8
GRAFTON	4.3	7.4	0.2	3.5	0.0	8.5
VISCOUNT	2.0	5.1	21.8	0.7	30.8	2.7
CONQUEROR	6.5	14.7	12.2	3.0	18.8	1.8
INVICTA	0.4	0.3	1.7	0.1	9.2	0.7
KWS STERLING	0.9	1.4	0.6	0.0	0.0	0.2
BELUGA	20.8	26.3	2.5	20.0	3.1	17.5
DENMAN	27.2	40.0	16.3	31.8	3.8	24.8
KWS PODIUM	11.8	16.6	8.3	7.7	11.4	12.6
KWS TARGET	4.0	9.7	8.4	3.2	4.3	12.6
KWS SANTIAGO	2.4	5.9	15.1	2.0	16.0	5.0
COCOON	1.5	1.9	2.2	0.0	5.4	0.3
GRAVITAS	22.9	38.3	14.9	17.6	6.3	29.5
TUXEDO	0.0	0.0	0.1	0.0	0.7	0.0
KWS GATOR	0.0	0.6	0.0	0.0	0.0	0.0
CHILTON	6.6	15.2	15.6	9.6	23.8	13.6
TORCH	56.4	60.3	18.4	45.5	11.9	41.3
RELAY	*	0.0	1.2	0.0	0.0	*
CRUSOE	0.0	0.0	0.0	0.0	0.2	0.1
HORATIO	14.3	30.3	15.0	15.1	10.7	25.3
MONTEREY	6.7	12.4	0.6	7.2	4.1	16.5
DELPHI	0.0	0.0	0.3	0.0	0.0	0.0
WEAVER	8.4	8.1	4.9	7.4	12.7	3.7
DICKENS	0.0	0.1	1.9	0.0	1.6	0.0
COUGAR	0.2	0.4	2.1	1.4	3.7	0.1
REVELATION	0.0	0.0	0.0	0.0	0.0	0.0
MYRIAD	0.4	1.8	1.0	0.3	0.9	0.7
KWS CROFT	0.2	0.2	0.2	7.4	0.7	1.3
KWS KIELDER	19.0	22.9	14.3	13.5	11.0	14.6
KWS ROWAN	25.0	31.0	17.4	20.1	13.8	38.0
LEEDS	2.9	9.5	2.4	8.7	5.1	9.8
CUBANITA	18.8	22.7	6.0	11.9	4.1	19.3
FUGUE	20.8	30.3	5.9	10.9	1.0	26.3
LANCASTER	5.1	17.9	3.1	19.3	7.5	10.8
KWS DALI	27.8	48.8	23.7	17.2	15.1	45.5

KWS BONHAM	2.8	2.8	0.1	0.8	0.0	0.4
KWS EVOKE	1.4	3.6	4.2	0.2	7.5	11.3
KWS CASHEL	0.0	0.0	0.0	0.0	0.0	0.0
TWISTER	7.0	21.2	9.1	8.7	6.3	20.5
ICON	0.0	0.0	0.0	0.0	0.0	0.0
SOLACE	0.0	0.0	0.1	0.0	0.2	0.0
GOLDENGUN	23.8	38.9	18.6	32.8	24.3	31.8
RW41094	0.5	1.0	5.0	0.4	3.0	4.4
ICEBREAKER	0.3	0.1	5.2	0.1	3.6	0.2
SKYFALL	15.9	24.3	5.0	17.5	2.2	16.1
ZULU	0.0	0.0	0.0	0.4	0.1	0.0
PANACEA	19.4	33.8	10.2	17.7	13.2	23.0
EVOLUTION	0.1	0.1	0.1	0.0	0.1	0.3
AMBITION	34.8	35.7	6.9	24.2	4.0	35.8
APACHE	2.7	6.6	*	9.8	0.1	13.1
BRIGADIER	8.1	4.2	32.6	0.2	36.6	4.2
BROCK	13.6	23.9	1.6	15.1	2.2	16.0
CADENZA	0.0	0.0	0.0	0.0	0.0	0.0
HOBBIT	7.0	16.7	8.6	5.2	21.5	11.4
HUSTLER	0.9	2.5	*	0.0	10.7	0.1
NAPIER	0.9	0.4	14.1	0.0	19.2	0.0
RENDEZVOUS	0.2	0.5	14.9	0.0	12.8	0.1
ROBIGUS	39.6	43.2	36.6	31.5	29.3	42.3
TALON	18.7	27.8	15.2	13.6	23.7	23.5
TIMBER	30.5	28.8	19.4	30.7	0.2	30.3
WARRIOR	6.8	13.3	0.4	4.3	0.4	23.6
ASHBY	15.6	18.8	5.3	12.8	0.6	19.0
PARAGON	15.1	14.5	7.7	13.0	4.0	11.1

* denotes missing plot

Table 7. Seedling test results of 6 isolates tested in adult plant tests (AIT = Average Infection Type).

Variety	WYR	12/85	12/83	12/86	12/16	12/59	12/75
Claire		3.0	3.0	4.0	3.0	3.0	2.9
Solstice		3.0	3.5	3.3	3.2	3.1	3.2
Cordiale		0.0	3.0	3.0	3.2	3.1	1.2
Alchemy		3.0	3.0	3.0	3.0	3.0	3.0
Duxford		2.8	3.0	3.2	3.1	3.1	3.0
JB Diego		3.0	3.0	3.0	3.0	3.2	3.0
Gallant		3.0	3.2	3.0	3.0	3.1	3.0
Scout		1.3	2.0	1.1	0.2	1.9	2.1
Panorama		3.0	2.9	3.0	2.9	3.0	3.1
Grafton		0.0	3.0	3.0	missing	3.0	1.0
Viscount		3.2	0.9	2.0	0.2	1.5	4.0
Conqueror		3.0	3.0	3.1	3.9	4.0	3.5
Invicta		2.8	3.1	2.1	3.1	3.0	3.2
KWS Sterling		0.0	1.3	0.6	2.1	3.0	0.0
Beluga		3.0	3.2	3.0	3.0	3.1	3.0
Denman		3.0	3.2	1.5	3.0	3.1	3.2
KWS Podium		3.0	3.0	3.1	3.0	3.1	3.0
KWS Target		3.0	3.0	3.1	3.0	3.0	3.0
KWS Santiago		3.0	0.4	3.0	0.2	3.0	3.0
Cocoon		3.0	3.1	3.0	2.8	3.0	3.0
Gravitas		3.0	3.2	3.0	3.2	3.2	3.0
Tuxedo		3.0	0.1	0.0	0.0	0.0	1.8
KWS Gator		1.8	2.0	0.6	0.8	2.2	2.2
Chilton		3.0	3.0	3.2	3.0	4.0	4.0
Torch		3.0	3.0	4.0	3.0	4.0	2.9
Relay		3.0	1.8	2.8	0.1	2.0	3.2
Crusoe		0.0	1.7	1.1	0.0	0.0	0.0
Horatio		3.0	3.0	3.0	3.0	4.0	3.0
Monterey		3.0	3.0	2.9	2.1	3.0	3.0
Delphi		3.0	2.4	1.9	1.8	3.0	3.0
Weaver		3.0	3.1	3.0	3.0	3.0	3.1
Dickens		3.0	1.7	0.0	0.1	1.6	3.1
Cougar		0.3	0.4	0.2	0.0	0.0	0.0
Revelation		2.2	3.0	0.2	2.3	1.8	3.0
Myriad		3.0	3.0	2.4	1.5	4.0	3.0
KWS Croft		2.5	3.0	3.0	3.0	4.0	2.0
KWS Kielder		3.0	3.0	3.0	3.8	3.0	4.0
KWS Rowan		3.0	3.0	3.0	4.0	2.8	3.1
Leeds		1.9	3.0	3.0	3.2	3.0	3.0
SY110110		0.2	3.0	4.0	3.2	3.0	1.3
SY110173		2.0	3.0	3.1	3.2	4.0	3.0
MH09-27		3.5	3.0	3.0	3.0	4.0	3.0
KWS W196		3.0	3.0	2.0	2.4	4.0	3.0
KWS W199		0.0	3.0	3.0	3.5	3.0	0.6

KWS W204		3.0	3.0	3.0	3.1	3.0	3.1
KWS W206		3.0	3.1	3.0	3.0	3.0	3.3
MH10-33		2.1	3.0	3.0	2.2	2.9	3.0
RW41057		0.2	3.0	2.9	0.5	3.0	1.6
RW41079		0.0	0.0	0.0	0.0	0.0	0.0
RW41088		3.2	3.0	3.0	3.0	2.9	3.0
RW41094		3.0	3.0	2.0	1.5	3.0	3.0
RW41097		3.0	3.0	2.7	2.3	3.0	3.0
S.J3326		0.0	3.0	3.2	2.2	3.1	0.0
LGW54		3.1	2.9	3.0	2.8	3.2	3.0
LGW56		3.0	3.0	3.0	3.0	3.2	3.1
Evolution		0.5	0.4	0.9	0.0	0.0	2.6
Ambition		1.6	4.0	3.2	3.3	4.0	3.0
Apache		0.0	4.0	3.0	3.1	3.2	0.0
Brigadier		3.0	3.0	2.6	2.5	2.4	3.0
Brock		2.0	3.0	3.1	3.1	3.2	0.8
Cadenza		0.0	4.0	3.0	3.2	3.0	0.1
Hobbit		3.0	3.1	3.1	3.1	3.0	3.0
Hustler		0.0	2.0	0.0	1.0	3.0	0.0
Napier		3.0	0.0	1.9	0.0	0.2	3.0
Rendezvous		3.2	0.4	0.0	0.0	1.5	3.1
Robigus		3.2	3.1	3.0	3.2	3.2	3.2
Talon		3.5	3.2	3.0	3.2	3.2	4.0
Timber		0.0	3.0	2.0	3.0	missing	1.5
Warrior		0.0	3.0	3.1	3.0	3.0	1.8
Ashby		0.0	3.5	3.0	3.0	3.0	0.0
Paragon		0.0	3.5	3.0	3.3	3.0	0.2
Chinese 166	1	3.0	3.5	3.0	3.5	3.0	3.0
Kalyansona	2	3.0	3.2	3.0	3.1	3.0	3.0
Vilmorin 23	3a+	3.0	3.2	3.0	3.0	3.0	3.0
Nord Desprez	3a+	3.1	3.2	3.0	3.1	3.0	3.0
Hybrid 46	(3b)4b	3.1	3.2	3.0	3.0	3.0	3.1
Heines Kolben	2,6	3.0	3.0	3.0	2.2	3.0	3.0
Heines Peko	2,6	3.0	3.0	3.0	2.8	3.0	3.0
Lee	7	2.0	3.0	3.0	3.0	3.0	2.1
Av x Yr7 NIL	7	3.0	3.0	3.2	3.1	3.1	3.0
Compair	8	0.0	0.0	0.0	0.0	0.0	0.0
Kavkaz x 4 Fed	9	3.0	3.0	3.0	3.5	3.2	3.1
Clement	9	3.0	3.0	3.0	3.1	3.2	3.1
AVS x Yr 15	15	missing	0.0	missing	missing	missing	missing
VPM 1	17	3.0	3.0	2.5	3.1	3.0	3.5
Av x Yr17	17	3.0	3.0	3.0	4.0	3.2	3.5
Carstens V	32	3.0	3.0	3.1	4.0	3.1	3.5
Av x Yr32	32	3.0	3.0	3.1	4.0	3.1	3.5
Spaldings Prolific	SP	0.0	3.5	3.5	3.2	3.0	3.0
Vuka	0	3.0	3.5	3.2	3.2	3.2	4.0

susceptible (AIT 2.8-4.0)

Intermediate (AIT 2.6-2.7)

Resistant (AIT 0.0-2.5)

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