UKCPVS 2008 ANNUAL REPORT

BROWN RUST OF WHEAT

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Virulence for Robigus and Oakley was detected in fewer than 15% of isolates tested in 2008. Isolates from 2007, previously identified as carrying virulence for seedlings of these two cultivars, were also virulent on adult plants. Robigus-virulent isolates were not virulent on cultivars carrying the adult plant resistance of Claire and Alchemy.

INTRODUCTION

Brown rust appeared in wheat crops later in the season than in 2007, when the epidemic was unusually early, and the disease was less widespread and damaging.

2008 ISOLATES: SEEDLING VIRULENCE TESTS

METHODS

Table 1. Cultivars from which brown rust isolates were tested

Cultivar	R genes/factors	1-9* rating	No. isolates tested
Battalion		8	1
Buzzer	?	8	1
Gladiator	*Lr26+*	7	1
Lear	?	7	1
Robigus	'Rob'	7	1
Oakley	'Rob'	6	1
Shogun	?	6	1
Hereward	Lr10,Lr13	5	1
Panorama	?	5	1
Gallant	?	4	1
Glasgow	*Lr1*	4	1
Alchemy	'Claire'	3	2
Solstice	Lr13?	3	2
Hereford	?	2	3
Buster	?		2
Lion	?		1
TOTAL			**21**

*HGCA Recommended List for 2009/2010

21 isolates were tested from 16 different wheat cultivars (Table 1).

Table 2 shows the locations from which the samples were collected. With the exception of a single isolate from Eire, all came from East Anglia.

Table 2. Locations from which brown rust isolates were tested

Region	County	No. of isolates tested
East Anglia	Cambridgeshire	17
	Suffolk	3
Eire	Co. Down	1
TOTAL		**21**

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, and 3) current cultivars with known or unknown resistance genes (Table 3).

Seedlings of the differential cultivars were grown in a spore-proof glasshouse and inoculated at the first leaf stage with a spore: talc mixture, using a rotary inoculator. Inoculated seedlings were placed in a sealed polythene bag in a refrigerator at 5^{o}C for 48 hours in the dark. They were then transferred to a controlled environment growth room where they were maintained at a constant temperature of 20^{o}C (12 hour photoperiod) for 12-14 days, after which they were assessed for reaction type.

Table 3. Differential cultivars used in 2008 seedling virulence tests

Differential cultivar	WBR factor	Lr gene
Standard WBR cultivars		
Clement	WBR 1	*Lr26*
Maris Fundin	WBR 2	*Lr17b*
Sappo	WBR 3	*Lr20*
Halberd	WBR 4	*Lr20*
Sterna	WBR 7	*Lr3a*
Armada	WBR 0	
Thatcher near isogenic lines		
Tc*6/Centenario		*Lr1*
Tc*6/ST-1.25		*Lr26*
Tc*8/VPM1		*Lr37*
Additional cultivars		
Glasgow		*Lr1*
Alchemy	'Claire'	*?*
Robigus	'Rob'	*?*
Timber	R	*?*
Oakley	'Rob'	*?*
Battalion		*Lr37+*
Hereford		
Mascot		*Lr37*
Benzine		
Marksman		*Lr37+*
Gladiator		*Lr26,Lr37*
Scout		
Cassius		
Viscount		
Lear		
Buzzer		

RESULTS

Seedling virulence frequencies are shown in Table 4.

A number of important brown rust resistances are of the adult plant type. These resistances are not effective at the seedling stage and corresponding virulence frequencies cannot therefore be deduced from the results of seedling tests. Adult plant resistances include the 'Claire' resistance, *Lr37* and WBR2.

Certain other resistances are of the overall type and are expressed both at adult and seedling stages. These include *Lr1*, *Lr26* and the 'Robigus' resistance. The frequency of virulence corresponding to resistances of this type can be inferred from seedling tests.

Table 4. Virulence frequencies 1998 - 2008

Virulence for		**% Frequency**									
		98	99	00	01	02	03	05	06	07	**08**
WBR cvs											
Clement	WBR 1	43	27	82	100	84	73	69	44	21	**24**
M. Fundin	WBR 2	75	32	60	94	56	73	100	100	100	**86**
Sappo	WBR 3	0	0	8	0	0	0	13	28	8	**5**
Halberd	WBR 4	0	0	4	0	0	0	13	24	8	**10**
Sterna	WBR 7	7	7	61	65	50	68	56	68	8	**14**
Armada	WBR 0	100	100	100	100	100	100	100	100	100	**100**
Thatcher NILs											
Tc*6/Centenario	*Lr1*	0	0	0	0	0	0	28	32	13	**14**
Tc*6/ST-1.25	*Lr26*	43	32	83	100	73	73	69	44	17	**33**
Tc*8/VPM1	*Lr37*								100	30	**91**
Additional cultivars											
Glasgow	*Lr1*								32	17	**19**
Alchemy	'Claire'								100	58	**100**
Robigus	'Rob'								32	30	**10**
Timber	R									0	**0**
Oakley	'Rob'									17	**14**
Battalion	*Lr37+*									17	**91**
Hereford											**100**
Mascot	*Lr37*									22	**100**
Rocky	'Rob'									38	**10**
Marksman	*Lr37+*									63	**81**
Gladiator	*Lr26,Lr37*										**19**
Scout											**14**
Cassius											**52**
Viscount											**10**
Lear											**14**
Buzzer											**81**
No. of isolates tested		43	22	23	17	14	22	32	25	24	**21**

Virulence for the 'Robigus' resistance was detected at a low to moderate level (10-14% of isolates). Isolates that were virulent on Robigus or Oakley were also virulent on the newer cultivars Viscount, Scout, Rocky and Lear, suggesting that they may have a resistance factor in common. Viscount and Scout are currently on the HGCA Recommended List with ratings of 9. Adult plant tests will be required to assess the impact of Robigus-virulent isolates on adult plants of these cultivars in the field.

Timber remained resistant to all isolates.

2007 ISOLATES: ADULT PLANT TESTS

METHODS

7 isolates (Table 5) were tested on a set of 43 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 2007

Code	Year	Location	Cultivar
07/02	2007	Hertfordshire	Alchemy
07/05	2007	Gloucestershire	Robigus
07/10	2007	Essex	Oakley
07/19	2007	Essex	Marksman
07/32	2007	Kent	Gladiator
07/49	2007	Perthshire	Alchemy
07/71	2007	Lincolnshire	Oakley

RESULTS AND DISCUSSION

The results are shown in Tables 6a and 6b

Three isolates, 07/05 from Robigus and 07/10 and 07/71 from Oakley, were virulent on both of these cultivars at seedling and adult stages, although 07/05 produced generally lower levels of infection than the other two isolates. Isolates carrying virulence for Robigus and Oakley were avirulent on the adult plant resistance of Claire and Alchemy.

Virulence for the adult plant resistances *Lr10* and *Lr13* was common. Two isolates, 07/9 and 07/32 were clearly virulent on adult plants of cultivars carrying the adult plant resistance *Lr37*. Evidence of virulence for *Lr37* in other isolates was less consistent. None of the *Lr37*-virulent isolates was able to overcome the resistance of Battalion, Marksman or Hyperion, which are thought to carry *Lr37* together with additional, unidentified, resistance.

Duxford and Limerick, which generally showed susceptible reactions at the seedling stage, appeared to have an adult plant resistance which was matched by some isolates but not others.

No virulence was detected for Timber, which remains resistant to all UK isolates tested.

Table 6a. Adult plant field tests 2008. Percentage leaf area infected with brown rust (mean of 4 assessments)

		07/05 Robigus	'07/10 Oakley	07/71 Oakley	07/02 Alchemy	07/49 Alchemy	07/19 Marksman	07/32 Gladiator
Robigus	'Rob'	**1.9**	**5.9**	**5.5**	*0.0*	*0.0*	*0.0*	*0.0*
Oakley	'Rob'	**3.0**	**19.1**	**10.6**	*0.2*	*0.0*	*0.2*	*0.7*
Claire	'Claire'	*0.3*	*0.2*	*0.0*	**7.1**	**5.7**	**2.6**	*0.7*
Istabraq	'Claire'	*2.8*	*0.1*	*0.2*	**17.9**	**14.4**	**7.0**	**5.4**
Zebedee	'Claire'	*3.7*	*0.1*	*0.7*	**8.0**	**11.1**	**5.9**	**5.4**
Alchemy	'Claire'	*0.7*	*0.3*	*0.0*	**2.2**	**6.5**	**2.3**	**3.9**
Maris Huntsman	*Lr13*	*0.8*	**10.8**	**8.0**	**8.3**	**6.3**	**5.1**	**6.2**
Solstice	*Lr13*	*5.8*	**10.1**	**11.4**	**21.4**	**24.3**	**11.1**	**14.7**
Riband	*Lr13,Lr17b*	*4.1*	**16.6**	**21.5**	**8.0**	**11.6**	**7.7**	**8.4**
Consort	*Lr10,Lr13*	*1.8*	**14.9**	**25.8**	**17.6**	**18.2**	**14.5**	**12.5**
Hereward	*Lr10,Lr13*	*2.6*	*0.1*	*1.0*	**9.4**	**7.3**	**6.4**	**6.9**
Einstein	*Lr10*	*0.9*	**3.8**	**3.1**	**6.9**	**4.7**	**3.3**	**4.9**
Xi19	*Lr13*	*0.1*	*0.8*	*0.8*	*0.0*	*0.0*	*0.0*	*0.1*
Clement	*Lr26*	*1.1*	*0.1*	**3.0**	*0.5*	*0.5*	*1.7*	**4.4**
Tanker	*Lr26*	**6.7**	*2.4*	*1.2*	*4.6*	*4.7*	**13.2**	**11.6**
Slepjner	*Lr26*	**2.6**	*0.1*	*0.2*	*1.5*	*0.2*	**4.9**	*0.5*
Gladiator	*Lr26,Lr37*	**3.5**	*0.1*	*0.1*	**2.5**	*1.9*	**3.2**	**2.7**
Savannah	*Lr26,Lr37*	*0.0*	*0.0*	*0.0*	*0.1*	*0.0*	**3.5**	**2.0**
Brigadier	*Lr26,Lr37*	**4.8**	*0.1*	*0.5*	*1.7*	*0.6*	**9.0**	**6.8**
Napier	*Lr10,Lr26,Lr37*	*1.7*	*0.3*	*1.2*	**3.5**	**5.0**	**11.0**	**10.7**
Access	*Lr10,Lr26,Lr37*	*0.1*	*0.2*	*0.0*	*0.7*	*0.7*	**8.4**	**6.7**
Reaper	*Lr37*	*0.3*	*0.0*	*0.3*	*1.1*	*0.4*	**7.8**	**7.5**
Mascot	*Lr37*	12.4	*2.9*	4.9	**10.4**	*7.3*	**22.3**	**31.9**
Humber	*Lr37*	*2.5*	*1.3*	*2.4*	*4.3*	*6.0*	**14.4**	**15.5**
Monty	*Lr37?*	*0.1*	*0.0*	*1.6*	*1.5*	*1.7*	**4.1**	**5.6**
Battalion	*Lr37+*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.2*
Marksman	*Lr37+*	*0.0*	*0.0*	*0.0*	*0.2*	*0.0*	*0.3*	*0.4*
Hyperion	*Lr37+*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.7*	*0.4*
Maris Ranger	WBR8	*0.0*	*0.0*	*0.0*	*0.5*	*0.0*	*0.0*	*0.2*
Sterna	WBR7	*0.0*	*0.0*	*0.0*	*0.1*	*0.0*	*1.7*	*1.6*
Gamin	WBR6	*0.7*	*1.4*	**5.5**	*1.8*	*2.1*	*1.7*	*1.7*
Timber	*R*	*0.0*	*0.0*	*0.2*	*0.0*	*0.0*	*0.0*	*0.0*
Duxford	*?*	**4.3**	**5.5**	**2.9**	*0.1*	*0.2*	*0.2*	*0.2*
Limerick	*?*	*0.1*	**2.9**	**6.5**	*0.0*	*0.6*	*0.2*	*0.0*
Soissons	*Lr14a*	*2.9*	*0.0*	*1.6*	*2.4*	*1.7*	**13.5**	**18.2**
Glasgow	*Lr1?*	*2.1*	*0.3*	*0.6*	**4.6**	**4.6**	**11.5**	**5.3**
Hereford	*?*	*4.8*	*4.0*	*5.4*	**20.9**	**31.2**	*10.6*	*9.6*
JB Diego	*?*	*1.6*	**3.6**	**6.5**	**4.3**	**6.2**	**8.0**	**7.3**
Avalon	WBR9	*0.9*	**8.8**	**5.1**	**8.3**	**4.9**	*2.3*	**4.4**
Buster	'Buster'	**21.7**	**22.5**	**16.6**	**13.7**	**22.4**	**16.7**	*6.1*
Armada	*O*	**12.3**	**14.0**	**13.1**	**6.6**	**8.7**	**4.7**	**4.4**
Maris Fundin	WBR2 / *Lr17b*	**19.6**	**24.1**	**29.2**	**16.7**	**8.7**	**8.7**	**11.4**
Cordiale	*?*	**15.7**	**21.7**	**18.8**	**8.1**	**10.8**	**14.9**	**7.3**

Highlighting has no statistical significance.
Highlighting is used to indicate high infection levels for a particular cultivar.

Table 6b. Seedling average infection types (0-4) for isolates and cultivars included in adult plant field tests 2008.

		07/05 Robigus	'07/10 Oakley	07/71 Oakley	07/02 Alchemy	07/49 Alchemy	07/19 Marksman	07/32 Gladiator
Robigus	'Rob'	3.0	3.0	3.0	0.0	1.0	0.0	0.0
Oakley	'Rob'	3.0	3.5	4.0	0.0	0.0	0.0	0.0
Claire	'Claire'	2.0	4.0	4.0	2.8	3.0	2.5	3.0
Istabraq	'Claire'	3.0	3.6	2.6	2.0	4.0	2.0	2.2
Zebedee	'Claire'	2.0	2.0	3.0	3.2	4.0	3.0	3.0
Alchemy	'Claire'	3.0	3.0	4.0	4.0	4.0	3.0	3.0
Maris Huntsman	*Lr13*	3.0	3.0	4.0	4.0	2.3	2.1	2.2
Solstice	*Lr13*	2.0	4.0	4.0	2.1	4.0	2.5	3.0
Riband	*Lr13,Lr17b*	4.0	4.0	3.0	2.0	3.0	3.0	4.0
Consort	*Lr10,Lr13*	4.0	3.6	4.0	3.1	3.5	3.0	3.0
Hereward	*Lr10,Lr13*	3.0	4.0	4.0	2.3	3.0	2.3	3.0
Einstein	*Lr10*	4.0	4.0	4.0	3.5	4.0	3.0	4.0
Xi19	*Lr13*	3.0	3.0	4.0	2.4	3.0	2.5	4.0
Clement	*Lr26*	2.1	1.0	1.0	1.0	0.0	2.0	2.2
Tanker	*Lr26*	3.0	2.2	1.0	1.0	1.0	2.6	3.0
Slepjner	*Lr26*	2.4	1.0	3.0	1.0	1.3	2.2	3.0
Gladiator	*Lr26,Lr37*	2.3	1.0	2.0	1.0	0.0	3.2	3.0
Savannah	*Lr26,Lr37*	2.0	2.0	1.0	1.0	0.0	2.3	2.0
Brigadier	*Lr26,Lr37*	3.0	1.0	1.0	0.1	0.0	3.0	3.0
Napier	*Lr10,Lr26,Lr37*	3.0	1.0	2.0	1.0	0.0	2.4	2.0
Access	*Lr10,Lr26,Lr37*	4.0	3.0	4.0	2.2	4.0	3.2	2.6
Reaper	*Lr37*	2.9	3.0	3.0	3.0	3.0	2.4	2.5
Mascot	*Lr37*	3.0	1.6	3.0	2.3	2.2	2.0	4.0
Humber	*Lr37*	2.0	0.5	1.0	1.0	1.0	2.5	2.0
Monty	*Lr37?*	2.0	1.4	1.0	1.0	1.0	2.0	4.0
Battalion	*Lr37+*	3.0	2.0	3.0	2.5	3.0	3.0	2.0
Marksman	*Lr37+*	1.0	2.0	3.0	2.5	4.0	3.0	4.0
Hyperion	*Lr37+*	1.0	3.0	1.2	2.9	2.0	1.8	2.0
Maris Ranger	WBR8	4.0	4.0	4.0	2.4	4.0	4.0	2.0
Sterna	WBR7	2.0	1.0	2.0	1.0	0.2	2.2	3.0
Gamin	WBR6	2.0	3.0	2.0	2.1	3.0	2.7	2.0
Timber	*R*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Duxford	*?*	3.0	3.0	4.0	4.0	3.3	2.8	3.0
Limerick	*?*	3.0	3.0	4.0	3.4	2.9	1.9	4.0
Soissons	*Lr14a*	4.0	2.4	3.0	2.0	2.0	2.5	3.0
Glasgow	*Lr1?*	2.0	1.0	2.0	1.0	0.4	3.0	3.0
Hereford	*?*	4.0	4.0	4.0	4.0	3.0	2.2	4.0
JB Diego	*?*	4.0	4.0	4.0	2.0	3.0	1.8	2.4
Avalon	WBR9	4.0	4.0	3.0	2.8	3.0	4.0	3.0
Buster	'Buster'	3.0	4.0	4.0	3.9	3.0	4.0	4.0
Armada	*O*	4.0	4.0	4.0	3.8	4.0	3.0	3.0
Maris Fundin	WBR2 / *Lr17b*	3.0	2.5	3.0	2.3	2.2	4.0	4.0
Cordiale	*?*	4.0	4.0	3.0	2.9	3.0	3.0	3.0

Highlighting is used to indicate susceptible reaction types.

UKCPVS 2008 ANNUAL REPORT

MILDEW OF WHEAT

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Virulence for the cultivar Robigus was detected at a moderate frequency in 2008. Virulence for resistances derived from spring wheat remained at low to moderate levels.

METHODS

A total of 110 single pustule isolates were tested in 2008. These comprised 69 isolates made from infected leaf samples collected from 13 different wheat cultivars (Tables 1 and 2) and 41 isolates from the universally susceptible cultivar Cerco exposed in mobile seedling trap nurseries (Table 3).

Table 1. Cultivars from which leaf sample isolates were tested

Cultivar	Rgenes/factors	1-9 rating*	No. of isolates tested
Buzzer	?	8	4
Ketchum	?	8	4
Robigus	Ml Ro	6	9
Timber	?	6	6
Glasgow	Unknown	5	3
Humber	*(Pm8)*	5	6
Istabraq	?	5	2
JB Diego	?	5	8
Oakley	Ml Ro	5	8
Solstice	0	5	8
Claire	*Pm2, Pm4b*	4	8
Lion	?		2
Maris Fundin	?		1

* HGCA Recommended List 2009/2010

Table 2. Locations from which leaf sample isolates were tested

Location	No. of isolates
Cambridge, Cambridgeshire	19
Edgmond, Shropshire	14
Crossnacreevy, Co. Down	13
Upsombourne, Hampshire	13
Wimbourne, Dorset	4
Caythorpe, Lincolnshire	6
TOTAL	69

Table 3. Locations from which trap nursery isolates were tested

Location	No. of isolates
Warbouys, Cambridgeshire	11
Cambridge, Cambridgeshire	9
Ousden, Suffolk	9
Harston, Cambridgeshire	6
Bishops Stortford, Hertfordshire	4
Shelford, Cambridgeshire	2
TOTAL	41

Isolates were tested for virulence in detached leaf tests using the differential cultivars and additional cultivars listed in Table 4.

Table 4. Differential cultivars used to determine virulence factors

Differential cultivar	Resistance Factors (European Codes)	Resistance genes
Standard set		
Cerco	0	*0*
Galahad	Pm2	*Pm2*
Chul	Pm3b	*Pm3b*
Armada	Pm4b	*Pm4b*
Flanders	Pm5	*Pm5*
Brimstone	Pm6	*Pm6*
Clement	Pm8	*Pm8*
Maris Dove	Mld	*Mld*
Brock	Pm2, MITa2	*Pm2, MITa2*
Mercia	Pm5, MITa2	*Pm5, MITa2*
Tonic	MlTo	*Pm3d+?*
Broom	Pm3d	*Pm3d*
Sicco	Pm5, MlSi2	*Pm5, MlSi2*
Wembley	MlSo	*MlSo*
Axona	MlAx	*MlAx*
Amigo	Pm17	*Pm17*
Shamrock	MlSh	*?*
Additional cultivars		
Bantam	?	
Battalion	?Mld	*Mld*
Duxford	?	
Glasgow	?	
Humber	?Pm8	*Pm8*
Hyperion	?Mld	*Mld*
JB Diego	?	
Ketchum	?	
Marksman	?	
Robigus	MlRo	
Timber	MlTi	
Walpole	?	
Zebedee	?	

RESULTS AND DISCUSSION

Virulence frequencies are shown in Table 5.

Table 5. Virulence frequencies 1998 - 2008

Virulence for	Frequency of virulence % 1998	1999	2000	2001	2002	2003	2004	2005	2006	**2008**
Pm2	100	100	100	100	99	100	100	99	100	**95**
Pm3b	1	2	1	4	6	7	4	25	10	**8**
Pm4b	100	99	99	100	100	100	100	97	99	**97**
Pm5	88	91	88	90	89	92	90	92	95	**92**
Pm6	100	100	99	100	100	100	99	97	98	**84**
Pm8	97	99	97	98	98	94	98	90	98	**62**
Mld	18	6	12	25	24	18	18	30	31	**23**
Pm2, MITa2?										**89**
Pm5, MITa2?	86	97	96	95	99	96	97	97	98	**80**
MlTo	16	16	5	24	20	20	20	27	36	**24**
Pm3d	16	15	8	24	27	20	21	30	37	**25**
Pm5, MlSi2	17	20	8	8	15	6	6	20	9	**11**
MlSo	10	6	4	6	11	4	4	16	10	**5**
MlAx	7	1	1	10	8	8	9	13	23	**16**
Pm17	8	22	2	9	13	4	6	11	9	**6**
MlSh		3	0	4	16	8	1	5	1	**0**
Additional cultivars										
Bantam										**34**
Battalion										**34**
Duxford										**23**
Glasgow									44	**61**
Humber										**87**
Hyperion									32	**34**
JB Diego										**85**
Ketchum										**34**
Marksman										**28**
Robigus								46	27	**35**
Timber									7	**16**
Walpole										**36**
Zebedee										**92**
No. isolates tested	328	187	148	286	165	209	376	219	160	**110**

Virulence for *Pm2, Pm4b, Pm5, Pm6, Pm8 and MlTa* remained at high frequencies, demonstrating that these resistances are largely ineffective against the current mildew population. These resistances have been used extensively in UK winter wheat breeding over many years. It is likely that cultivars such as Zebedee, Humber and JB Diego, for which similarly high levels of virulence were detected, carry one or more of these resistances. Cultivars with these resistances are entirely dependent on their 'background' or 'partial' resistance to protect them from infection in the field.

In contrast, virulence for spring wheat resistances such as *MlAx, MlTo, Mld* and *Pm3d* remained at intermediate levels, generally well below 50%. Intermediate virulence frequencies were also detected for the cultivars Walpole, Bantam, Battallion, Hyperion,

Marksman, Ketchum and Duxford, which have spring wheat in their pedigrees. It is possible that these resistances still afford a degree of protection in the field, but it is likely that virulence would increase rapidly if cultivars carrying one or other of these resistances became widely grown.

Virulence for Robigus has increased only slightly over the past two years, to around 35%, despite its popularity and the increasing popularity of the cultivar Oakley, believed to carry the same resistance.

Virulence for Shamrock, which has always been at a low level and has been declining since its peak of 16% in 2002, was absent in 2008.

Virulence for the genes *Pm3b* and *Pm17*, which as far as we are aware are not in use in UK cultivars, continued to be detected at low levels, indicating that these resistances would be of no long term benefit to UK breeding programmes.

UKCPVS 2008 ANNUAL REPORT

RHYNCHOSPORIUM OF BARLEY

A M WELLS and R A BAYLES

41 isolates of Rhynchosporium collected in 2007 were tested for virulence on seedlings of differential cultivars. Four isolates were also tested on adult plants of winter or spring cultivars in field nurseries. The results confirm a high degree of pathogenic variation within the population and illustrate effects on the expression of cultivar resistance.

METHODS

41 isolates collected in 2007 were tested for virulence in seedling tests. Four of these were then tested on adult plants in field isolation nurseries in the following season, 2008. Isolates tested on seedlings came from 33 winter and 8 spring barley cultivars (Table 1).

Table 1. Cultivars from which Rhynchosporium isolates were tested in seedling tests

Cultivar	**1–9[+] disease rating**	**No. of isolates tested**
Winter cultivars		
Accentura	8	1
Boost	8	2
Cassata	8	1
Flagon	8	3
Pict	8	1
Camion	7	1
Carat	7	1
Pearl	7	2
Wintmalt	7	1
Saffron	6	7
Spectrum	6	2
Sumo	5	8
Unknown	-	3
Spring Cultivars		
Doyen	7	1
Maltby	7	1
Sweeney	7	1
NFC Tipple	4	3
Optic	4	1
Waggon	4	1
TOTAL		**41**

[+]HGCA Recommended List for 2007/2008

Table 2 shows the locations from which the samples were collected.

Table 2. Locations from which Rhynchosporium isolates were tested in seedling tests

Region	County	No. of isolates tested
England	Cambridgeshire	3
	Yorkshire*	15
Eire	Co. Down	4
	Co. Tyrone	2
Scotland	Aberdeen	2
	Perth	4
Wales	Gwent	2
	Usk	9
TOTAL		**41**

* samples from LINK trial at ADAS High Mowthorpe

Isolates were inoculated onto seedlings of the standard set of differential cultivars carrying different specific resistant genes (Table 3). Following inoculation, plants were incubated and assessed as described previously (Jones & Newton, UKCPVS Annual Report for 2003).

Table 3. Differential cultivars used in 2007 seedling virulence tests

Differential cultivar	BRR factor
Maris Mink	0
Armelle	1
Astrix	2
Athene	3
Igri	4
La Mesita	5
Osiris	6
Pirate	7
Digger	8

Isolates tested on adult plants in field nurseries in 2008 are shown in Table 5. Isolates 07-14 and 07-26, from winter cultivars, were inoculated onto 16 winter cultivars and isolates 07-42 and 07-52, from spring cultivars, were inoculated onto 17 spring cultivars. The isolates differed in virulence phenotype.

Table 5. Isolates tested on adult plant field tests in 2008

Code	Year	Location	Cultivar	Virulence
07-14	2007	Usk	Camion	BRV 4
07-26	2007	Perth	Pearl	BRV 2,3,5
07-42	2007	Aberdeen	Doyen	BRV 3,8
07-52	2007	Perth	Maltby	BRV 1

RESULTS AND DISCUSSION

Seedling virulence frequencies are shown in Table 4, with the 2007 results presented separately for winter and spring barley isolates.

Table 4. % Virulence frequencies, 1995-2007

		% frequency								
Virulence for	**BRR factor**	**1995**	**1997**	**1999**	**2001**	**2003**	**2004**	**2005**	**2007 WB**	**SB**
Armelle	1	26	31	76	89	67	25	33	**48**	**63**
Astrix	2	26	31	76	89	67	25	33	**21**	**13**
Athene	3	91	100	100	99	95	100	100	**88**	**13**
Igri	4	65	96	64	94	100	93	96	**36**	**0**
La Mesita	5	30	2	20	4	5	5	7	**12**	**0**
Osiris	6	13	2	16	2	5	5	7	**0**	**0**
Pirate	7	26	37	32	80	62	27	7	**0**	**0**
Digger	8	-	2	0	4	0	2	11	**9**	**13**
No. of isolates tested		**23**	**45**	**25**	**85**	**21**	**44**	**27**	**33**	**8**

Virulence was detected for six of the eight standard rhynchosporium resistance factors, the exceptions being BRR6 (Osiris) and BRR7 (Pirate), for which virulence was absent. There appears to have been a decline in virulence for Igri (BRR4) which was previously at a high level.

There are indications of differences in virulence frequency between isolates collected from winter and spring cultivars, with higher frequencies of virulence for Astrix (BRR2), Athene (BRR3), Igri (BRR4) and La Mesita (BRR5) amongst isolates from winter cultivars and for Digger (BRR8) and Armelle (BRR1) amongst isolates from spring cultivars. However these comparisons should be interpreted with caution due to the relatively small number of isolates collected from spring cultivars.

Results of adult plant tests are given in Tables 5 and 6

Table 5. Adult plant field tests winter barley.
% leaf area infected with Rhynchosporium (mean of 4 assessments)

Cultivar	Resistance rating*	Isolate 07-26	Isolate 07-14
Maris Otter	(2)**	13.40	28.10
Saffron	6	10.50	0.10
Pelican		9.00	0.00
Flagon	8	6.40	0.00
Sequel	8	5.10	0.00
Carat	7	4.30	0.00
Amarena	8	3.10	0.00
Pearl	7	2.60	0.40
Colibri	7	1.50	0.00
Boost	8	0.30	0.00
Suzuka	9	0.30	0.00
Accrue	8	0.10	0.00
Cassata	8	0.00	0.00
Retriever	8	0.00	0.00
Bronx		0.00	0.00
Wintmalt	6	0.00	0.00

* 1-9 resistance rating HGCA Recommended List 2009/2010
** from NIAB Recommended List of Winter Barleys 1979

Table 6. Adult plant field tests spring barley.
% leaf area infected with Rhynchosporium (mean of 4 assessments)

	Resistance rating*	Isolate 07-42	07-52
Waggon	3	35.30	33.50
Doyen	7	33.80	12.10
Optic	4	28.90	16.90
Appaloosa		26.90	27.80
Decanter	6	24.00	20.10
Nfc tipple	4	21.30	23.90
Scout	5	19.80	32.60
Sweeney	5	14.00	21.40
Maris Mink	(1)**	12.50	12.40
Oxbridge	7	11.50	19.10
Cocktail	6	9.80	33.10
Jolika	5	8.80	17.60
Westminster	8	0.50	11.80
Rebecca	8	0.30	12.50
Quench	8	0.20	20.50
Belgravia	7	0.20	19.10
Publican	8	0.00	8.90

*1-9 resistance rating HGCA Recommended List 2009 / 2010
** from NIAB Recommended List of Spring Barleys 1979

Isolates 07-26 (BRV2,3,5) and 07-14 (BRV4) differed clearly in their virulence for adult plants of winter barley cultivars. Maris Otter, the universally susceptible control cultivar, was susceptible to both isolates. However, whereas 07-26 produced significant infection on several other cultivars, 07-14 failed to do so.

In the spring barley nurseries, the two isolates tested produced similar levels of infection on the universally susceptible control cultivar Maris Mink. However, there were indications of cultivar x isolate interactions. For example, several cultivars, including four with high resistance ratings of 8 (Westminster, Rebecca, Quench and Publican), showed good resistance to 07-42 (BRV3,8) but became quite heavily infected by isolate 07-52 (BRV1). In contrast, the cultivar Doyen, which is believed to carry BRR8, was more heavily infected by isolate 07-42, carrying the corresponding virulence BRV8, than by 07-52, which lacked this virulence.

The results of adult plant tests illustrate the potential impact of pathogenic variation on the expression of cultivar resistance to Rhynchosporium. It is not surprising to encounter apparent discrepancies in cultivar resistance, depending on the virulence of the local pathogen population.

UKCPVS 2008 ANNUAL REPORT

YELLOW RUST OF WHEAT

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An isolate virulent on the resistant cultivar Solstice was identified as pathotype WYV1,2,3,4,6,9,17,32,'Rob'. The impact of this new type for current resistant cultivars is being assessed.

INTRODUCTION

There was a moderate incidence of yellow rust in wheat in 2008, predominantly in the susceptible cultivar Robigus.

2008 ISOLATES: SEEDLING VIRULENCE TESTS

METHODS

25 yellow rust isolates were selected for testing on the basis of source cultivar and location. Four of the isolates produced poor test results and have been excluded from the results.

The cultivars from which isolates were tested are shown in Table 1. The most common was the popular yellow rust susceptible cultivar Robigus, which occupied around 10% of the UK wheat area in 2008.

Isolates came from a wide geographic spread (Table 2), but with the majority from the relatively high risk regions of East Anglia, Lincolnshire and the East of Scotland.

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 differential set.

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

Cultivar	WYR factors	1-9 Resistance rating*	No. of Isolates tested
Claire	R?	9	1
Solstice	?	9	2
Cordiale	WYR7	8	1
Hereford	?	8	1
Lear	?	8	1
Timber	?	8	1
Gallant	?	6	1
Conqueror	Rob	5	3
Hereward	WYR32+	5	1
Robigus	Rob	2	8
Buster		-	1
TOTAL			**21**

*HGCA resistance ratings for 2009/10.

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

Region	County	No. of isolates tested
East Anglia	Cambridgeshire	5
	Suffolk	2
East Midlands	Lincs	4
West Midlands	Shropshire	1
	Herefordshire	1
Yorkshire	Humber	1
South East	Hants	1
Scotland	Perthshire	1
	East Lothian	3
Ireland	County Down	2
TOTAL		**21**

Table 3. Differential cultivars used in 2008 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*
Brock	WYR7	*Yr7*
Compair	WYR8	*Yr8*
Kavkaz x 4 Fed	WYR9	*Yr9*
Clement	WYR9	*Yr9*
AVS xYr15	WYR15	*Yr15*
VPM 1	WYR17	*Yr17*
Rendezvous	WYR17	*Yr17*
Carstens V	WYR32	*Yr32*
Talon	WYR32	*Yr32*
Additional cultivars*		
Robigus	WYR'Rob'	
Battalion (8)	WYR17+	
Marksman (8)	WYR17+	
Hornet	WYR6,9	
Madrigal	WYR6,9,17	
Cadenza	R	
Buster	R	
Claire (9)	?	
Humber (9)	?	
Solstice (9)	?	
Duxford (8)	?	
Hereford (8)	?	
JB Diego (8)	?	
Lear (8)	?	
Timber (8)	?	
Gallant (6)	?	
Conqueror (5)	?	

* with HGCA resistance ratings in brackets for current cultivars

RESULTS and DISCUSSION

Virulence frequency data for 2008, together with data from 1998-2007, are shown in Table 4.

Table 4. % Virulence frequencies from 1998 to 2008

Virulence for		**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**
WYR 1		99	99	100	100	97	100	100	100	-	-	100
WYR 2		99	99	100	100	97	100	100	100	-	-	100
WYR 3		100	100	100	100	97	100	93	100	-	-	91
WYR 4		79	87	90	74	63	86	50	87	100	100	81
WYR 6		7	21	32	39	31	50	42	10	19	4	19
WYR 7		4	10	4	0	3	36	4	8	11	4	0
WYR 8		0	0	0	0	0	0	0	0	0	0	0
WYR 9		99	99	92	90	88	93	100	95	100	94	93
WYR 15					0	0	0	0	0	0	0	0
WYR 17		99	100	96	77	88	93	85	97	100	88	83
WYR 32		1	4	16	42	73	64	38	85	89	92	79
<u>Additional cvs</u>												
Robigus	WYR Rob							31	79	89	84	81
Battalion (8)	WYR 17+										0	0
Marksman (8)	WYR 17+										0	0
Hornet	WYR 6,9									19	4	19
Madrigal	WYR 6,9,17								8	11	4	19
Cadenza	R				0	0	0	0	0	0	0	0
Buster	R											5
Claire (9)	?								23	0	4	14
Humber (9)	?										4	10
Solstice (9)	?											10
Duxford (8)	?											0
Hereford (8)	?										0	24
JB Diego (8)	?										0	14
Lear (8)	?											29
Timber (8)	?									7	0	5
Gallant (6)	?											19
Conqueror (5)	?											86
No. of isolates tested		94	97	50	31	36	14	48	39	27	25	21

Virulence frequencies in 2008 were broadly similar to those in 2007. There were high frequencies of virulence for WYR1, WYR2, WYR3, WYR4, WYR9, WYR17, WYR32 and 'Rob', while virulence for WYR6 remained at a relatively low level.

Virulence for WYR7, which has been found at low levels in recent years, was not detected in 2008.

Two isolates collected from plots of the resistant cultivar Solstice proved to be virulent on seedlings of this cultivar and on another resistant cultivar Humber. The pathotype of these widely virulent isolates was WYV1,2,3,4,6,9,17,32,'Rob'. The next step will be to make a full assessment of the impact of this new pathotype on current commercial cultivars.

Virulence for Timber was confirmed in a single isolate collected from the cultivar.

Low levels of virulence were detected for a number of other current cultivars, including Claire, Hereford, JB Diego, Lear, and Gallant.

There was a high frequency of virulence for Conqueror, which appears to carry the same resistance as Robigus, one of its parents.

2007 ISOLATES: ADULT PLANT TESTS

METHODS

Three isolates (Table 5) were tested on a set of 40 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 2008.

Code	Year	Location	Cultivar	Virulence in initial virulence tests
07/1	2007	Lincs	Victo	4,9,17,CV, Robigus, Monty, Claire
07/4	2007	Essex	Robigus	4,9,17,CV, Robigus
07/20	2007	Herts	Monty	4,9,17,CV, Robigus, Monty

RESULTS AND DISCUSSION

The results of adult plant tests, with parallel seedling tests, are given in Table 6.

Table 6

Adult Plant infection % (mean of 3 assessments)

		07/1	07/4	07/20
Robigus	CV+	**43.8**	**42.0**	**44.8**
Monty	CV+	**21.8**	**15.6**	**13.5**
Oxbow	CV+	**35.4**	**23.0**	**18.6**
Consort	CV+	**17.8**	**13.3**	**12.8**
Talon	CV	**12.6**	**13.2**	**7.1**
Hereward	CV+	**8.8**	**12.8**	**8.9**
Clement	9	**32.50**	**35.80**	**32.30**
Slejpner	9	**48.30**	**45.90**	**40.30**
Reaper	17	**24.10**	**18.30**	**22.80**
Maris Huntsman	13	**8.70**	**9.40**	**8.70**
Hobbit	14	**17.10**	**15.70**	**16.00**
Glasgow	0	**15.30**	**15.80**	**16.90**
vuka	0	**25.40**	**23.70**	**20.00**
Hornet	6,9	**12.6**	**25.8**	**34.9**
Haven	6,9	*0.8*	**11.0**	**12.2**
Mascot	6,17	*0.3*	**15.2**	**20.2**
Napier	6,9,17	*0.5*	**13.4**	**15.6**
Access	6,9,17	*0.3*	**13.5**	**12.8**
Oakley	6	*0.7*	**11.6**	**11.2**
Battalion	17+	*0.0*	**8.2**	**6.8**
Marksman	17+	*0.1*	**6.8**	**10.9**
Einstein	?6	*0.00*	*0.50*	*1.6*
Cordiale	7,14	**6.10**	*0.40*	*1.10*
Brock	7,14	**2.70**	*0.90*	*0.40*
Hereford	?	**6.60**	**6.00**	*0.80*
JB Diego	?	**1.40**	**2.40**	*0.20*
Claire	R	1.20	0.30	0.10
Solstice	R	0.00	0.00	0.00
Humber	R	0.00	0.00	0.00
Limerick	R	0.00	0.00	0.00
Cadenza	R	0.00	0.00	0.00
Gladiator	R	0.20	0.10	0.40
Timber	?	0.60	0.30	0.30
Duxford	?	0.00	0.40	0.40
Buster	R	0.70	1.20	0.80
Istabraq	R	0.80	0.70	0.10
Zebedee	R	0.60	0.20	0.10
Alchemy	R	0.20	0.10	0.00
Xi19	R	0.00	0.00	0.00

Seedling average infection type (0-4)

		07/1	07/4	07/20
Robigus	CV+	3.0	3.2	3.4
Monty	CV+	3.0	3.2	3.5
Oxbow	CV+	3.2	3.0	3.0
Consort	CV+	2.9	3.0	3.0
Talon	CV	3.0	3.0	3.0
Hereward	CV+	0.8	2.6	2.0
Clement	9	3.0	3.0	3.0
Slejpner	9	3.0	4.0	3.0
Reaper	17	3.0	3.0	3.0
Maris Huntsman	13	3.0	3.0	3.0
Hobbit	14	2.2	3.0	2.6
Glasgow	0	3.0	3.0	3.0
Vuka	0	4.0	4.0	3.5
Hornet	6,9	0.0	0.0	0.4
Haven	6,9	0.0	0.0	0.1
Mascot	6,17	0.0	0.0	0.2
Napier	6,9,17	0.0	0.0	0.4
Access	6,9,17	0.0	0.0	0.5
Oakley	6	0.0	0.0	0.4
Battalion	17+	0.0	0.0	0.0
Marksman	17+	0.1	0.0	0.1
Einstein	?6	0.0	0.0	0.0
Cordiale	7,14	0.0	0.0	0.0
Brock	7,14	0.0	0.0	0.0
Hereford	?	0.4	0.2	0.1
JB Diego	?	0.0	0.0	0.0
Claire	R	2.2	0.2	1.6
Solstice	R	0.0	0.0	0.0
Humber	R	0.0	0.0	0.5
Limerick	R	0.0	0.0	0.0
Cadenza	R	0.0	0.0	0.0
Gladiator	R	0.0	0.0	0.0
Timber	?	0.0	0.0	0.0
Duxford	?	0.0	0.1	0.0
Buster	R	0.1	0.3	0.4
Istabraq	R	0.1	0.4	0.0
Zebedee	R	0.0	0.0	0.0
Alchemy	R	0.0	0.0	0.0
Xi19	R	0.0	0.0	0.0
Hybrid 46	(3b)4b	3.2	3.3	3.0
Heines Kolben	2,6	0.1	0.0	0.1
Heines Peko	2,6	0.0	0.0	0.1
Lee	7	0.0	0.1	0.0
Compair	8	0.0	0.0	0.0
Kavkaz x 4 Fed	9	3.3	3.0	3.0
AVS x Yr 15	15	0.0	0.0	0.0
VPM 1/Rendevous	17	3.0	4.0	3.0
Carstens V	CV	3.0	3.0	3.0
Brigadier	9,17	3.0	2.8	3.0
Madrigal	6,9,17	0.0	0.3	0.6

Highlighting has no statistical significance.
In adult plant tests, highlighting is used to indicate high infection levels for a particular cultivar.
In seedling tests, highlighting is used to indicate susceptible reaction types.

The three isolates were of identical pathotype in seedling tests, that is WYV3,4,9,17,32,'Rob' (note: differentials for WYR1 and WYR2 were not included in the test) and were avirulent on WYR6 and WYR7. However, in adult plant nurseries, WYR6 cultivars became severely infected in two of the three beds and WYR7 cultivars were moderately infected in the third bed. The most likely explanation for these results is contamination by virulent inoculum from nearby inoculated trials.

Isolate 07/1, chosen for testing because it produced susceptible infection types on Claire in initial virulence tests, gave only very low levels of infection on adult plants of the cultivar.

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.