UKCPVS 2007 ANNUAL REPORT

BROWN RUST OF WHEAT

A M WELLS & R A BAYLES

Brown rust was severe and widespread in 2007. Virulence for the overall resistances *Lr26* (WBR1) and *Lr1* (in Glasgow) declined. Virulence for the overall resistance of Robigus, first detected in 2006, was restricted to isolates from Robigus and related cultivars. Adult plant tests of isolates collected in 2006 confirmed that virulence for the adult plant resistance in Claire and related varieties was common, as was virulence for cultivars carrying *Lr37*.

INTRODUCTION

Brown rust was severe and widespread in the UK in 2007, with an unusually early start to the epidemic following a mild winter and warm April.

24 isolates were tested from 13 wheat cultivars (Table 1).

Table 1. Cultivars from which brown rust isolates were tested in 2007

Cultivar	R genes/factors	1–9[+] rating	No. isolates tested
Hyperion	*Lr37* +	9	2
Timber	R	9	1
Gatsby	*Lr26* +	8	1
Gladiator	*Lr26* +	8	1
Marksman	*Lr37* +	8	1
Musketeer	*Lr37* +	8	1
Rocky	? Rob	8	1
Oakley	Rob	6	3
Robigus	Rob	6	5
Claire	R Claire	5	1
Alchemy	R Claire	4	4
Soissons	*Lr14a*	4	1
Zebedee	R Claire	3	2
TOTAL			**24**

[+]HGCA Recommended List for 2008/2009

Table 2 shows the locations from which the isolates tested were collected. The majority were from the east of England, and in particular from East Anglia. The most northerly sample was from Errol, Perthshire.

Table 2. Locations from which brown rust isolates were tested in 2007

Region	County	No. isolates tested
East Anglia	Cambridgeshire	4
	Suffolk	2
South East	Essex	4
	Hertfordshire	3
	Kent	7
South West	Gloucestershire	1
	Hampshire	1
East Midlands	Lincolnshire	1
Scotland	Perthshire	1
TOTAL		**24**

SEEDLING VIRULENCE TESETS OF ISOLATES COLLECTED IN 2007

METHODS

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 2007 seedling virulence tests

Differential cultivar	WBR factor	Lr gene
Standard WBR cultivars		
Clement	WBR 1	*Lr26*
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/Exchange		*Lr10*
Tc*6/ST-1.25		*Lr26*
Tc*8/VPM1		*Lr37*
Additional cultivars		
Consort		*Lr10, Lr13*
Napier		*Lr10, Lr26, Lr37*
Savannah		*Lr26, Lr37*
Glasgow		*Lr1*
Alchemy	R Claire	*?*
Robigus	R Rob	*?*
Hyperion		*Lr37 +*
Timber	R	*?*
Oakley	R Rob	*?*
Humber		*Lr26,37 +*
Battalion		*Lr37 +*
Gatsby		*Lr26 +*
Mascot		*Lr37*
Rocky	? R Rob	*?*
Marksman		*Lr37 +*

RESULTS

Seedling virulence frequencies are shown in Table 4.

Virulence for WBR1 / *Lr26* fell once again in 2007 and is now at a level of around 20%, compared with a peak of 100% in 2001. This is in line with the declining acreage of *Lr26* cultivars.

Virulence for Robigus was at a similar level to that detected in 2006, at 30%. This was a direct reflection of the number of samples tested from Robigus and cultivars believed to carry the same resistance (Oakley and Rocky). Virulence for Robigus was not detected in isolates from cultivars other than these three.

Virulence for *Lr1* and for Glasgow (believed to carry *Lr1*) was lower than in 2006, consistent with a reduction in the acreage of Glasgow and also in the number of isolates from this cultivar which were tested (4 isolates in 2006 to no isolates in 2007).

No virulence was detected for Timber, although one isolate collected from the cultivar was tested.

Unusually, avirulence was detected in some isolates for certain adult plant resistances which are not usually expressed at the seedling stage i.e. Alchemy ('Claire' resistance), and the Thatcher NILs for *Lr10* and *Lr37*. This resulted in corresponding virulence frequencies of less than the expected 100%. The reason for this is unknown, but may be due to minor variation in testing conditions.

Table 4. Virulence frequencies 1998 - 2007

Virulence for		**% Frequency**[†]								**2007**
		1998	1999	2000	2001	2002	2003	2005	2006	
WBR cvs										
Clement	WBR 1	43	27	82	100	84	73	69	44	**21**
Fundin	WBR 2	75	32	60	94	56	73	100	100	**100**
Sappo	WBR 3	0	0	8	0	0	0	13	28	**8**
Halberd	WBR 4	0	0	4	0	0	0	13	24	**8**
Sterna	WBR 7	7	7	61	65	50	68	56	68	**8**
Armada	WBR 0	100	100	100	100	100	100	100	100	**100**
Thatcher NILS										
Tc6/Centenario	*Lr1*	0	0	0	0	0	0	28	32	**13**
Tc*6/Exchange	*Lr10*								96	**54**
Tc*6/Frontana	*Lr13*								100	**-**
Tc6/ST-1.25	*Lr26*	43	32	83	100	73	73	69	44	**17**
Tc*8/VPM1	*Lr37*								100	**30**
Thatcher	0	-	-	-	100	100	100	100	100	**-**
Additional cultivars										
Consort	*Lr10, Lr13*								96	**92**
Napier	*Lr10,Lr26,Lr37*								36	**8**
Savannah	*Lr26,Lr37*								40	**13**
Glasgow	*Lr1*								32	**17**
Claire	R Claire								100	**-**
Alchemy	R Claire								100	**58**
Robigus	R Rob								32	**30**
Hyperion	*Lr37* +								60	**21**
Timber	R									**0**
Oakley	R Rob									**17**
Humber	*Lr26,37* +									**8**
Battalion	*Lr37* +									**17**
Gatsby	*Lr26* +									**25**
Mascot	*Lr37*									**22**
Rocky	? R Rob									**38**
Marksman	*Lr37* +									**63**
Number of isolates tested		43	22	23	17	14	22	32	25	**24**

ADULT PLANT TESTS

METHODS

5 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 2007

Code	Year	Location	Cultivar	*Virulence (seedling tests)
06/23	2006	Hants	Glasgow	WBV 1,2,7, V *Lr1*, *Lr26*
06/29	2006	Cambs	Claire	WBV 1,2,7, V *Lr1*, *Lr26*
06/31	2006	Cambs	Timber	WBV 1,2,7, V *Lr1*, *Lr26*
06/94	2006	Kent	Robigus	WBV 2,7,Rob
06/98	2006	Cambs	Robigus	WBV 2,7,Rob

* virulence for overall type resistances, detectable at seedling stage

The results of adult plant tests are shown in Table 6.

Isolates 06/98 and 06/94, both from Robigus, were virulent on Robigus at the seedling stage and gave high levels of infection on adult plants of the cultivar. The other three isolates were avirulent on Robigus at all growth stages. Oakley reacted in a similar way to Robigus. The conclusion is that Robigus and Oakley carry an unidentified resistance gene of the overall type.

The two Robigus-virulent isolates were avirulent on cultivars carrying the *Lr26* resistance, and infection levels on *Lr26* cultivars in adult plant tests were low. This applied equally to cultivars carrying *Lr26* alone, or in combination with other resistances such as *Lr37* or *Lr10*.

Isolates 06/29 and 06/23 were widely virulent on the majority of cultivars, with the exception of Robigus and Oakley.

Isolate 06/31, originating from Timber, proved to be avirulent on seedlings and adult plants of the cultivar. The resistance of this cultivar remains effective against all isolates. The adult plant resistance of Hyperion and Battalion also remained highly effective. These appear to be the only commercial cultivars which currently have good resistance to the UK brown rust population.

Table 6 Adult plant field tests 2007. Percentage leaf area infected with brown rust, GS80.
(* = virulence for 'overall' resistances; WBR factors in normal font, *Lr* genes in italics)

		Isolate code and virulence*				
		06/98	06/94	06/29	06/23	06/31
Cultivar	**WBR factors**	2,7,Rob	2,7,Rob	*1,2,7, 1,26*	*1,2,7 1,26*	*1,2,7 1,26*
Robigus	'Rob'	45	50	0	0	2
Oakley	'Rob'	38	18	5	2	4
Claire	Claire'	5	19	10	5	2
Alchemy	Claire'	4	9	14	8	13
Deben	Claire'	8	14	5	15	12
Istabraq	Claire'	9	17	16	31	12
Zebedee	Claire'	7	19	3	14	2
Xi19	*Lr13*	13	14	12	8	5
Maris Huntsman	*Lr13*	27	30	26	18	16
Solstice	*Lr13?*	9	9	22	22	21
Riband	*Lr13,Lr17b*	15	8	17	12	1
Consort	*Lr10,Lr13*	24	11	15	19	5
Malacca	*Lr10,Lr13*	2	3	10	13	9
Hereward	*Lr10,Lr13*	6	9	35	22	17
Einstein	*Lr10*	8	6	3	17	2
Brompton	*Lr26*	0	1	12	5	3
Tanker	*Lr26*	8	10	24	18	9
Clement	*Lr26*	15	17	70	29	43
Gatsby	*Lr26+*	0	1	11	11	5
Gladiator	*Lr26,Lr37*	5	2	22	15	10
Ambrosia	*Lr26,Lr37*	0	4	0	10	1
Humber	*Lr26,Lr37*	6	6	10	22	15
Savannah	*Lr26,Lr37*	0	2	10	4	4
Buchan	*Lr26,Lr37*	3	5	5	16	10
Napier	*Lr10,Lr26,Lr37*	5	5	24	25	14
Access	*Lr10,Lr26,Lr37*	0	5	5	14	5
Mascot	*Lr37*	23	24	43	48	40
Glasgow	*Lr1*	11	19	53	53	23
Benedict	*Lr1?*	6	1	16	18	8
Maris Fundin	WBR2 / *Lr17b*	38	68	22	53	25
Gamin	WBR6	23	15	33	6	15
Sterna	WBR7 / *Lr3a+*	1	2	10	11	5
Maris Ranger	WBR8	2	1	12	4	6
Avalon	WBR9	60	38	40	28	14
Soissons	*Lr14a*	18	20	63	70	30
Cordiale	?	23	16	20	22	6
Sahara	?	5	3	11	10	8
Hyperion	*Lr37+*	0	0	0	0	0
Battalion	*Lr37+*	0	1	0	2	0
Timber	?	0	0	0	0	0

UKCPVS 2007 ANNUAL REPORT

YELLOW RUST OF WHEAT

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Yellow rust of wheat was more common in 2007 than in 2006. Samples were received from a range of popular cultivars and some outdated ones. Almost all isolates tested were found to carry the virulence factors WYV9,17,CV, with virulence for Robigus. One isolate possessed the virulence combination WYV6,9,17, which has now become uncommon. Virulence for Timber was detected for the second year running in adult plant tests.

INTRODUCTION

Yellow rust was more common and widespread in 2007 than in recent years, due in part to the mild winter and warm spring, which resulted in an unusually early epidemic.

SEEDLING VIRULENCE TESTS OF ISOLATES COLLECTED IN 2007

METHODS

25 isolates were selected for testing based on their source cultivar and the location from which they had been collected (Table 1). The most common source cultivar was the widely grown yellow rust susceptible cultivar Robigus, which occupied around 15% of the UK wheat area in 2007.

Isolates were tested from 8 regions across the UK (Table 2). The majority, including one from an inoculated disease nursery, were from East Anglia, predominantly Cambridgeshire.

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 included in the differential set.

Table 1. Cultivars from which yellow rust isolates were tested in 2007

Cultivar	WYR factors	1-9 Resistance rating*	No. of Isolates tested
Claire	Rx	9	3
Deben	R	9	2
Timber	R	9†	1
Gladiator	R	8	1
Glasgow	?0	4	1
Robigus	Rob	3	6
Hereford	?	8	1
JB Diego	?	9	2
Marksman	?WYR17	7	1
Monty	?Rob	6	4
Victo/Vuka	0	1	2
Others			1
TOTAL			**25**

*HGCA resistance ratings for 2008/09.
†Isolates of yellow rust which can infect Timber were found in the UK in 2007, but so far disease levels have been low.

Table 2. Locations from which yellow rust isolates were tested in 2007

Region	County	No. of isolates tested
East Anglia	Cambridgeshire	5
	Norfolk	2
South East	Essex	3
	Herts	2
	Kent	2
South West	Gloucs	1
East Midlands	Lincs	4
West Midlands	Shropshire	1
Yorkshire	Yorkshire	1
Scotland	Perthshire	3
Ireland	Co. Down	1
TOTAL		**25**

Table 3. Differential cultivars used in 2007 seedling virulence tests.

Differential cultivar	WYR factor	Gene designation
Core set		
Hybrid 46	WYR 4	*Yr4*
Heines Kolben	WYR 2,6	*Yr2, Yr6*
Heines Peko	WYR 2,6	*Yr2, Yr6*
Lee	WYR 7	*Yr7*
Brock	WYR 7	*Yr7*
Compair	WYR 8	*Yr8*
Kavkaz x 4 Fed	WYR 9	*Yr9*
Clement	WYR 9	*Yr9*
AVS xYr15	WYR 15	*Yr15*
VPM 1	WYR 17	*Yr17*
Carstens V	WYR CV	*Yr32*
Vuka	WYR 0	
Additional cultivars		
Reaper	WYR 17	
Talon	WYR CV	
Robigus	WYR Rob	
Battalion	WYR CV+	
Hornet	WYR 6,9	
Mascot	WYR 6,17	
Madrigal	WYR 6,9,17	
Oakley	WYR 6?	
Einstein	WYR6?	
Claire	WYRx	
Timber	WYR?	
Cadenza	R	
Deben	R	
Gladiator	R	
Humber	R	
Zebedee	R	
Hereford	?	
JB Diego	?	
Marksman	?	
Monty	WYR Rob?	

RESULTS and DISCUSSION

A reduced core set of differential cultivars was used in 2007, omitting WYR 1, WYR 2, WYR 3, WYR 10 and WYR Sp (Table 3). The list of additional cultivars was updated to

include Timber, a new RL cultivar previously resistant to all isolates, Hornet WYR 6,9 and Mascot WYR 6,17 along with a number of resistant RL varieties and candidates.

Virulence frequency data for 2007, together with data from 1996-2007 is given in Table 4.

As in 2006, there was a very high frequency of virulence for WYR 4, WYR 9, WYR CV and for Robigus.

76% of isolates were of the pathotype WYV 4,9,17, CV, Rob. These isolates were also virulent on Monty, consistent with other indications that Monty may carry the same resistance as Robigus.

Virulence for WYR 6 was detected in only a single isolate – pathotype WYV 4,6,(7),9,17 which was also virulent on the additional cultivars Madrigal, Einstein, Hornet, Mascot, Humber and Oakley.

Table 4. % Virulence frequencies from 1997 to 2007

Virulence for		**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**
WYR 1		100	99	99	100	100	97	100	100	100	-	-
WYR 2		100	99	99	100	100	97	100	100	100	-	-
WYR 3		100	100	100	100	100	97	100	93	100	-	-
WYR 4		47	79	87	90	74	63	86	50	87	100	100
WYR 6		1	7	21	32	39	31	50	42	10	19	4
WYR 7		7	4	10	4	0	3	36	4	8	11	8
WYR 8		0	0	0	0	0	0	0	0	0	0	0
WYR 9		99	99	99	92	90	88	93	100	95	100	94
WYR 15						0	0	0	0	0	0	0
WYR 17		99	99	100	96	77	88	93	85	97	100	88
WYR CV		13	1	4	16	42	73	64	38	85	89	92
WYR Sp			0	0	0	0	0	7	0	0	-	-
<u>Additional cvs</u>												
Reaper	17										100	64
Talon	CV										85	80
Robigus	Rob								31	79	89	84
Battalion	CV+											0
Hornet	6,9										19	4
Mascot	6,17										11	4
Madrigal	6,9,17									8	11	4
Oakley	6,(9),17											4
Einstein	6?									5	11	4
Claire	Rx									23	0	4
Timber	R?										7	0
Cadenza	R					0	0	0	0	0	0	0
Deben	R											0
Gladiator	R											0
Humber	R											4
Zebedee	R											0
Hereford	?											0
JB Diego	?											0
Marksman	?											0
Monty	WYR Rob?											80
No. of isolates tested		**138**	**94**	**97**	**50**	**31**	**36**	**14**	**48**	**39**	**27**	**25**

- not included in test

ADULT PLANT TESTS

METHODS

5 isolates (Table 5) were tested on a set of 41 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	Virulence
05/31	2005	Lincs	Robigus	1,2,3,4,6,9,17,(*CV*), (*Rob*), (*Oxb*)
06/1	2006	Cambs	Vuka	1,2,3,4,(*6*),9,(*17*)
06/11	2006	Durham	Glasgow	1,2,3,4,9,17,CV, Rob,Oxb
06/29	2006	Scotland	Robigus	1,2,3,4,(*7*),9,17,CV,Rob,Oxb
06/505	2006	Cambs	Timber	1,2,3,4,(*6*),9,17,(*CV*), (*Rob*), (*Oxb*)

RESULTS AND DISCUSSION

The results of adult plant tests are given in Table 6.

Two isolates (06/11 and 06/29) were typical of the commonly identified Robigus – virulent pathotype. They produced increased levels of infection on adult plants of cultivars thought to carry the CV resistance, and also on WYR9 and WYR17 cultivars, but not on WYR6 cultivars.

Isolate 05/31 was tested for the first time in adult plant tests in 2006. It was re-tested in 2007 because, as well as appearing to combine virulence for Robigus with virulence for WYR6, it also infected the resistant cultivar Timber. 06/505 was an isolate taken from this infected plot of Timber. In 2007 tests, 05/31 and 06/505 appeared broadly similar as expected. Both gave high infection on WYR6 cultivars, but infection levels on the Robigus group of cultivars tended to be more moderate. Only 06/505 produced infection on Timber. Taken together with seedling virulence test results, a possible explanation is that the original stock of 05/31 may have been mixed with respect to virulence for Timber. However, what is clear is that virulence for this previously resistant cultivar has now been detected in the UK yellow rust population.

Isolate 06/1 was one of only 3 isolates tested in 2006 which proved to be avirulent on Robigus in seedling tests. This was confirmed at the adult plant stage. There were indications that this isolate was virulent on WYR6 and possibly also on WYR17, although results were not conclusive.

The 17 cultivars listed in the second part of Table 6 maintained their adult plant resistance to all isolates tested.

An updated diversification scheme for currently Recommended varieties of winter wheat is given in the Appendix . This is derived from UKCPVS data on yellow rust virulence frequencies together with information on the specific resistances of varieties.

Table 6. Adult plant field tests 2007. Percentage leaf area infected with yellow rust (mean of 3 assessments)

		Isolate code and WYV factors				
		06/11	06/29	06/1	05/31	06/505
Cultivar	**WYR factors**	1,2,3,4,9,17,CV, Rob,Oxb	1,2,3,4,(7),9,17,CV ,Rob,Oxb	1,2,3,4,(6),9,(17)	1,2,3,4,6,9,17,(CV), (Rob), (Oxb)	1,2,3,4,(6),9,17,(CV), (Rob), (Oxb)
Robigus	CV+	23	26	6	10	12
Consort	CV+	7	4	0	3	1
Oxbow	17,CV+	17	15	9	9	9
Hereward	CV+	6	5	3	0	0
Talon	CV	14	9	17	13	9
Mascot	6,17	2	1	5	9	9
Hyperion	6,(9),17	0	0	1	6	5
Ambrosia	6,(9),17	0	0	1	7	2
Napier	6,9,17	4	0	3	7	7
Hornet	6,9	3	3	10	14	13
Oakley	6	0	0	5	6	3
Einstein	6+	1	0	2	1	2
Battalion	17+	0	0	0	3	1
Timber	?	0	0	0	0	6
Brigadier	9,17	20	27	28	19	20
Reaper	17	8	9	4	7	8
Clement	9	19	13	8	22	9
Slejpner	9	20	19	15	19	20
Brock	7,14	0	5	1	1	0
Cordiale	7	0	0	0	0	0
M Huntsman	13	7	5	2	3	0
Hobbit	14	9	6	6	6	1
Vuka	0	11	11	14	8	8
Glasgow	0?	10	9	3	6	2

Highlighting has no statistical significance
Dark yellow = high infection level, indicative of cultivar x isolate interaction
Pale yellow = intermediate infection level, may be indicative of cultivar x isolate interaction, but may have arisen due to contamination from adjacent isolate tests.

Table 6 contd. Adult plant field tests 2007. Percentage leaf area infected with yellow rust (mean of 3 assessments)

		Isolate code and WYV factors				
		06/11	06/29	06/1	05/31	06/505
Cultivar	**WYR factors**	1,2,3,4,9,17,CV, Rob,Oxb	1,2,3,4,(7),9,17,CV ,Rob,Oxb	1,2,3,4,(6),9,(17)	1,2,3,4,6,9,17,(CV), (Rob), (Oxb)	1,2,3,4,(6),9,17,(CV), (Rob), (Oxb)
Buster	R	0	0	0	0	0
Cadenza	R	0	0	0	0	0
Malacca	R	0	0	0	0	0
Claire	Rx	0	0	0	0	0
Alchemy	R	0	0	0	0	0
Soissons	?R3+	0	0	1	0	0
Deben	R	0	0	0	0	0
Xi19	R	0	0	0	0	0
Solstice	R	0	0	0	0	0
Istabraq	R	0	0	0	0	0
Gladiator	R	0	0	1	0	0
Brompton	R	0	0	0	0	0
Zebedee	R	0	0	0	0	0
Gatsby	R	0	0	0	0	0
Gulliver	R	0	0	0	0	0
Sahara	R	0	0	0	0	0
Humber	R	0	0	0	0	0

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APPENDIX

VARIETY DIVERSIFICATION SCHEME TO REDUCE SPREAD OF YELLOW RUST IN WHEAT, 2008

Yellow rust can spread between wheat varieties that are susceptible to the same race of the pathogen.
The risk of severe and widespread infection may be reduced by:

(1) Growing varieties with good resistance to yellow rust (as indicated by high resistance ratings on the HGCA Recommended List)
(2) Diversifying the varieties grown on a farm so that they are not all susceptible to the same race of yellow rust. This is achieved by using the Variety Diversification Scheme.

Choosing varieties to grow together

1. Select a first-choice variety and find its Diversification Group (DG).
2. Go to the selection matrix and find this DG under 'Chosen DG' on the left hand side of the table.
3. Read across the table to find the risk of disease spread for each companion DG.

+ = low risk of spread of yellow rust
y = moderate risk of spread of yellow rust
Y = high risk of spread of yellow rust

4 Wherever possible choose combinations of varieties marked '+'. A combination marked 'y' is a lower risk than one marked '**Y**'.
5 If there is a choice of varieties in a companion DG, give preference to those with higher resistance ratings (see 1-9 ratings in HGCA Recommended List)

DG1
Alchemy
Brompton
Claire
Deben
Gatsby
Gladiator
Humber
Istabraq
JB Diego
Malacca
Nijinsky
Solstice
Timber
Xi19
Zebedee

DG3
(WYR13)
Riband

DG4
(WYR7)
Cordiale

DG7
(WYR CV+)
Consort
Hereward
Robigus

DG10
(WYR6
(WYR6,17;
WYR6,9,17)
Ambrosia
Einstein
Hyperion
Mascot
Oakley
Welford

DG11
Battalion
Marksman

DG0
Glasgow
Soissons

Unclassified*
Duxford

Chosen DG	Companion DG 1	3	4	7	10	11	0
1	+	+	+	+	+	+	+
3	+	**Y**	+	y	y	y	**Y**
4	+	+	**Y**	+	+	+	**Y**
7	+	y	+	**Y**	+	y	**Y**
10	+	y	+	+	**Y**	y	**Y**
11	+	y	+	y	y	**Y**	**Y**
0	+	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**

* = risk of spread to varieties in other DGs unknown. Further tests in progress.

UKCPVS 2007 ANNUAL REPORT

BROWN RUST OF BARLEY

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Virulence for BBR1, BBR4 and BBR8 remained at, or around, 100% in brown rust isolates collected in 2006. Virulence for BBR7 has still not been detected. Virulence corresponding to the other BBR factors was at intermediate levels. BBV3 was more common in isolates from spring barley than from winter barley cultivars. Adult plant tests of spring barley cultivars indicated that BBR3 may be less effective in adult plants than seedlings. This emphasises the importance of adult plant tests in evaluating the reaction of cultivars to the pathogen.

INTRODUCTION

This report is for barley brown rust samples collected in 2006, tested for virulence in seedling tests in the same year and on adult plants in 2007.

Brown rust was widespread in barley in 2006. Samples were received from both winter and spring barley varieties between March and July 2006.

SEEDLING VIRULENCE TESTS OF ISOLATES COLLECTED IN 2006

METHODS

22 isolates were selected for testing based on their host cultivar (Table 1) and the location from which they originated (Table 2). These comprised 11 isolates from winter barley cultivars and 11 from spring barley cultivars, representing a range of resistance ratings from 4 (susceptible) to 8 (resistant).

Although the majority of isolates came from Cambridgeshire there was an extremely wide geographical spread.

Seedling virulence tests were conducted using a core set of differential cultivars together with five additional cultivars, of particular relevance to UK breeding (Table 3).

Seedlings of the differential cultivars were grown to the first leaf stage in a sporeproof glasshouse. They were then inoculated and incubated at 100% relative humidity in the dark at 6 °C for 48 hours. Tests were then transferred to controlled environment rooms

with a light and temperature regime of 16 hours light at 18 °C and 8 hours dark at 11 °C for approximately 14 days. Assessments of infection type were made on a 0-4 scale.

Table 1. Cultivars from which brown rust isolates were tested in 2006

Cultivar	Spring / Winter	R genes/ factors	1-9 resistance rating*	No. isolates tested
NFC Tipple	S	?3	8	1
Waggon	S	?3	8	2
Cellar	S	?3	7	1
Colibri	W		7	1
Pict	W		7	1
Static	S	?3	7	1
Wicket	S		7	1
Sequel	W		6	1
Oxbridge	S		6	1
Cannock	W		5	1
Optic	S	10	5	1
Boost	W		4	6
Chalice	S		4	1
Tocada	S		4	2
Marado	W		-	1
TOTAL				**22**

*HGCA resistance ratings for 2007/08.

Table 2. Locations from which barley brown rust samples were tested in 2006.

Region	County	No. of isolates tested
East Anglia	Cambridgeshire	10
East Anglia	Norfolk	1
Yorkshire	N. Yorkshire	1
South East	Hants	3
South West	Dorset	1
Wales	Gwent	1
Scotland	Scotland	1
Ireland	Co. Down	4
TOTAL		**22**

RESULTS

Virulence frequency data for 2006, together with data from 1997-2005 (Jones, 2002, 2004 and 2005), are shown in Table 3. Virulence frequencies should be interpreted with caution due to the non-random sampling and the small number of isolates tested in some years.

Virulence for BBR 1 and BBR 4 was detected in all isolates. Virulence for BBR 8 was also high, occurring in 91% of isolates.

Virulence for BBR 2, 5, 6, 9 and 10 was detected in a moderate number of isolates, with virulence frequencies ranging from 50-68%.

32% of isolates were virulent on BBR 3. This was similar to the frequency of virulence for cultivars Waggon and NFC Tipple which are thought to carry BBR 3.

Virulence for the cultivars Static and Cellar was detected in 36% of isolates and for Optic in 41%.

As previously, no virulence was identified for BBR 7.

Table 3. Virulence Frequencies from 1997 to 2006.

Differential cultivar	**BBR factor**	**Rph gene**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**
Core set												
Sudan	BBR 1	1	100	100	100	100	100	100	100	100	100	100
Peruvian	BBR 2	2	100	100	100	100	100	100	100	100	100	59
Simon	BBR 3	3	30	23	36	50	34	36	65	40	42	32
Gold	BBR 4	4	100	100	100	100	100	100	100	100	100	100
Quinn	BBR 5	2+5	88	96	100	83	80	82	90	75	78	50
Bolivia	BBR 6	2+6	100	100	100	100	100	100	100	100	100	55
Cebada Cepa	BBR 7	7	0	0	0	0	0	0	0	0	0	0
Egypt 4	BBR 8	8	100	100	100	100	100	100	100	100	100	91
Hordeum 2496	BBR 9	9	55	33	50	83	61	68	90	100	100	55
Trumpf	BBR 10	12	88	45	50	83	61	68	90	100	100	68
Additional cultivars												
NFC Tipple	?3											27
Waggon	?3											32
Static	?3											36
Cellar	?3											36
Optic	10											41
No. isolates tested			**33**	**27**	**14**	**6**	**41**	**33**	**29**	**20**	**26**	**22**

Table 4 shows virulence frequencies for isolates collected from winter barley and from spring barley cultivars separately. Bearing in mind the small number of isolates in each group, there was still a clear indication that virulence for BBR3 and for BBR10 was more

common amongst isolates from spring barley cultivars. Many current spring cultivars carry one or other of these specific resistances, which do not appear to be present in winter barley cultivars.

Table 4. Virulence frequencies for isolates collected from winter and spring cultivars, 2006.

Differential cultivar	**BBR factor**	**Rph gene**	**W**	**S**
Core set				
Sudan	BBR 1	1	100	100
Peruvian	BBR 2	2	64	55
Simon	BBR 3	3	0	64
Gold	BBR 4	4	100	100
Quinn	BBR 5	2+5	73	27
Bolivia	BBR 6	2+6	64	46
Cebada Cepa	BBR 7	7	0	0
Egypt 4	BBR 8	8	91	91
Hordeum 2496	BBR 9	9	36	73
Trumpf	BBR 10	12	36	100
Additional cultivars				
NFC Tipple	?3		0	55
Waggon	?3		0	64
Static	?3		9	64
Cellar	?3		27	55
Optic	10		9	64
No. isolates tested			11	11

ADULT PLANT TESTS 2007

METHODS

Two isolates from the 2006 survey (Table 5) were tested during 2007 on a set of 12 winter barley cultivars and a set of 18 spring barley cultivars in field isolation nurseries.

Table 5. Isolates tested on adult plants in 2007

Code	Year	Location	Cultivar	Virulence
06/05	2006	Norfolk	Boost	1,2,4,5,6,8,9,10
06/28	2006	Cambs	Waggon	1,2,3,4,9,10

RESULTS

Infection levels in the winter barley nurseries were poor, failing to reach 5% in any cultivar and results for these nurseries have therefore been omitted.

Results of the spring barley nurseries are shown in Table 7.

All cultivars were susceptible to both isolates, although there were quantitative differences in infection level between cultivars. Although isolate 06/05 was avirulent on BBR3 at the seedling stage, it appeared to be virulent on adult plants of cultivars thought to carry BBR3. This suggests that the BBR3 resistance may become less effective at later growth stages and that other resistance genes / factors may play a more important role in determining the resistance of these cultivars at the adult stage. This emphasises the importance of adult plant tests in evaluating the reaction of cultivars to the pathogen.

Table 7. Adult plant field tests (spring barley cultivars). Percentage leaf area infected with brown rust at GS 75.

			Isolate code and BBV factors	
			06/05	06/28
Cultivar	**Resistance rating* (1-9)**	**BBR Factor**	1,2,4,5,6,8,9,10	1,2,3,4,9,10
Cocktail	7		4.5	4.0
Doyen	7		5.0	4.0
Appaloosa	6		5.5	6.5
Rebecca	5		8.0	8.0
Publican	5		8.0	8.0
Troon	5		9.0	6.5
Riviera	4		5.5	6.5
Quench	3		9.0	12.5
Kirsty	8	BBR3	6.5	4.0
NFC Tipple	8	BBR3	4.5	4.5
Waggon	7	BBR3	6.0	9.0
Wicket	7	BBR3	7.0	8.5
Cellar	7	BBR3	7.5	5.5
Oxbridge	5	BBR3	10.0	4.5
Power	7	BBR10	7.5	6.5
Decanter	5	BBR10	6.5	7.5
Optic	5	BBR10	9.0	10.0
Westminster	5	BBR10	10.0	8.0

* HGCA Recommended List for 2008 /2009

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UKCPVS 2007 ANNUAL REPORT

MILDEW OF WHEAT

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INTRODUCTION

Wheat mildew is routinely monitored in alternate years. Having been monitored in 2006, this pathogen was not due for full monitoring again until 2008. However, additional testing was carried out in 2007, aimed at detecting changes in the frequency of virulences which had been at low or intermediate levels in 2006.

METHODS

Mobile seedling nurseries of the universally susceptible cultivar Cerco were exposed at 5 sites in East Anglia to provide air spora samples largely independent of selective effects of host cultivars (Table 1). A total of 58 single pustule isolates from these nurseries were tested for virulence on detached leaf segments of the cultivars listed in Table 3.

A further 24 isolates were made from infected leaf samples of the cultivar Timber, for which virulence was first detected at a very low level in 2006 (Table 2). These were tested for virulence on the same set of cultivars.

Table 1. Location of mobile seedling nurseries (cv Cerco) 2007

Location	No. isolates tested
Biggleswade, Bedfordshire	5
Bishops Stortford, Hertfordshire	9
Ely, Cambridgeshire	13
Harston, Cambridgeshire	8
Newmarket, Suffolk	23
TOTAL	**58**

Table 2. Source of isolates from cv Timber 2007

Location	No. isolates tested
Cambridge, Cambridgeshire	8
Duxford, Cambridgeshire	12
Sandy, Bedfordshire	2
Wye, Kent	2
TOTAL	**24**

RESULTS

Virulence frequencies are shown in Table 3.

Table 3. Virulence frequencies in 2007, compared with 2006

			Virulence Frequency %		
Virulence for cultivar	**1–9[+] rating**	**R factors**	**All isolates 2006**	**Seedling nurseries (cv Cerco) 2007**	**Leaf samples cv Timber 2007**
Timber	8	?	7	5	92
Gatsby	7	?	38	14	21
Glasgow	6	?	44	53	25
Oakley	6	?'Rob'	-	28	21
Robigus	6	'Rob'	27	31	21
Xi19	7	MlAx	-	7	33
Hyperion	6	Mld	32	14	33
No. isolates			160	58	24

[+]HGCA Recommended List for 2008/2009

Virulence for the unknown resistance factor(s) of Timber was confirmed in nearly all of the isolates derived from leaf samples of the cultivar. However, virulence remained at an extremely low level in the mildew population as a whole, as demonstrated by its 5% frequency in the set of seedling nursery isolates.

Based on results from the seedling nurseries, virulence for the unknown resistance factor(s) of Gatsby appeared to be slightly less frequent than in 2006, while that for Glasgow remained at a similar level.

Virulence for Robigus and Oakley remained at a similar level to 2006, at around 30%, whilst virulence for the resistances MlAx and Mld, in Xi19 and Hyperion respectively, both appeared to have fallen.

As in 2006, there was evidence that Glasgow and Robigus may share a resistance factor. Al isolates that were virulent on Robigus were also virulent on Glasgow, whilst all those that were avirulent on Robigus were also avirulent on Glasgow. A number of isolates were virulent on Glasgow, but not on Robigus, suggesting that Robigus may have one resistance factor in common with Glasgow, together with an additional resistance.

Overall, there was no evidence that virulence for any of the resistances or cultivars monitored had increased in 2007 as compared with 2006. With the exception of Glasgow, the frequency of virulence for the cultivars examined was well below 50%, indicating that the resistances concerned may continue to offer a degree of protection against the UK mildew population for a period of time.

UKCPVS 2007 ANNUAL REPORT

MILDEW OF BARLEY

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Virulence for many of the mildew resistances exploited commonly in UK barley cultivars remained at very high levels. Virulence for *Mla6*, *Mlk1*, *Mla13* and 'Van' were detected at intermediate frequencies and for *Mla3*, *Mla9* and the unidentified resistance of the cultivar Amarena at low frequencies.

INTRODUCTION

The incidence of barley mildew was low in 2007. To compensate for the unusually low number of infected leaf samples received, mobile seedling nurseries of the universally susceptible cultivar Golden Promise were exposed at locations in the Cambridge to provide additional air spora samples for testing.

METHODS

A total of 85 single pustule isolates were tested in 2007. These comprised 74 isolates from leaf samples and an additional 11 isolates from seedling nurseries of Golden Promise.

Table 1 shows the host cultivars from which isolates were tested. Two isolates were tested from the resistant winter barley cultivar Amarena, with a current RL resistance rating of 9 and four isolates from the *mlo* spring barley cultivars Decanter and Riviera.

The locations from which isolates originated are shown in Table 2. The majority of isolates came from County Down, N. Ireland.

The differential and additional cultivars used in seedling tests are listed in Table 3.

Table 1. Cultivars from which mildew isolates were tested

Winter cultivars	Resistance factors	1-9 resistance rating*	No. of isolates tested
Amarena	?	9	2
Colibri	*Mlh, Mlra*	8	4
Boost	*Mlh,Mlra,Mla6*	7	2
Flagon	*Mlh, Mlra*	7	2
Pearl	*Mlh, Mlra,Mlg,Ml(CP)*	6	1
Camion	*Mlh, Mlra,Mlg,Ml(CP)*	5	2
Carat	*Mlra,Mlg,Ma12*	5	2
Suzuka		5	2
Cassata		4	3
Wintmalt		4	2
Saffron	*Mlh,Mlra,Mlg,Ml(CP),Mla6*	3	4
AC-99/077/13		?	4
Cannock	*Mlra*	4	2
Colossus	*Mlh,Mlra*	4	6
Spectrum	*Mlh,Mlra,Mla7*	5	2
TOTAL (from winter cultivars)			**40**

*HGCA resistance ratings for 2008/09.

Spring cultivars	Resistance factors	1-9 resistance rating*	No. of isolates tested
Decanter	*mlo*	9	1
Riviera	*mlo*	8	3
Cocktail	*Mla13+?*	7	3
Doyen	*Mla3*	7	2
Oxbridge	*Van*	7	2
Rebecca	*Van*	6	2
Wicket	*Mla12,Ml(AB)*	6	6
Optic	*Mla12,Ml(AB)*	5	6
Fairytale		8	2
Knightsbridge		7	1
Maltby		8	3
Snakebite		7	3
Golden Promise (seedling nurseries)			11
TOTAL (from spring cultivars)			**45**

*HGCA resistance ratings for 2008/09.

Table 2. Locations from which mildew isolates were tested *

Region	County	No. of isolates tested
East Anglia	Cambridgeshire	15
	Suffolk	4
South East	Beds	1
Wales	Gwent	4
Scotland	Aberdeenshire	6
	Ayrshire	2
	Borders	5
Ireland	Co. Down	46
	Co. Tyrone	2
TOTAL*		**85**

* includes seedling nursery isolates

RESULTS AND DISCUSSION

Table 3 shows virulence frequencies estimated from seedling tests.

Virulence for many of the resistance genes found in UK barley varieties remained at very high levels in 2007. These included *Mlh, Mlra, Mlg, MlCP, MlLa, Mla12, Mla7, Ml(Ab)* and *Mla1*.

Virulence for *Mla6, Mlk1, Mla13* and the 'Van' resistance continued to be detected at intermediate frequencies. Of these, virulence for *Mla6,* present in the winter barley cultivars Boost, Saffron and Sequel, appears to have increased over recent years.

There were low levels of virulence for *Mla3* (in Doyen), for *Mla,9* and for the winter barley cultivar Amarena (unknown resistance).

No virulence was detected for *mlo* and this resistance continues to provide effective protection to a large proportion of UK spring barley cultivars.

An updated diversification scheme for currently Recommended varieties of winter and spring barley is given in the Appendix . This is derived from UKCPVS data on mildew virulence frequencies together with information on the specific resistances of varieties.

Table 3. % Virulence frequencies from 1997 to 2007.

Differential cultivar	Resistance factor	97	98	99	00	01	02	03	04	05	07
Core set											
Weihenstephan 37/136	*Mlh*	68	61	58	50	68	83	92	97	99	92
Weihenstephan 41/145	*Mlra*	100	100	100	100	100	100	100	100	96	80
Goldfoil	*Mlg*	95	97	97	97	99	99	100	93	96	98
Zephyr	*Mlg,Ml(CP)*	93	94	95	96	98	97	99	91	94	79
Midas	*Mla6*	25	31	26	23	19	20	9	13	22	44
Lofa	*MlLa*	58	72	89	88	95	92	97	91	98	92
Hassan	*Mla12*	73	76	87	88	99	99	98	93	93	84
Hordeum 1063	*Mlk1*	71	73	66	61	57	52	35	25	43	35
Porter	*Mla7*	73	76	85	95	99	96	96	90	96	73
Lotta	*Ml(Ab)*	52	53	71	79	95	95	95	89	85	81
Triumph	*Mla7,(Ml(Ab)*										73
Tyra	*Mla1*	36	45	64	65	67	73	80	79	81	66
Roland	*Mla9*	33	32	25	29	28	15	11	5	15	8
Digger	*Mla13*	39	25	19	11	17	13	9	9	22	38
Ricardo	*Mla3*	1	1	1	5	1	2	5	1	8	11
Apex	*mlo*										0
Riviera	*mlo*										0
Additional cultivars†											
Vanessa	*'Van'*						20	14	24	40	28
Cocktail	*Mla13+?*						0	?	5	19	21
Doyen	*Mla3?*							0	1	8	20
Amarena	*?*								0	2	4
Quench	*?*										0
Publican	*?*										0
Appaloosa	*?*										0
No. of isolates		551	743	629	689	235	339	413	407	134	**85**

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HGCA. Recommended List Spring Barley 2008/09.

APPENDIX

VARIETY DIVERSIFICATION SCHEME TO REDUCE SPREAD OF BARLEY MILDEW 2008

Mildew can spread between barley varieties that are susceptible to the same race of the pathogen.
The risk of severe and widespread infection may be reduced by:

(1) Growing varieties with good resistance to mildew (as indicated by high resistance ratings on the HGCA Recommended List)

(2) Diversifying the varieties grown on a farm so that they are not all susceptible to the same race of mildew. This is achieved by using the Variety Diversification Scheme.

Choosing varieties to grow together

1. Select a first-choice variety and find its Diversification Group (DG).
2. Go to the selection matrix and find this DG under 'Chosen DG' on the left-hand side of the table.
3. Read across the table to find the risk of spread of mildew for each companion DG.
   + = Low risk of mildew spread **M = High risk of mildew spread**
4. Wherever possible choose combinations of varieties marked '+'.
5. If there is a choice of varieties in a companion DG, give preference to those with higher resistance ratings (see 1-9 ratings on HGCA Recommended List)

DG1
Winter Varieties
Amarena

Spring Varieties
Appaloosa
Belgravia
Cellar
Decanter
Jolika
NFC Tipple
Publican
Quench
Riviera
Scout
Static
Sweeney
Waggon
Westminster

DG3 *(Mla3)*
Spring varieties
Doyen

DG4 (*Mla13*)
Spring Varieties
Cocktail

DG5 (*Mla12*)
Winter Varieties
Carat

DG9 (*Mla12, Ml*(*Ab*))
Spring Varieties
Optic
Wicket

DG10 (*Mla6*)
Winter Varieties
Boost
Saffron
Sequel

DG14 ("*Van*")
Spring Varieties
Oxbridge
Rebecca

DG0 *(Mlra/Mlh/Mlg/Mla7/unknown)*
Winter Varieties
Accrue
Bronx
Camion
Cassata
Colibri
Flagon
Pearl
Pelican
Pict
Retriever
Wintmalt
Suzuka

Chosen DG	Companion DG							
	1	**3**	**4**	**5**	**9**	**10**	**14**	**0**
1	+		+	+	+	+	+	+
3	+	M	+	+	+	+	+	
4	+	+	M	+	+	+	+	M
5	+	+	+	M	M	M	+	M
9	+	+	+	M	M	+	+	M
10	+	+	+	M	+	M	+	M
14	+	+	+	+	+	+	M	M
0	+	M	M	M	M	M	M	M