MILDEW OF WHEAT

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For the first time, mildew was detected on the variety Robigus in variety trials and crops. This variety previously had a resistance rating of 9 and less than 1% of mildew isolates tested in 2004 showed any indication of virulence. 100 isolates (46% of those tested) were confirmed as being virulent on Robigus.

The identity of the specific resistance of Robigus is unknown. Isolates virulent on Robigus had very similar virulence frequencies to those avirulent on Robigus.

The frequencies of virulence factors identified in mildew isolates were similar to those described in 2004. Virulence factors *V2, V4b, V5, V6, V8, VTa2* and *VSs* were present in more than 90% of the mildew population. Virulence frequencies of *V17* and *VAx* were low, present in less than 15% of mildew isolates. Virulence for *Mld* (the resistance carried by Cordiale) increased slightly, from 18% to 30%. Virulence for *Pm3b* increased in frequency from 4% in 2004, to 29% in 2005 - despite the fact that this resistance has never been used in a commercial UK variety.

The winter variety Dover (grown in trials but not included in the 2005-6 Recommended List) was resistant to all isolates tested.

INTRODUCTION

Sample numbers were high in 2005 - 187 samples of infected leaves were received compared to 87 viable leaf samples in 2004. From these samples 219 isolates were cultured from single pustules. Isolates were received from 22 locations across the UK (Table 1).

This increase in the donation of samples was for the most part in response to a particular request for mildew on Robigus wheat. In previous years Robigus-virulent isolates were only occasionally detected in the mildew population (Slater, 2004). In response to the widespread observation of mildew on Robigus in the field in 2005 however, the Survey reacted quickly to analyse in particular those isolates and pathotypes able to infect Robigus. Robigus is by far the most widely grown winter wheat, and accounts for 19% of the total wheat area cultivated in the UK.

METHODS

219 mildew isolates were collected in 2005, from 16 different wheat varieties and 22 different locations across the UK (Table 1). The majority of wheat samples (96%) were derived from sites in England, and only 2% of samples came from Scotland, and 2% from Ireland.

The counties from which samples were collected are shown in Figure 1. Though the geographic range from which samples were drawn was large, the majority of samples were collected from the East of England (44% from Cambridgeshire, 8% from Suffolk and Norfolk).

Table 1. The locations from which tested isolates were collected in 2005.

Location	No. of isolates tested	Location	No. of isolates tested
Cambridgeshire	97	Norfolk	4
Lincolnshire	24	Oxfordshire	2
Suffolk	14	Scotland	4
Yorkshire	14	County Kildare	2
Shropshire	9	Cumbria	2
Dorset	9	Gloucestershire	1
Kent	8	Northern Ireland	2
Cheshire	6	Northamptonshire	2
Herefordshire	8	Nottinghamshire	1
Essex	3	Staffordshire	2
Lancashire	4	Wiltshire	1
TOTAL			**219**

Figure 1. English counties from which viable mildew isolates samples were collected in 2005.

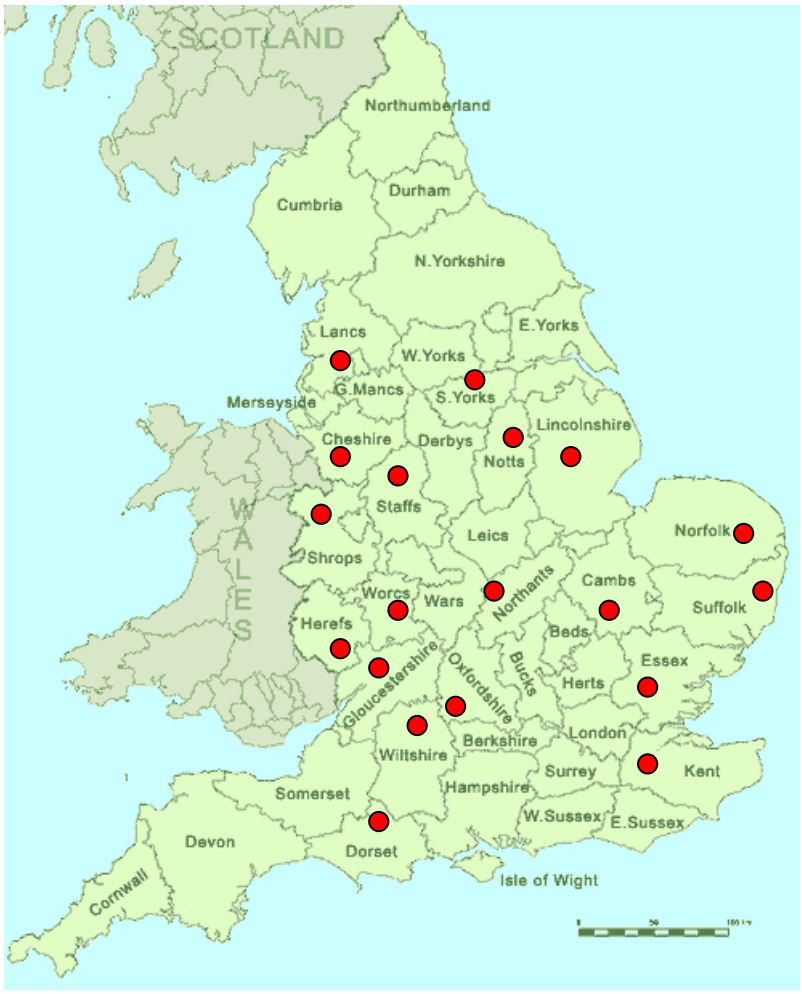

Table 2 shows the 16 wheat cultivars from which tested isolates were derived. A high proportion of isolates (46% of the total) were collected from Robigus hosts, in response to a request from the Survey for Robigus samples in particular, infected with mildew. 25% of all isolates analysed in 2005 were obtained from Cerco, collected mostly from the Cambridgeshire area. The other most frequent host varieties on which samples were collected were Claire (8% of all isolates) and Solstice (6% of the population was derived from samples on this host).

Table 2. The cultivars from which tested isolates were collected in 2005.

	No. of isolates		No. of isolates
Alchemy (W)	4	Glasgow (W)	5
Brompton (W)	1	Malacca (W)	1
Cerco (W)	54	Robigus (W)	100
Claire (W)	18	Slejpner (W)	1
Clement (W)	2	Solstice (W)	13
Cordiale (W)	1	Stetson (W)	2
Einstein (W)	2	Tara (W)	2
Gatsby (W)	8	Xi19 (W)	5
TOTAL			**219**

(W) winter wheat (S) spring wheat

The varieties used to determine which virulence factors were present in mildew isolates, together with their associated resistance factors are shown in Table 3. These cultivars constitute the standard list of differential factors used to screen mildew races (with the exception of Robigus, which is not part of the standard differential set).

Table 3. The differential cultivars used to determine virulence factors in isolates of mildew of wheat.

Differential cultivar	Resistance Factor	Corresponding Virulence Factor
Cerco	-	-
Galahad	*Pm2*	*V2*
Chul	*Pm3b*	*V3b*
Armada	*Pm4b*	*V4b*
Flanders	*Pm5*	*V5*
Brimstone	*Pm2, Pm6*	*V2, V6*
Clement	*Pm8*	*V8*
Maris Dove	*Mld*	*Vd*
Brock	*Pm2, MlTa2*	*V2, unknown*
Mercia	*Pm5, MlTa2*	*V5, unknown*
Tonic	*MlTo*	*V2, V3d, unknown*
Broom	*MlBr*	*V3d*
Sicco	*Pm5, MlSi2*	*V5, unknown*
Wembley	*MlSo*	*unknown*
Axona	*MlAx*	*unknown*
Amigo	*Pm17*	*V17*
Soissons	*MlSs**	*unknown*
Shamrock	*MlSh**	*unknown*
Robigus	*MlRo***	*VRo***

* tentative designation for specific resistance factor (according to Slater, 2004).

** tentative designation for specific resistance/virulence factor.

RESULTS AND DISCUSSION

Virulence frequencies in 2005 (Table 4) were similar to those reported in previous years. Virulence factors *V2*, *V4b*, *V6*, *VSs* and *VTa2* were detected in 97-99% of the isolates tested. Virulence factors *V5* and *V8* were also common in populations, and were detected in 90% or more of isolates tested. These virulence factors correspond to the resistance factors carried by the majority of winter wheat cultivars currently grown, with the exception of *Mld*-carrying Cordiale, and *MlAx*-carrying Ashby.

The most noticeable increase in virulence frequency was observed for virulence factor *V3b*, which was present in 25% of the population in 2005 (compared to 4% in the previous year). The selection pressure responsible for the increase in frequency of this virulence factor is unclear, as *Pm3b* is not carried by any of the current Recommended List varieties. Resistance for *VSo* (carried by Wembley) was detected in 16% of mildew isolates – the highest frequency for which this virulence factor has been observed since 1996.

Virulence factors *Vd*, *VTo* and *VBr* were present in approximately 20% of isolates in 2004, increasing to almost 30% of all isolates by 2005. *V17* and *VAx* were less frequent, observed in less than 15% of the isolates tested. Though the frequency of *VSh* increased slightly compared to levels in the population in 2004, it remained the least common virulence factor present in isolates. As proposed in the 2004 report (SE Slater 2004), as Shamrock is no longer a popular cultivar, a reduction in selection pressure is probably responsible for the overall low frequency of *VSh*.

Table 4. Frequency of wheat mildew virulence factors in leaf samples collected (1996- 2005).

	Frequency of virulence factors									
Virulence factor	1996	1997	1998	1999	2000	2001	2002	2003	2004	**2005**
V2	100	100	100	100	100	100	99	100	100	**99**
V3b	3	4	1	2	1	4	6	7	4	**25**
V4b	93	98	100	99	99	100	100	100	100	**97**
V5	93	95	88	91	88	90	89	92	90	**92**
V6	96	99	100	100	99	100	100	100	99	**97**
V8	96	98	97	99	97	98	98	94	98	**90**
V17	15	16	8	22	2	9	13	4	6	**11**
Vd	33	26	18	6	12	25	24	18	18	**30**
VTa2	92	93	86	97	96	95	99	96	97	**97**
VTo	29	29	16	16	5	24	20	20	20	**27**
VBr	32	30	16	15	8	24	27	20	21	**30**
V5,Si2	32	21	17	20	8	8	15	6	6	**20**
VSo	15	15	10	6	4	6	11	4	4	**16**
VAx	24	20	7	1	1	10	8	8	9	**13**
VSs			65	57	74	82	93	90	86	**98**
VSh				3	0	4	16	8	1	**5**
Number of isolates tested	265	313	328	187	148	286	165	209	376	**219**

As in previous years, the dominant mildew pathotype was *V2,V4b,V5,V6,V8,VTa2*, though this accounted for only 30% of isolates sampled in the population, compared to 52% in 2004 (data not shown). A greater variety of pathotypes were detected in 2005 compared to 2004, despite the lower number of isolates analysed. It is probable that the decrease in the frequency of the dominant pathotype, and the corresponding increase in pathotype variability, was due to the greater geographic range from which samples were collected in 2005 (22 locations), compared to 2004 (7 locations).

Robigus-virulent isolates

100 of the 219 isolates tested were virulent on Robigus. These isolates have been classified as carrying the tentative virulence factor *VRo*.

The frequency of virulence factors for isolates virulent and avirulent on Robigus are compared in Table 5. In both sets of isolates, the most common virulence factors, detected in 96% or more of isolates, were *V2*, *V4b*, *V5*, *V6*, *VTa2*, and *VS*. There were indications that isolates able to infect Robigus showed a higher frequency of virulence for *Vd*, *V3b*, and *VAx*. Only 23% of the isolates virulent on Robigus were also virulent on Axona, which does not support the previous suggestion that Robigus may carry the Axona resistance (*MlAx*).

The practical significance of this is that there are already pathotypes in the mildew population which carry virulence for Robigus combined with virulence for all the other resistance factors used in wheat varieties on the UK Recommended List. There is therefore a risk of cross infection between Robigus and other RL wheat varieties.

Table 5. Frequency of virulence factors in Robigus-virulent and avirulent isolates.

Virulence Factor	Frequency in Robigus-virulent isolates	Frequency in Robigus-avirulent isolates
V2	100	98
V3b	35	17
V4b	97	97
V5	96	89
V6	96	97
V8	89	91
V17	7	14
Vd	43	19
VTa2	98	96
VTo	33	22
VBr	35	26
V5,Si2	23	17
VSo	20	13
VAx	22	5
VSs	100	96
VSh	7	3
VRo	100	0
Total No. of isolates tested	**100**	**119**

REFERENCE

Slater, S.E. (2004). Mildew of Wheat. *UK Cereal Pathogen Virulence Survey 2003 Annual Report*, pp. 1-9.

MILDEW OF BARLEY

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ABSTRACT

2005 was not an epidemic year for mildew, and leaf sample numbers were relatively low. Isolates were collected on 26 different varieties (15 spring barleys, and 11 winter barleys), from 11 regions across the UK. Virulence factors *Vh*, *VLa*, *Vra*, *Vg*, *V(CP)*, *Va12* and *Va7* were detected at high levels (in 90% or more of the population), whilst *Va9* and *Va3* occurred at low levels (in 15% or less of all isolates tested). As in previous years, the majority of pathotypes carried 9 virulence factors. The dominant pathotype *Vh,Vra,Vg,V(CP),VLa,Va12,Va7,V(Ab),Va1* was detected in 18% of mildew isolates tested. This pathotype is able to infect most of the Recommended List varieties, with the exception of *Mla3*-carrying Doyen, *Mla13*-carrying varieties Centurion, Cocktail and Spire, and those varieties carrying resistance for *Mla6* and the "*Van*" resistance. Amarena remained resistant to all of the isolates tested. Many of the spring varieties carry *mlo* resistance, which remains effective in the field.

INTRODUCTION

2005 was not an epidemic year for mildew, a total of 87 infected leaf samples were collected in 2005 (a similar number to 2004). Samples were received from all over the UK, and suggested that infection in winter barley was most prevalent in Scotland (51% of all isolates were obtained from Scottish counties). High levels of mildew were also reported in Northern Ireland and the East of England.

mlo resistance continued to remain effective, though partially virulent isolates were detected in the population in 2005. 14% of isolates were partially virulent on the *mlo* variety Apex, and 11% on Riviera.

METHODS

Virulence Survey of the Mildew Population

87 samples of infected leaves, from 26 different varieties were collected in 2005, from which 134 viable isolates were tested. The 11 locations from which samples were received are shown in Table 1.

Table 1. The locations from which tested isolates were collected in 2005.

Location	Number of isolates	Location	Number of isolates
Cambridgeshire	24	North Borders	8
County Down	21	Easter Ross	7
South Borders	21	Northern Ireland	7
Fife	16	Norfolk	4
Ayr	15	Perthshire	1
Suffolk	10		
Total number of isolates tested			**134**

The 26 varieties from which isolates were collected are listed below (Table 2).

Table 2. The varieties from which tested isolates were collected in 2005.

Spring Cultivars	No. isolates		No. isolates
Centurion	1	Optic	10
Carafe	5	Oxbridge	6
Cocktail	8	Poker	6
Cribbage	1	Putney	2
Doyen	5	Rebecca	10
Golden promise	24	Spire	4
Kirsty	4	Tocada	13
		Wicket	6
Total number of isolates tested (from spring cultivars)			*105*

Winter Cultivars	No. isolates		No. isolates
Boost	2	Pearl	2
Camion	2	Regina	9
Cannock	2	Sequel	2
Colossus	2	Siberia	1
Fahrenheit	2	Surtees	2
Flagon	3		
Total number of isolates tested (from winter cultivars)			*29*
Total number of isolates tested			**134**

The cultivars used to determine which virulence factors were present in mildew isolates, together with their associated resistance factors are shown in Table 3. These cultivars constitute the standard list of differentials used to screen mildew races.

Table 3. The differential cultivars used to determine virulence factors in isolates of barley mildew.

Cultivar	Resistance Factor	Corresponding Virulence Factor
Golden Promise	none	-
Weihenstephan 37/136	*Mlh*	*Vh*
Weihenstephan 41/145	*Mlra*	*Vra*
Goldfoil	*Mlg*	*Vg*
Zephyr	*Mlg, Ml(CP)*	*Vg, V(CP)*
Midas	*Mla6*	*V6*
Lofa	*MlLa*	*Vla*
Hassan	*Mla12*	*Va12*
Hordeum 1063	*Mlk1*	*Vk1*
Porter	*Mla7*	*Va7*
Lotta	*Ml(Ab)*	*V(Ab)*
Triumph	*Mla7, Ml(Ab)*	*Va7, V(Ab)*
Tyra	*Mla1*	*Va1*
Roland	*Mla9*	*Va9*
Apex	*mlo*	-
Riviera	*mlo*	-
Digger	*Mla13*	*Va13*
Ricardo	*Mla3*	*Va3*

In addition to the differential cultivars used to screen isolates, the following varieties were also included in tests: Vanessa, Carafe, Cocktail, Doyen. Kirsty, Tocada, Rebecca, Sumo, Amarena, and Oxbridge. These varieties either carry a resistance of particular interest, or an unknown resistance.

RESULTS AND DISCUSSION

Virulence

Virulence frequencies in 2005 (Table 4) were similar to those reported in previous years. Virulence factors *Vh* and *VLa* were detected in 97-99% of the population. Virulence factors *Vra*, *Vg*, *V(CP)*, *Va12* and *Va7* were also common, and were detected in 90% or more of the isolates tested. There was a noticeable increase in the frequency of virulence factors *Va6* (which increased from 13% in 2004, to 22% in 2005) and *Vk1* (which increased from 13% in 2004, to 22% in 2005). In 2005 approximately 20% or fewer isolates were found to contain virulence factors *Va9* and *Va13,* and less than 10% of isolates possessed *Va3*.

Table 4. Virulence frequencies in barley mildew, from 1995 to 2005.

Virulence factor	Virulence Frequency (%)										
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	**2005**
Vh	70	78	68	61	58	50	68	83	92	97	**99**
Vra	100	100	100	100	100	100	100	100	100	100	**96**
Vg	95	96	95	97	97	97	99	99	100	93	**96**
V(CP)	90	90	93	94	95	96	98	97	99	91	**94**
Va6	34	30	25	31	26	23	19	20	9	13	**22**
VLa	31	56	58	72	89	88	95	92	97	91	**98**
Va12	71	70	73	76	87	88	99	99	98	93	**93**
Vk1	72	76	71	73	66	61	57	52	35	25	**43**
Va7	73	76	73	76	85	95	99	96	96	90	**96**
V(Ab)	67	62	52	53	71	79	95	95	95	89	**85**
Va1	27	38	36	45	64	65	67	73	80	79	**81**
Va9	33	37	33	32	25	29	28	15	11	5	**15**
Va13	37	41	39	25	19	11	17	13	9	9	**22**
Va3	<1	<1	1	1	1	5	1	2	5	1	**8**
No. of isolates	552	428	551	743	629	689	235	339	413	407	**134**

The frequency of virulent isolates on the varieties tested in addition to the differential cultivars listed in Table 3, are shown below (Table 5). Nearly all isolates were virulent on Sumo (which has been removed from the 2006-07 Recommended List) and Tocada. Approximately 10% of the population were virulent on Carafe and Doyen.

Table 5. Virulence frequency of mildew isolates on the additional varieties included in the 2005 tests.

Additional Variety	Virulence Frequency (%)
Vanessa	41
Carafe	11
Cocktail	19
Doyen	8
Kirsty	45
Tocada	69
Rebecca	46
Sumo	99
Oxbridge	37

Despite the greater sampling range in 2005, *Vh,Vra,Vg,V(CP),VLa,Va12,Va7,V(Ab),Va1* remained the most common pathotype across the whole of the UK, present in 18% of the mildew population (compared to 54% of the population in 2004)(data not shown).

Infection of Barley Cultivars – Seedling Tests

The trend towards an increase in the proportion of isolates able to infect varieties carrying "*Van"* resistance continued in 2005. Potentially, approximately 40% of the mildew population is able to infect each of the varieties listed in Table 6. Despite being susceptible to such a high proportion of the mildew population, Vanessa, Kirsty and Oxbridge retained mildew ratings of 8, 7 and 7 (respectively) suggesting that these "*Van*" varieties carry a good non-specific resistance.

Table 6. The change in virulence frequency for cultivars which may carry Vanessa ("*Van*") resistance.

	2003*	2004*	**2005**
Vanessa (W)	28	41	**40**
Kirsty (S)	24	38	**44**
Rebecca (S)	25	35	**46**
Oxbridge (S)	-	20	**36**
No. of isols.	411	407	**134**

(W) = Winter (S) = Spring

* = combined leaf and air-spora data (Slater, 2004).

The pathotypes of isolates carrying virulence for Vanessa were examined more closely, to see whether there appeared to be a link between virulence for Vanessa, and Kirsty, Oxbridge and Rebecca. The results of this analysis is shown in the contingency tables in Figure 1. Generally it seems that the majority of isolates if carrying "*Van*" virulence, are also virulent on Kirsty, or Rebecca or Oxbridge. If isolates are unable to infect Vanessa, they are typically also unable to infect the other 3 varieties. This suggests that these varieties share the same specific resistance as Vanessa.

Figure 1. The proportion of isolates carrying virulence for Vanessa, Kirsty, Rebecca and Oxbridge, in a total population of 134 mildew isolates.

	Van +	Van -
Kirsty +	53	7
Kirsty -	3	71
TOTAL		**134**

	Van +	Van -
Oxbridge +	50	2
Oxbridge -	6	76
TOTAL		**134**

	Van +	Van -
Rebecca +	52	10
Rebecca -	4	68
TOTAL		**134**

Resistance factors in new cultivars

New spring variety candidates for 2006 included Appaloosa, Poker, Cribbage, Putney, Hydra, Beatrix and Centurion (*). Of these only Appaloosa made it onto the 2006-07 Recommended List. Carafe and Prestige were removed from the 2006-07 Recommended List (~).

New winter variety candidates included Surtees, Celebrity, Cypress, Dolphin, Fahrenheit, Colibri, Mona Lisa and Boost (*). Of this selection only Colibri and Boost were added to the 2006-07 Recommended List. Winter varieties Vanessa, Regina, Sumo, Pastoral and Jewel were removed from the List (~).

The resistance factors carried by HGCA Recommended List barley cultivars are shown in Table 7.

Table 7. Resistance factors of barley cultivars in trials (2006-07 HGCA Recommended List Cultivars are in **bold**).

Mlra	*Mla12*	*mlo*
Cannock (W)	Jewel (W) ~	**Cellar** (S)
Pastoral (W) ~		**Chalice** (S)
Pict (W)		Cribbage (S) *
Regina (W) ~	*Mla13+?*	**Decanter** (S)
	Centurion (S) *	Hydra (S) *
	Cocktail (S)	**NFC Tipple** (S)
Mlh,Mlra	**Spire** (S)	**Power** (S)
Colibri (W) *		Prestige (S) ~
Colossus (W)		**Riviera** (S)
Cypress (W) *	*Mlra,Mlg,Mla12*	**Static** (S)
Dolphin (W) *	**Carat** (W)	**Troon** (S)
Flagon (W)		**Waggon** (S)
Haka (W)		**Westminster** (S)
Siberia (W)	*Mlh,Mlra,Mla7*	
Surtees (W) *	**Spectrum** (W)	
		Unknown
		Amarena (W)
Mlra, Mla12	*'Van'*	**Appaloosa** (S) *
Farenheit (W) *	**Kirtsy** (S)	Carafe (S) ~
	Oxbridge (S)	Poker (S) *
	Putney (S) *	Sumo (W) ~
Mlh,Mlra,Mla6	**Rebecca** (S)	**Tocada** (S)
Boost (W) *	Vanessa (W) ~	
		Mlra, Mla6
Mlh,Mlra,Mlg,Ml(CP)	*Mla3*	Monalisa (W) *
Celebrity (W) *	**Doyen** (S)	**Sequel** (W)
Camion (W)		
Pearl (W)		
Scylla (W)	*Mla12,Ml(Ab)*	*Mlra,Mlg,Ml(CP)*
	Optic (S)	**Fanfare** (W)
	Wicket (S)	
Mlg,Ml(CP),MlLa,Mla12,Mla7		*Mlh,Mlra,Mlg,Ml(CP), Mla6*
Beatrix (S) *		**Saffron** (W)

* new candidates for the 2006-07 List ~ varieties removed from the 2006-07 List

(W) winter cultivar (S) spring cultivar

The proportion of mildew isolates which were tested in 2005-06 and found to be able to infect barley cultivars in 2006-7 HGCA Recommended List trials are shown in Table 8 (the

disease ratings for mildew are indicated in brackets). Having identified which resistance factors were carried by the varieties, it was possible to predict what proportion of mildew isolates would be able to infect them, based upon the frequency of corresponding virulence factors in the mildew population (Table 4).

Varieties in **bold** in Table 8 were actually tested in 2005-06, and the proportion of isolates able to infect that variety were derived directly from test data. (All other figures were calculated by multiplying the virulence frequecies together, corresponding to the resistance factors carried by an untested variety).

Only partial virulence was detected on *mlo*-varieties.

Table 8. Proportion of mildew isolates able to infect barley cultivars in HGCA 2006-07 Recommended List trials (Rating for mildew in brackets).

Winter cultivars	Resistance factors carried	Proportion (%)	Winter cultivars	Resistance factors carried	Proportion (%)
Amarena (9)	*unknown*	2	Haka (7)	*Mlh,Mlra*	96
Boost (7) *	*Mlh,Mlra,Mla6*	21	Pearl (7)	*Mlh,Mlra,Mlg,Ml(CP)*	87
Camion (5)	*Mlh,Mlra,Mlg,Ml(CP)*	87	Pict (7)	*Mlra*	96
Cannock (4)	*Mlra*	96	Saffron (4)	*Mlh,Mlg,Ml(CP).Mla6,Mlra*	19
Carat (6)	*Mlra,Mlg,Mla12*	87	Scylla (6)	*Mlh,Mlra,Mlg,Ml(CP)*	87
Colibri (7) *	*Mlh,Mlra*	96	Sequel (7)	*Mlra,Mla6*	22
Colossus (4)	*Mlh,Mlra*	96	Siberia (5)	*Mlh,Mlra*	96
Fanfare (6)	*Mlra,Mlg,Ml(CP)*	87	Spectrum (5)	*Mlh,Mlra,Mla7*	92
Flagon (7)	*Mlh,Mlra*	96			

Spring cultivars	Resistance factors carried	Proportion (%)	Spring cultivars	Resistance factors carried	Proportion (%)
Appaloosa (8) *	*unknown*	-	Power (8)	*mlo*	0
Cellar (9)	*mlo*	0	**Rebecca** (7)	*"Van"*	46
Chalice (9)	*mlo*	0	Riviera (8)	*mlo*	0
Cocktail (7)	*Mla13 + ?*	22	Spire (6)	*Mla13 + ?*	22
Decanter (9)	*mlo*	0	Static (9)	*mlo*	0
Doyen (7)	*Mla3*	8	**Tocada** (6)	*unknown*	69
Kirsty (7)	*"Van"*	45	Troon (9)	*mlo*	0
NFC Tipple (9)	*mlo*	0	Waggon (9)	*mlo*	0
Optic (5)	*Mla12, Ml(Ab)*	81	Westminster (9)	*mlo*	0
Oxbridge (7)	*"Van"*	37	Wicket (7)	*Mla12,Ml(Ab)*	81

* New varieties for the 2006-07 HGCA Recommended List.

Though the specific resistance carried by most winter cultivars is matched by the majority of the mildew population (Slater, 2004), some varieties also have good non-specific resistance. Winter barleys Flagon, Colibri and Haka (each of which carry resistance factors *Mlh,Mlra*)

for example, are potentially susceptible to 96% of the mildew population, yet they each retain a mildew disease rating of 7. A similar example is that of Pict and Wicket, potentially vulnerable to infection from 96% of mildew isolates – yet both varieties have a mildew rating of 7 indicating good resistance in the field.

Winter barley Amarena was screened against all isolates collected in 2005, and although two isolates gave types 1-2 infection, this variety remained resistant to the whole population.

Winter varieties Boost and Sequel were estimated to be susceptible to only 22% of the mildew population. Though the potential virulence frequency of isolates against these two varieties appears low when compared with the other winter barleys, the proportion of isolates able to infect Sequel increased from 13% in 2004, to 22% in 2005.

The majority of spring barleys with good specific to mildew carry the *mlo* gene. The exception to this is Doyen, which carries *Mla3,* has a disease rating of 7 and is only susceptible to 8% of the population. Virulence on Doyen has increased however, from only 1% of isolates in 2004.

Cocktail and Spire (both spring barleys carrying *Mla13*) are potentially susceptible to 22% of the mildew population. Though relatively low, virulence on these two varieties has also increased compared to 2004 (when less than 10% of isolates were able to infect Cocktail or Spire).

Virulence for *mlo* cultivars

Fewer isolates produced infection on Apex and Riviera cultivars (the *mlo* differentials) in 2005 tests than in previous years (Table 13) The area of *mlo*-varieties grown has not significantly changed (32% of all spring barley planted in 2005 carried *mlo* resistance, equivalent to 16% of the total spring and winter barley planted in the UK).

Table 9. The proportion of isolates infecting Apex and Riviera in differential tests, and the area of the UK sown with *mlo* carrying cultivars.

Year	Apex	Riviera	Area of mlo cultivars *
2000	44	32	17
2001	48	34	22
2002	30	13	19
2003	43	27	23
2004	21	12	17
2005	**14**	**11**	**16**

* percentage of total barley area

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MILDEW OF OATS

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INTRODUCTION

Mildew levels were generally high on unsprayed susceptible winter and spring crops. Despite this, only 10 samples were received (Table1).

Table1. Source cvs and geographic origins of 2005 oat mildew samples.

Cultivar *[1-9] rating	Country of Origin	Cultivar [1-9] rating	Country of origin
Winter oat		**Spring oat**	
Millennium [5]	Co Down	Drummer [6]	Co Down
Mascani [6]	Co Down	Emotion [6]	Fife
Gerald [4]	Essex	Firth [8]	Fife
Dalguise [3]	Co Down	Winston [8]	Fife
		Drummer [6]	Grampian
		Emotion [6]	Co Down

*HGCA Recommended List disease rating 2006/07

SEEDLING TESTS WITH 2005 ISOLATES

Methods

Isolates of *Blumeria graminis* DC Speer f.sp. *avenae* were cultured from 5 samples and were inoculated onto seedlings of the differential cvs (Table 2). Post-inoculation plants were incubated in the glasshouse at approximately 15^{o}C for 14 days. Isolate/cv. interactions were classified on the standard 0-4 scale as resistant (0-2) or susceptible (3-4).

Table 2 Differential cultivars used for isolate testing

OMR Group	Differential cultivar
0	Milford
1	Manod
2	Cc 4146
3	9065 Cn/6/3/74
4	Cc 6490

Results

Based on the reactions of the differential cvs, the isolates were identified as carrying the widely virulent race 7 (OMV-1,2,3,4). Race 5 (OMV-1,2,3) has been dominant in recent years but the 2005 isolates additionally carried OMV-4 which overcomes the resistance of the differential cv. Cc6490 (OMR-4), a translocation line carrying a chromosomal fragment from *Avena barbata*. Pathotypes carrying OMV-4 have been at a mean frequency of around 12% in the sampled population since they were first identified in 1980. OMR-4 is not thought to be carried by any recommended cvs but may be in some advanced breeding lines. Previous years tests have identified all the currently recommended winter and spring oat cvs to be seedling susceptible to race 5 isolates but there does appear to be good levels of adult plant resistance, particularly in spring oats as indicated by their disease ratings on the HGCA Recommended List of Spring Oats.

YELLOW RUST OF WHEAT

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SUMMARY

Virulence for Robigus was identified in 79% of the isolates tested. All of these carried the virulence combination WYV9,17,CV, with other virulences.
Combined virulence for Robigus and for WYR6, was provisionally identified in two isolates.
Many new and established cultivars were resistant to all isolates.

INTRODUCTION

Yellow rust was detected more widely in 2005 than in 2004, although the overall incidence was again very low.

SEEDLING VIRULENCE TESTS OF ISOLATES COLLECTED IN 2005

Methods

56 samples of wheat yellow rust were received between January and July 2005, of which 39 were successfully cultured and tested.
The majority of samples came from the popular cultivar Robigus, which occupied some 15% of the wheat acreage (Table 1).

Table 2 shows the locations from which samples were received. Although the majority of samples once again came from Cambridgeshire, there was a wider geographic distribution than in 2004.

In addition to the samples collected from natural infections, seven samples were collected from inoculated plots at Cambridge. Results from these are reported separately.

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 also included. Some of these possess resistance that is effective against all known UK pathotypes.

Table 1. Cultivars from which yellow rust samples were received and tested in 2005.

Cultivar	WYR factors	1-9 resistance rating*	% Area #	No. of samples received	No. of samples tested
RL varieties					
Robigus	CV+	3	15.4	24	14
Consort	CV+	6	10.0	3	2
Glasgow	0	4	0.4	3	2
Hereward	CV+	5	4.2	2	1
Mascot	6(,9),17	6	0.0	1	0
Richmond	R	8	2.0	1	0
Other cultivars					
Vuka	0	-	-	4	3
Victo	0	-	-	3	3
Brigadier	9,17	-	-	3	3
Clement	9	-	-	3	3
Oxbow	CV+	-	-	3	2
Slejpner	9	-	-	2	2
Hybred	?	-	-	2	2
Reaper	17	-	-	1	1
Stetson	1,9	-	-	1	1
TOTAL			**32.0**	**56**	**39**

*HGCA resistance ratings for autumn 2005.
From UK seed production statistics – weights of seed certified harvest 2004.

Table 2. Locations from which yellow rust samples were received and tested in 2005.

Region	County	No. of samples received	tested
East Anglia	Cambridgeshire	18	13
East Anglia	Norfolk	2	1
East Anglia	Suffolk	2	0
Yorkshire	N. Yorkshire	12	10
North East	Northumberland	7	7
East Midlands	Lincolnshire	4	3
East Midlands	Northamptonshire	1	1
South East	Hants	5	0
West Midlands	Shropshire	2	2
North West	Merseyside	1	1
South West	Gloucestershire	1	0
Scotland	Scotland	1	1
TOTAL		**56**	**39**

Table 3. Differential cultivars used in 2005 wheat seedling virulence tests.

Differential cultivar	WYR factor	Designation of main Yr-gene
Core set		
Chinese 166	WYR 1	*Yr1*
Kalyansona	WYR 2	*Yr2*
Vilmorin 23	WYR 3	*Yr3+*
Nord Desprez	WYR 3	*Yr3+*
Hybrid 46	WYR 4	*Yr4*
Heines Kolben	WYR 2,6	*Yr2, Yr6*
Heines Peko	WYR 2,6	*Yr2, Yr6*
Lee	WYR 7	*Yr7*
Reichersberg 42	WYR 7	*Yr7*
Brock	WYR 7	*Yr7*
Compair	WYR 8	*Yr8*
Kavkaz x 4 Fed	WYR 9	*Yr9*
Clement	WYR 9	*Yr9*
Moro	WYR 10	*Yr10*
AVS xYr 15	WYR 15	*Yr15*
VPM 1	WYR 17	*Yr17*
Rendezvous	WYR 17	*Yr17*
Carstens V	WYR CV	*Yr32*
Spaldings Prolific	WYR Sp	*Yr Spaldings Prolific*
Additional cvs		
Reaper	WYR 17	
Talon	WYR CV	
Robigus	WYR CV+	
Oxbow	WYR CV+	
Madrigal	WYR 6,9,17	
Einstein	WYR 6?	
Claire	Rx	
Buster	R	
Cadenza	R	
Charger	R	
Solstice	R	
Xi 19	R	

Results

Virulence frequency data for 2005, together with data from 1990 – 2004 (Bayles *et al*, 2004), are shown in Table 4. Virulence frequencies should be interpreted with caution due to the non-random sampling and the small number of isolates tested in some years.

As in previous years, virulence for WYR1, WYR2 and WYR3 was detected in all isolates. Other virulences detected at high frequencies were WYV4, WYV9, WYV17 and WYV CV. As in 2004, the frequency of WYV7 was low at 8%. The frequency of WYV6 fell markedly to 10%, its lowest level for seven years.

Virulence for the cultivars Oxbow and Robigus was identified in 82% and 79% of isolates respectively, a substantial increase over its 2004 level of 31%.

Virulence for Claire was detected in 23% of isolates. Claire currently has effective adult plant resistance, but infection is occasionally found on seedlings and juvenile plants. To date, none of the isolates with apparent seedling virulence for Claire has proved to be virulent on adult plants. Some of these 2005 isolates will be tested on adult plants to investigate whether there has been a change.

No virulence was detected for the differentials WYR8, WYR10, WYR15 or for the additional cultivars Charger, Cadenza, Option, Solstice or Xi19.

Table 5 shows the frequencies of pathotypes in 2005, compared with their 2004 values. The isolates tested in 2005 were of eight different pathotypes. The commonest pathotype identified was WYV 9,17,CV, with virulence for Oxbow and Robigus.

Only 5% of isolates represented pathotypes combining virulence for Robigus with virulence for WYR 6. This virulence combination is still extremely uncommon. The isolates concerned will be examined in adult plant tests in 2006.

Table 6 shows the pathotypes of seven isolates taken from inoculated plots. Six of these were virulent on Madrigal, carrying the virulence combination WYV6,9,17. One of these also appeared to be virulent on Robigus.

Table 4. Virulence frequencies from 1990 to 2005.

Virulence for		**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**
WYR 1		85	91	88	89	65	90	97	100	99	99	100	100	97	100	100	100
WYR 2		100	100	100	98	100	99	97	100	99	99	100	100	97	100	100	100
WYR 3		100	100	100	100	100	100	100	100	100	100	100	100	97	100	93	100
WYR 4		91	86	86	89	86	67	59	47	79	87	90	74	63	86	50	87
WYR 6		69	64	88	68	41	35	16	1	7	21	32	39	31	50	42	10
WYR 7		9	19	7	8	4	0	3	7	4	10	4	0	3	36	4	8
WYR 8			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WYR 9		94	88	76	84	94	95	97	99	99	99	92	90	88	93	100	95
WYR 15													0	0	0	0	0
WYR 17							57	84	99	99	100	96	77	88	93	85	97
WYR CV						75	55	9	13	1	4	16	42	73	64	38	85
WYR A										84	91	88	90	97			
WYR So										78	91	90	77	67	93		
WYR Sd										100	98	100	84	81	100		
WYR Sp										0	0	0	0	0	7	0	0
Additional cvs																	
Robigus	CV +															31	79
Oxbow	CV +											16	32	50	50	31	82
Claire	Rx																23
Madrigal	6,9,17																8
Einstein	6																5
Charger	R																0
Buster*	R				3	0	0	0	0	0	0	0	0	0	7	0	0
Cadenza	R												0	0	0	0	0
Option	R													0	0	0	0
Solstice	R													6	7	0	0
Xi19	R													0	0	0	0
No. of isolates tested		**67**	**42**	**77**	**63**	**49**	**83**	**32**	**138**	**94**	**97**	**50**	**31**	**36**	**14**	**48**	**39**

* or Parade (believed to carry same resistance)

Table 5. Frequency (%) of pathotypes detected in 2005, with their 2002-04 values. (Pathotype designation based on 'core set' differentials listed in Table 3).

Pathotype (WYV)	2002	2003	2004	2005
1,2,3,4,9,17,CV*	31	14	19	74
1,2,3,9,17,CV*	11	7	15	5
1,2,3,4,6,9,17,CV*	6	7	2	5
1,2,3,6,9,17	6	7	13	3
1,2,3,4,6,7,9,17	3	0	0	3
1,2,3,9,17	6	0	6	5
1,2,3,4,7	0	0	0	3
1,2,3,4,17	3	0	0	3

* also virulent on Oxbow / Robigus

Table 6. Pathotypes of seven isolates collected from inoculated plots

WYV factors	Virulence for additional cvs	No. isolates
1,2,3,4,6,9,17	Madrigal, Einstein	2
1,2,3,6,9,17	Madrigal, Einstein	1
1,2,3,4,6,7,9,17	Madrigal, Einstein	1
1,2,3,4,6,9,17,CV	Robigus, Oxbow, Madrigal	1
1,2,3,4,6,9,17,CV	Madrigal	1
1,2,3,4,9,17,CV	Robigus, Oxbow	1

ADULT PLANT TESTS

Methods

10 isolates (Table 7) were tested on a set of 52 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 7. Isolates tested on adult plant in 2005.

Code	Year	Location	Cultivar	Virulence
96/31	1996	Lincs	Hereward	3,4,6,CV
02/70	2002	Norfolk	Robigus	1,2,9,CV
02/84	2002	Cambs	Imp	3,4,CV
03/7	2003	Lincs	Brock	1,2,3,4,7
03/515	2003	Cambs	Goodwood	1,2,3,4,6,7,9,17,CV
04/32	2004	Cambs	Robigus	1,2,3,4,9,17,CV
04/33	2004	Cambs	Einstein	1,2,3,4,6,9,17
04/37	2004	Cambs	Defender	1,2,3,4,6,9,17,(CV)
04/38	2004	Cambs	Nijinsky	1,2,3,4,9,17,CV
04/44	2004	Cambs	Oxbow	1,2,3,4,9,17,CV

Results

Results of adult plant tests are shown in Tables 8a and 8b.

Table 8a comprises varieties that were susceptible to one or more isolates. Table 8b comprises resistant varieties. The first five isolates on the left hand side of the tables were collected prior to 2004. The five isolates on the right hand side were collected during 2004. Highlighting has been used to indicate increased levels of infection suggesting cultivar x isolate interactions. However, higher than expected infection levels sometimes result from contamination by inoculum from adjacent nurseries. This is particularly evident in the case of highly susceptible varieties such as Talon, Brigadier, Slejpner and Brock.

Results for the pre-2004 isolates largely confirmed their previous performance. 02/70 did however give lower levels of infection on the Robigus group of cultivars than expected from its performance it 2003 tests. The combined virulence of 03/515 for Talon and Hereward (WYR CV) and for WYR 6,9,17 cultivars was confirmed. As previously, this isolate also gave increased infection on Einstein, but not on Oxbow and Robigus.

The first three of the 2004 isolates were of the Robigus-virulent type, and were avirulent on WYR6. 04/37 was different in that it appeared to be virulent on the Robigus group of cultivars and also the WYR6,9,17 group and Einstein (WYR6 +?). This isolate will be re-tested in 2006. 04/33 was a WYV6,9,17 pathotype, virulent on cultivars such as Napier and Access.

The 25 cultivars in Table 8b showed a high level of resistance to all isolates. Slight infection was recorded on eight of these cultivars. With a single exception, this was in nurseries inoculated with isolates collected in 2004. There may be early indications here of pathogen adaptation, but further tests will be required to establish whether apparent cultivar x isolate interactions are repeatable, or merely an inconsistent effect of the high inoculum pressure in this type of test.

Of the new RL cultivars, Hyperion and Mascot appear to fall into the WYR 6,(9),17 group, whilst Alchemy and Gatsby are resistant to all isolates. The highlighted infection values for isolates with corresponding virulence indicate that Mascot is similar to Access and Napier in its degree of susceptibility. Hyperion appears to be somewhat less susceptible.

CONCLUSIONS

Virulence for Robigus was identified in 79% of the isolates tested in 2005. All of these carried WYV9,17,CV, with other virulences.

Combined virulence for Robigus and for WYR6 was provisionally identified in two 2005 isolates. This differs from an isolate collected in 2003 which, although it carried WYV6,9,17,CV, proved not to be virulent on Robigus.. The significance of the potential new pathotype would be its capacity to overcome the resistance of cultivars in both of the two main groups of susceptible cultivars being grown in the UK, thus limiting options for effective diversification.

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Table 8a Adult plant field tests – susceptible varieties. Percentage leaf area infected with yellow rust (mean of 3 assessments)

	Isolate Code	02/70	03/7	96/31	02/84	03/515	04/44	04/38	04/32	04/37	04/33
	Virulence	1,2,9,CV	1,2,3,4,7	3,4,6,CV	3,4,CV	1,2,3,4,6,7,9,17,CV	1,2,3,4,9,17,CV	1,2,3,4,9,17,CV	1,2,3,4,9,17,CV	1,2,3,4,6,9,17,(CV)	1,2,3,4,6,9,17
Cultivar	WYR										
Talon	CV	14.4	13.3	23.0	22.8	31.9	15.5	19.8	16.5	17.4	17.8
Hereward	CV+	0.6	1.1	**7.1**	8.3	17.3	10.1	7.5	9.5	5.6	0.7
Consort	CV+	3.6	0.4	0.0	0.0	2.2	11.8	13.0	11.5	3.4	0.0
Dickson	CV+	7.5	2.2	1.1	3.5	2.0	24.8	21.6	21.9	23.4	0.7
Oxbow	CV+	3.9	5.8	4.4	1.6	5.1	**27.0**	23.8	18.8	19.4	0.0
Robigus	CV+	**9.5**	3.3	2.2	0.4	8.4	25.6	21.0	**17.8**	19.0	0.2
Access	6,9,17	3.1	0.3	0.1	11.0	24.9	7.6	6.3	5.0	20.8	13.3
Ambrosia	6,17	1.1	0.0	0.3	3.2	11.3	4.3	3.8	5.0	20.9	11.6
Hyperion	6,(9),17	0.8	0.0	0.0	1.0	18.5	2.6	2.7	1.1	12.0	14.4
Mascot	6,(9),17	6.3	0.0	0.9	2.9	26.9	11.9	2.9	6.3	28.3	17.0
Napier	6,9,17	0.3	0.4	0.0	8.1	24.3	6.7	4.8	6.9	28.8	15.4
Welford	6,17	0.0	0.0	0.0	0.6	9.6	0.2	0.1	0.2	5.5	2.4
Brigadier	9,17	9.1	15.6	26.4	20.3	32.0	29.4	32.5	27.3	33.1	20.6
Reaper	17	2.6	3.5	9.0	8.5	17.3	24.8	16.1	19.6	20.3	14.8
Savannah	9,17	4.9	0.9	11.3	9.1	16.0	13.1	11.3	12.1	15.8	9.4
Clement	9	10.1	6.1	14.4	9.8	28.8	32.5	30.0	32.9	37.3	26.5
Slejpner	9	8.8	11.1	17.9	8.4	33.5	29.8	28.3	31.5	31.3	21.0
Stetson	1,9	5.7	3.6	8.9	9.5	17.1	28.5	19.0	25.5	17.4	8.9
Einstein	6+?	0.5	0.8	3.9	5.0	14.6	0.2	0.7	1.9	5.8	**2.6**
Hornet	6,9	5.4	5.0	1.1	12.3	26.0	11.8	10.4	11.9	30.4	20.5
Brock	7,14	13.6	**12.1**	14.8	11.8	19.0	8.9	10.9	12.8	4.7	5.4
Cordiale	7	9.9	9.8	8.5	8.9	3.4	2.4	10.5	10.5	3.0	1.6
Thatcher	?7	45.5	48.3	50.8	42.5	29.3	30.0	35.6	27.8	25.6	19.1
M. Huntsman	13	6.3	1.4	10.5	5.1	13.4	14.8	11.0	12.4	13.9	10.0
Hobbit	14	10.0	10.9	10.5	11.4	25.4	19.4	9.0	10.4	23.8	15.8
Glasgow	?0	12.4	13.4	11.0	13.0	14.6	12.5	13.6	13.5	18.5	8.1
Vuka	0	16.3	13.6	16.6	13.3	24.8	20.3	18.0	20.0	18.0	15.8

Highlighting indicates increased infection levels (compared to what? why not highlight compatible combinations of variety and isolate?) , which may point to increased virulence of particular isolates for certain varieties (I don't understand….). It has no statistical significance.
Underlined values indicate the cultivar from which the isolate originated.

Table 8b Adult plant field tests – resistant varieties. Percentage leaf area infected with yellow rust (mean of 3 assessments) if you would like to highlight the risk you could chose to show data from the date with max. disease – instead of mean)

	Isolate code	02/70	03/7	96/31	02/84	03/515	04/44	04/38	04/32	04/37	04/33
	Virulence	1,2,9,CV	1,2,3,4,7,14	3,4,6,CV	3,4,CV	1,2,3,4,6,7,9,17,CV	1,2,3,4,9,17,CV	1,2,3,4,9,17,CV	1,2,3,4,9,17,CV	1,2,3,4,6,9,17,CV	1,2,3,4,6,9,17
Cultivar	WYR										
Alchemy	R	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Asagai	R	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.3	0.3	0.0
Brompton	Rx	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.6	0.0
Cadenza	R	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Claire	Rx	0.0	0.1	0.0	0.1	0.6	0.0	0.1	0.4	0.0	0.0
Deben	Rx	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.5	0.0
Director	R	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.1	0.1	0.0
Gatsby	R	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0
Hurley	Rx	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Istabraq	R	0.0	0.0	0.0	0.0	0.0	1.1	0.1	0.1	0.0	0.0
Kipling	R	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Malacca	R	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Piranha	R	0.0	0.0	0.0	0.0	0.4	0.3	0.0	0.0	0.1	0.0
Smuggler	Rx	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2	1.4	0.0
Tara	R (?7,9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xi19	R	0.0	0.0	0.0	0.0	0.5	0.6	0.1	0.0	0.1	0.0
Zebedee	R	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Buster	R	0.0	0.0	0.0	0.0	0.4	5.4	1.1	2.4	0.2	0.0
Defender	Rx	0.0	0.2	1.0	0.2	4.8	5.0	2.9	2.8	**4.1**	1.9
Dover	R	0.0	0.0	0.0	0.0	0.1	4.0	2.4	6.0	0.3	0.0
Fastnet	R	0.0	0.0	0.0	0.0	0.1	1.3	0.6	2.2	0.9	0.2
Gladiator	Rx	0.0	0.0	0.0	0.0	0.6	0.0	1.2	1.8	2.2	0.0
Nijinsky	R	0.0	0.0	0.0	0.0	0.0	0.5	**0.5**	2.3	0.1	0.0
Richmond	Rx	0.0	0.0	0.0	0.0	0.2	3.2	1.3	4.8	0.2	0.0
Solstice	R	0.0	0.0	0.0	0.0	0.2	0.8	0.0	0.0	2.5	0.0
universally susceptible											
Glasgow	?0	12.4	13.4	11.0	13.0	14.6	12.5	13.6	13.5	18.5	8.1
Vuka	0	16.3	13.6	16.6	13.3	24.8	20.3	18.0	20.0	18.0	15.8

Highlighting indicates increased infection levels which may point to increased virulence of particular isolates for certain varieties. It has no statistical significance.
Underlined values indicate the cultivar from which the isolate originated.

YELLOW RUST OF BARLEY

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INTRODUCTION

Yellow rust of barley was uncommon in 2005. Background levels of this disease remain low throughout England and Wales.

METHODS

Seven samples of barley yellow rust were received in 2005. Only one isolate was successfully cultured and tested. All samples came from Scotland.

The source cultivars from which the isolates originated are shown in Table 1. The majority of samples came from winter barley volunteers, No samples were received from commercial barley cultivars.

Table 1. Cultivars from which samples of barley yellow rust were collected in 2005.

Source cultivar	Number of samples received	Number of samples cultured	tested
Unknown	1	1	1
Volunteers	5	0	0
Breeding lines	1	0	0
TOTAL	**7**	**1**	**1**

Table 2 lists the standard differential cultivars and additional cultivars that were used in the 2005 seedling virulence tests.

Table 2. Differential cultivars used to test isolates of barley yellow rust in 2005.

Cultivar	BYR factor
Astrix	BYR 1
Atem	BYR 1
Bigo	BYR 2
Varunda	BYR 2
Mazurka	BYR 2
Triumph	BYR 3
Additional cultivars	
Gleam	Rx
Pearl	Rx
Fanfare	Rx
Manitou	Rx
Derkado	R
Parasol	R
Optic	Rx or R

Rx = interacts with isolates, but specific resistance not identifiable as BYR1, BYR2 or BYR3.

RESULTS

Table 3 shows the virulence frequencies for 1987-2005 (no samples were received in 1996, 1997 or 1998). These figures should be viewed with caution due to the low incidence of the disease and small number of samples sent in for testing.

The only isolate tested in 2005 carried virulence for BYV 1,3 and was also virulent on the additional cultivars Gleam, Pearl and Fanfare.

Table 3. Percentage frequency of barley yellow rust virulence factors for 1987 -2005.

		'87	'89	'90	'91	'92	'93	'94	'95	'99	'00	'01	'02	'03	'04	'05
BYV1		100	100	100	100	100	100	100	100	100	86	100	100	92	100	100
BYV2		100	100	0	100	100	100	100	100	100	71	0	0	23	0	0
BYV3		22	75	0	0	0	0	100	0	100	71	0	50	38	0	100
Gleam	Rx												38	100	100	100
Pearl	Rx												33	15	33	100
Fanfare	Rx												38	77	0	100
Manitou	Rx												50	15	100	0
Optic	Rx												13	31	0	0
Derkado	R												0	0	0	0
Parasol	R												-	-	-	0
No. of Isolates tested		9	4	1	1	2	1	1	3	1	7	3	8	13	3	1

CONCLUSIONS

Yellow rust of barley was rare in 2005, levels of the disease are clearly very low but it should be noted that for the past two years all isolates received have originated from Scotland. Scotland may have more favourable conditions for barley yellow rust and this situation must continue to be monitored.

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BROWN RUST OF WHEAT

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In 2005, the previously resistant cv. Glasgow was infected at very high levels in some fields. Several other cvs including Claire, Alchemy and Zebedee also showed high than expected levels of wheat brown rust in some fields, particularly in east and south-east England. This may be linked to the high temperatures experienced in some regions during late May and June: several cvs have temperature-sensitive resistances which are less effective at high temperature. However, temperature-controlled adult plant and seedling tests using isolates originating from some of these cvs, suggest the evolution of increased pathogen virulence to cv. Claire and derivative cvs, to cv. Glasgow and possibly to other cvs. These observations require further confirmatory studies including field trials. There also appears to be increased virulence to Thatcher isolines carrying genes Lr13 and Lr37 which are thought to be among the most commonly deployed in UK cvs. The complex virulence combination WBV-1,2,3,4,7 was identified for the first time. Also for the first time, resistance conferred by gene Lr1 was overcome. Similarities in the responses of the Thatcher Lr1 line and cv. Glasgow suggest that cv. Glasgow may carry Lr1. Of potential new cvs in HGCA Recommended List Trials, only Oakley and Timber were seedling resistant to most isolates but even these showed some susceptibility at 25^{o}C. The apparent evolution of new virulences seen in 2005 isolates indicates the need for vigilance in monitoring wheat brown rust if environmental change increases occurrence of conditions that impair temperature-sensitive resistances and favour the disease.

INTRODUCTION

Brown rust was at higher levels on the winter crop than in recent years. During June, high temperatures, conducive to development of the disease in some cvs, saw rust develop rapidly in some crops (Crop Monitor, Winter Wheat Survey, 2005). Seventy-eight samples, the highest number since 1993, were received from a range of winter wheat cvs (Table1), the majority of which were collected at trial sites in the east of England (Table2).

Several samples were from cvs which had resistant disease ratings e.g. Claire [8], Alchemy [9] and Glasgow [8]. Some of these samples, all from trial sites in the east or south east of England, came from cvs that showed much higher levels of disease than expected (Table3). However, in other cases from the same regions and from other areas of the UK, these cvs did not appear to show increased susceptibility. It therefore appears that increased virulence may be starting to evolve towards cv. Claire and its descendents (cvs Zebedee and Alchemy), and to cvs Glasgow and Ambrosia, although the relevant virulence(s) is not yet universally present in the fungal population. The currently

recommended cvs Claire, Alchemy, Ambrosia and Glasgow occupied around 15% of the UK winter wheat hectarage in 2005(NIAB,2005).

Table 1 Source winter wheat cultivars of 2005 brown rust samples

Cv. *[1-9 rating]	No. of samples	Cv. [1-9 rating]	No. of samples	Cv. [1-9 rating]	No. of samples
Claire [6]	13	Zebedee [4]	2	Einstein [6]	1
Consort [3]	9	Deben [4]	2	Malacca [7]	1
Glasgow[7]	6	Ambrosia [8]	2	Richmond[9]	1
Alchemy[5]	5	Gladiator [8]	2	Marvel	1
Solstice [5]	4	Cordiale [4]	2	Dover [9]	1
Br.lines	4	Hereward [6]	2	Fastnet [8]	1
Nijinsky[6]	3	Victo	1	Hyperion [9]	1
Istabraq[5]	3	Goodwill	1	Defender [8]	1
Vuka	3	Director [8]	1	Access [8]	1
Dickson	2	Mascot [6]	1	Riband [3]	1

*HGCA Recommended List for 2006/2007

Table 2 Geographic origins of 2005 brown rust samples

County/region of origin	No. of samples	County/region of origin	No. of samples	County/region of origin	No. of samples
Cambs	20	Kent	6	Glos.	2
Norfolk	15	Suffolk	4	Warks	2
Lincs	11	Shrops	4	Essex	1
Yorks	9	E.Midlands	3	S.East	1

Table 3 Origins of 2005 samples from cultivars showing higher than expected levels of disease.

Cv. *[1-9rating]	% infection	County of origin	Cv. [1-9rating]	% infection	County of origin
Zebedee [8]	25	Norfolk	Alchemy [9]	25	Cambs
Alchemy [9]	10	Norfolk	Glasgow [8]	25	Cambs
Glasgow [8]	High	Lincs	Ambrosia [8]	10	Cambs
Claire [8]	High	Lincs	Claire [8]	15	Cambs
Claire [8]	15	Kent	Claire [8]	12	Suffolk
Glasgow [8]	80	Kent	Glasgow [8]	80	Lincs
Zebedee [8]	20	Cambs			

*HGCA Recommended List for 2005/2006

VIRULENCE FREQUENCIES AS DETERMINED BY GLASSHOUSE SEEDLING TESTS WITH YEAR 2005 ISOLATES

Methods

Isolates of *Puccinia triticina* were cultured from 32 of the samples and tested on three sets of wheat lines: 1) differential cvs which comprise the standard WBR cvs (Table 4); 2) the core set of 'Thatcher' Near Isogenic Lines (NILs) carrying different Lr resistance factors (Table 5); 3) potential new, currently recommended and outmoded winter and spring wheat cvs (Table 6).

Table 4 * Standard WBR cvs used in tests with 2005 isolates

Cultivar	WBR-factor	Lr gene
Clement	1	26
Fundin	2	17b
Sappo	3	20
Halberd	4	20
Sterna	7	3a

*The differential cvs Huntsman (WBR-5, Lr13), Gamin (WBR-6), Ranger (WBR-8) and Avalon (WBR-9) were not included as their resistances are of the adult plant type.

Table 5 Differential set of 'Thatcher' near isogenic lines used to identify leaf rust virulence

Lr gene	Pedigree
1	Tc6/Centenario
2a	Tc6/Webster
2b	Tc6/Carina
2c	Tc6/Loros
3	Tc6/Democrat
9	Transfer/Tc6
11	Tc6/Hussar
15	Tc5/Kenya W1483
17	Klein Lucero/Tc6
19	Tc7/T4
21	Tc6/R.L.54'06
23	Lee 310/Tc6
24	Tc6/Agent
26	Tc6/ST-1.25
28	Tc6/C77.1
Tc	Thatcher

Table 6 Recommended, outmoded and potential new winter wheat cvs included in tests with isolates from the 2005 survey

Hurley	Piranah	Humber
Dover	Claire	Gulliver
Alchemy	Glasgow	Oakley
Hyperion	Sahara	Contender
Zebedee	Timber	Benedict
Fastnet	Battalion	Ochre

Plants were grown in a spore-proofed glasshouse and, following inoculation, were placed in dew simulation chambers at 15°C for 24 h in the dark. They were then transferred to one of two post-inoculation environments, namely a low temperature regime (10°C and 12 h photoperiod) or a high temperature regime (25°C and 16 h photoperiod).
Isolate:cv. interactions were classified on the standard 0-4 scale as resistant (R: 0-2) or susceptible (S: 3-4). In cvs with temperature-sensitive resistance factors, interactions were classified as susceptible only if that reaction was expressed at both temperatures. Some of the cvs/lines expressed a mixture of resistant and susceptible infection types to the isolates making classification as susceptible or resistant difficult.

Results

Virulence was identified to all of the standard differential cvs (Table 7) and the susceptible check cv. Armada (WBV-0)

Table 7 Virulence frequencies corresponding to WBR factors present in differential cvs 1995-2005

Cv.	WBR factor	Frequency†							
		1995	1998	1999	2000	2001	2002	2003	2005
Clement	1	0.55	0.43	0.27	0.82	1.00	0.84	0.73	0.69
Fundin*	2	0.67	0.75	0.32	0.60	0.94	0.56	0.73	1.00
Sappo*	3	0	0	0	0.08	0	0	0	0.13
Halberd*	4	0	0	0	0.04	0	0	0	0.13
Sterna*	7	0.11	0.07	0.07	0.61	0.65	0.50	0.68	0.56
Armada	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Number of isolates tested		18	43	22	23	17	14	22	32

†Isolate numbers tested in 1996, 1997 and 2004 were small and these data are excluded.
*Temperature-sensitive resistance

WBV-1 has shown a gradual decline in frequency since 2001 and this is probably associated with the reduced area sown to winter wheat cvs carrying the matching resistance factor WBR-1(Lr26). It is estimated that Lr26 cvs occupied around 11% of the hectarage in 2005(NIAB, 2005) compared to more than 20% in 2003(NIAB, 2003). Despite this WBV-1 remains at a fairly high level in the population. Virulence to cv. Fundin (WBR-2), which carries gene Lr17b, was carried by all the isolates. This increase

in frequency of WBV-2 is difficult to explain as although the temperature-sensitive resistance, WBR-2, was deployed in several commercially grown cvs in the early 1980s, more recently only cv. Riband, whose popularity is in decline, is thought to carry Lr17b where it is combined with Lr13 (Singh *et al.*, 2001). Virulence to cvs Sappo (WBR-3) and Maris Halberd (WBR-4), identified only occasionally over the previous decade, were carried by 4 isolates. Both cvs carry gene Lr20 whose resistance is less effective against some isolates at higher temperatures. The frequency of WBV-7 remains stable. It was identified at increased levels in 2000, when a relatively high hectarage of the spring wheat crop was sown to cvs Chablis and Shiraz which carry the correponding resistance, WBR-7 (Lr3). Prior to 1998, WBV-7 was identified only occasionally.

The virulence factors were combined in 6 different WBV-groups.(Table 8).

WBV-1, WBV-2 and WBV-7 were combined in 44% of the isolates thus making WBV-1,2,7 the dominant form. The high frequency of WBV-1,2,7 isolates since 2000 is associated with the increased frequency of WBV-7 (Table 7). The four isolates identified as carrying WBV-3 and WBV-4 also carried virulence to the all other differential cvs. This is the first time that the complex virulence combination, WBV-1,2,3,4,7, has been identified. Isolates carrying this virulence combination were cultured from samples of cvs Claire, Zebedee, Glasgow and Ambrosia all of which showed higher than expected levels of disease (Table3) in some areas: three of the samples were from the same trial site in Cambridge. This supports the view that evolution of complex virulence capable of overcoming the resistance of certain cvs is underway.

Table 8 Virulence combinations and their frequencies identified from 2005 isolates and previous years

WBV formula	Frequency†							
	1995	1998	1999	2000	2001	2002	2003	2005
0	0.22	0.18	0.50	0.18	0	0.14	0.14	0
1	0.11	0.05	0.18	0.09	0.06	0.22	0	0
2	0.22	0.37	0.23	0	0	0	0.09	0.32
7	0	0.02	0	0	0	0	0.05	0
1,2	0.34	0.33	0.09	0.04	0.29	0.14	0.09	0.12
1,7	0	0	0	0.09	0	0.07	0.09	0
1,2,7	0.11	0.05	0	0.52	0.65	0.43	0.54	0.44
1,3,4	0	0	0	0.04	0	0	0	0
1,2,3,4	0	0	0	0.04	0	0	0	0
1,2,3,4,7	0	0	0	0	0	0	0	0.12
Number of isolates tested	18	43	22	23	17	14	22	32

†Isolate numbers tested in 1996, 1997 and 2004 were small and these data are excluded

Virulence frequencies in the 2005 isolates corresponding to each Thatcher-Lr backcross line are given in Table9 where they are compared against the previous years.

Table 9 Virulence frequencies corresponding to each Thatcher-Lr backcross line for years 1998-2005†

Thatcher Line (Lr gene)	Frequency						
	1998	1999	2000	2001	2002	2003	2005
1	0	0	0	0	0	0	0.28
2a	0	0	0	0	0	0	0
2b	0.17	0.22	0	0.47	0	0	0.09
2c	0.52	0.26	0.04	0.53	0	0.23	0.72
3	0.07	0	0.29	0.65	0.29	0.50	0.56
9	0	0	0	0	0	0	0
11	0.96	0.49	0.61	0.53	0.29	1.00	0.78
15	0.04	0	0.08	0.47	0.29	0.50	0.75
17	0.04	0	0.08	0.53	0.22	0.55	0.72
19	0	0	0	0	0	0	0
21	0.02	0	0	0.53	0	0.77	0.47
23	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0
26	0.43	0.32	0.83	1.00	0.73	0.73	0.69
28	0.07	0	0	0.53	0.56	0.73	-
Tc	-	-	-	1.00	1.00	1.00	1.00
Number of isolates	43	22	23	17	14	22	32

†Only 2 isolates were tested in 2004 and these data are excluded

Incubation temperature differentially affected the expression of resistance in some, but not all of the Thatcher lines. Lines carrying Lr9, Lr19 and Lr24 were resistant at to all isolates at both temperatures although Lr24 has been susceptible to some isolates at 10°C in previous years' tests. Line Lr23 was also resistant to all the isolates at 25°C but susceptible at 10°C. The resistance of the Thatcher line Lr2a, effective at 25°C, was overcome by 3 isolates at the lower temperature.

Several lines were infected more frequently than previously. Virulence to Lr15 and Lr17 first increased in frequency in 2003 and showed a further increase in 2005. Line Lr2c, whose resistance is more effective at low temperatures (and virulence to which has fluctuated between years) was susceptible to 72% of the 2005 isolates. In the past, line Lr1 has been resistant to all isolates but in the current tests it was clearly susceptible to 28% of the 2005 isolates. However, this line also showed a type 3 (susceptible) response to some of the other isolates but since few pustules developed these cases were classified as resistant. These data therefore offer further warning of evolving virulence in the fungal population.

Of the additional cvs (Table6) included in tests, the majority were susceptible. Cvs Alchemy, Zebedee, Piranah and Claire, which showed surprisingly high susceptibility at some trial sites in 2005, were susceptible to all isolates. Previous tests showed the resistances of Alchemy and Piranah was more clearly expressed at low temperature and at later growth stages, and while in 2005 infection at 10°C gave a mixed reaction type to some isolates, the susceptible type dominated. Cv. Hyperion was also classified as susceptible but like Alchemy and Piranah it also gave a mixed reaction to some isolates. The resistance of cv. Fastnet was effective only against those isolates lacking virulence to gene Lr26 (present in differential cv. Clement; WBR-1). The temperature-sensitive resistances of cvs Dover and Hurley were effective against some, but not all isolates at 10°C, and cv. Hurley also expressed resistance to some isolates at 25°C.

Test data supported field observations (Table 3) indicating increased virulence to cv. Glasgow that has been previously been classified as resistant. It was susceptible to four of the 2005 isolates which also overcame Thatcher line Lr1 that had previously been fully resistant. Three of these isolates originated from samples of cv. Glasgow. When inoculated with any other isolate, cv. Glasgow was mainly resistant but it showed a very low frequency of infection 3-4 type pustules (susceptible). This is similar to the reaction shown by Thatcher line Lr1 to some isolates. These data suggest that cv. Glasgow may carry gene Lr1 but further test are required for confirmation.
Of the potential new cvs Ochre, Benedict, Contender, Gulliver, Humber and Sahara were susceptible to all isolates. Cvs Oakley and Timber were resistant to most isolates but their resistance(s) was overcome by the same 2 isolates at 25^{o}C. Cv. Battalion has a temperature-sensitive resistance which was ineffective at 25^{o}C but was effective against some isolates at 10^{o}C.

FURTHER TESTS ON TEMPERATURE SENSITIVITY

Methods

Winter and spring wheat cvs which have previously shown high levels of brown rust resistance were grown in a spore-proofed glasshouse until full emergence of the flag leaf. Also included were the differential cvs Avalon(WBR-9) and Gamin(WBR-6), the cv. Thatcher backcross lines carrying the known specific genes Lr10, Lr13, Lr26 and Lr37 (which are thought to be the most commonly deployed Lr genes in UK wheat cvs) and cv. Thatcher (as a susceptible check). Two replicates of each cv. were inoculated with one each of the isolates:

WBRS-05-14 (WBV- 1,2,7)	ex. cv.Zebedee, Norfolk
WBRS-05-35 (WBV- 1,2,3,4,7)	ex. cv.Claire, Kent
WBRS-05-45 (WBV- 2)	ex. cv.Alchemy, Cambridge
WBRS-05-78 (WBV- 2)	ex. cv.Glasgow, Lincoln.

The isolates were cultured from field samples collected from previously resistant cvs showing higher than expected disease levels (Table3). Post-inoculation plants were incubated at low (10^{o}C) or high (25^{o}C) temperatures as described previously (Jones and Clifford, 1997). Adult plants were assessed on percentage flag leaf area infected and reaction type classified on the standard 0-4 scale as resistant (R: 0-2) or susceptible (S: 3-4).

Results (Table 10)

Group 1: These cvs, whose resistance(s) is more effective at low temperature, have previously shown high levels of field resistance. Cv. Claire has, however been infected at levels of up to 15% by an isolate in controlled environment tests in 2003.
Cv. Claire and its derivative cvs Alchemy, Zebedee and Piranah were infected at much higher levels than seen previously by isolates WBRS-05-14, WBRS-05-35 and WBRS-05-45 which were cultured from highly infected cvs carrying the same resistance(s). They were also heavily infected by isolate WBRS-05-78 originating from cv. Glasgow

which is not thought to carry the came resistance, although they gave a more mixed reaction type to this isolate at 10 °C. Cvs Richmond and Xi19 showed a similar pattern of responses to the isolates. The high levels of disease, particularly at 10°C, again suggests evolution of increased virulence to these cvs in the fungal population. This needs to be confirmed in field nurseries as increased virulence in controlled environment tests is not always repeated under field conditions where fluctuations in temperature may affect host:pathogen interactions.

As a consequence of the high levels of disease seen on Group1 cvs, the disease resistance rating of some has been reduced on the HGCA Winter Wheat Recommended List for 2006/7. Cv Claire has a revised rating of 6, Alchemy 5 and Zebedee 4. The ratings of cvs Richmond [9] and Xi19 [8], which apparently maintained their field resistance in 2005, are unchanged. However, their current test responses suggest that they may be at risk of increased infection and they should be watched carefully in the 2006 season.

Group 2: Cv. Glasgow, which showed increased field susceptibility in 2005, was heavily diseased by isolates WBRS-05-35 and WBRS-05-78. The latter originated from a plot of cv. Glasgow showing disease levels of up to 80% and was one of four samples received from plots showing much higher than expected levels of infection (Table3). The current tests support the view that virulence to cv. Glasgow has arisen, although, again its potential susceptibility needs to be confirmed in the field. Cv. Hyperion was also susceptible to the same isolates although its reaction type was mixed at 10°C. Although its disease rating of 9 is maintained in the 2006/07 recommended list because there were no reports of increased field susceptibility in 2005, the test evidence suggests it may be vulnerable to some pathotypes.

Group 3: Seedling tests indicate cv. Fastnet carries WBR-1 (Lr26) and the current test showed that it was resistant only to isolate WBRS-05-78, the only one lacking matching virulence (WBV-1). It was susceptible to all other isolates at 25°C but at 10°C it expressed a mixed reaction. In past tests, other WBR-1 cvs have expressed additional adult plant resistance although these are not generally temperature-sensitive. Cv. Dover showed a similar pattern of responses to the test isolates but there is no evidence to suggest that it carries WBR-1.

Group 4: Cv. Hurley and the spring wheat cv. Belvoir were resistant at 10°C and susceptible at 25°C to three of the isolates. To the other, WBRS-05-35, they differed only in that cv. Belvoir showed a mainly resistant infection type at 10°C while cv. Hurley expressed a mainly resistant reaction at 25°C. The temperature-sensitive resistances of these cvs remain effective.

Group 5: The highly resistant cvs Robigus and Tybalt, whose resistances are also effective as seedlings, showed no visible signs of infection.

Group 6: This group comprises standard WBR differential cvs whose resistances are of the adult plant type and Thatcher lines carrying different Lr genes. Cvs Avalon (WBR-9) and Gamin (WBR-6) were fully susceptible to the isolates as were Thatcher lines Lr10 and Lr13. This latter observation suggests increased virulence Lr13 in the 2005 population since in past tests Lr13 has previously expressed a mainly resistant reaction to a range of isolates at 25 °C. Currently, neither Lr13 nor Lr10 offer protection in the field when deployed singly. Thatcher line Lr26 was resistant to isolate WBRS-05-78 but unlike cv. Fastnet (Group3), which carries this gene, it was susceptible at both temperatures to other isolates. Cvs carrying Lr37 have previously shown good field resistance. They have also generally shown good levels of resistance at 10°C in controlled environment tests as has the Thatcher line Lr37. Only 1 isolate, WBRS-01-04, gave a mainly susceptible response on line Lr37 at 10°C although infection was less than

at 25°C. Additionally, compared to previous tests with other isolates, in 2005 line Lr37 showed higher levels of susceptible reaction type to isolates WBRS-05-35 and WBRS-05-78 at 10°C. This again suggests the possibility of evolution to virulence that requires confirmation in the field.
Group 7: The susceptible check, cv. Thatcher, was susceptible.

ADULT PLANT TESTS IN FIELD ISOLATION NURSERIES

Methods

Winter and spring wheat cvs, including those on the HGCA Recommended Lists, potential new cvs, outmoded cvs, the standard differential cvs and cv. Thatcher lines carrying different Lr resistance genes, were sown in each of two nurseries. The nurseries were inoculated with one of two isolates differing in their virulence according to seedling tests. Isolate WBRS-03-11 (WBV-1,7) was cultured from a sample of cv. Claire. In 2003 controlled environment tests, this isolate gave high level flag leaf infection in cv. Claire. However this result was not confirmed in 2004 field nurseries where contamination by endemic pathotypes was suspected. The other isolate, WBRS-01-04 (WBV-1,2,7) originated from cv. Buchan, in 2001 seedling tests it infected a number of previously resistant cvs (Jones, 2002) and in 2002 adult plant tests in the field and in controlled environments it gave relatively high infection in the previously resistant cvs Access and Buchan (carrying gene Lr37).
Tables 11 and 12 show, where identified, the WBR factors, the Lr genes, and the resistance type of the cvs tested. With the exception of the standard differential cvs, postulation of the Lr genes is based on:

1) host : pathogen interactions in seedling and adult plant tests at IGER
2) association with stripe rust resistance (WYR) factors (Bayles *et al.,* 2004).
3) seedling and adult plant tests at the Plant Breeding Institute, Cobbitty, Australia (Singh, Park and McIntosh, 2001)

Plants were assessed throughout the season on percentage leaf area infected (Tables 11 and 12). Note was also made of reaction type classified on the standard 0-4 scale as resistant (R: 0-2) or susceptible (S: 3-4).

Results

Winter wheats (Table 11): High levels of brown rust built up on the spreader cv. Arina which was infected at similar levels by both isolates. However, as in 2004, the majority of the cvs, developed little if any disease.
Isolate WBRS-03-11 gave relatively high levels of infection on the differential cvs Fundin (WBR-2) and Huntsman (WBR-5) but the remainder of the cvs were, as in 2004, either resistant to or infected at very low levels. They included the seedling differential cv. Clement (WBR-1), to which the isolate was previously identified as carrying matching virulence, and the highly resistant cv. Claire which it infected in previous adult plant controlled environment tests.
Isolate WBRS-01-04 carried virulence compatible with the resistances of the differential cvs Clement (WBR-1), Fundin (WBR-2), and Avalon (WBR-9). Cv.Gamin (WBR-6),

which was susceptible to the isolate in a 2003 field nursery, was infected at only a low level. Although seedling tests identified WBRS-01-04 as carrying WBV-7, the adult plant resistance of cv. Sterna was effective although its seedling resistance gene (WBR-7) was matched by virulence of the isolate (WBV-7).
Several cvs were more heavily infected by isolate WBRS-01-04 than WBRS-02-011. They included the WBR-1 (Lr26) cvs Tanker, Kipling and Brompton which showed moderate levels of a susceptible infection type. Also relatively susceptible were cvs Consort and Riband which carry Lr13 in combination with other, different Lr genes. Other cvs, e.g. Director, Ambrosia and Defender, postulated as carrying Lr26, but which are thought to carry additional genetic factors conferring adult plant resistance, expressed a more resistant reaction.

Spring Wheats (Table 12): Susceptible cvs within the nursery inoculated with WBRS-01-04 showed high levels of brown rust. However little disease developed within the nursery infected with WBRS-03-11 where the susceptible check cv. Thatcher showed just 2% infection. For this reason data from this nursery are omitted.
Except for cv. Chablis, all the commercial cvs exposed to WBRS-01-04 were resistant or infected at low levels. Although previous tests have indicated that cv. Chablis carries adult plant resistance additional to the WBR-7 gene for seedling resistance, this adult plant resistance was ineffective against the isolate. The majority of the Thatcher lines were heavily diseased. They included those carrying genes Lr3, Lr10, Lr13, and Lr 26 which, together with Lr37, are thought to be the most commonly deployed in UK cvs. However, line Lr37, which has previously shown good levels of field resistance, was again only infected at low levels. Lines Lr1, Lr20 and Lr23 also showed little infection. Line Lr1 has previously shown resistance to this and all other isolates in seedling tests. However, as mentioned previously, Lr1 was seedling susceptible to some 2005 isolates, some of which also infected the previously resistant cv. Glasgow as a seedling and adult in 2005 controlled environment tests. Line Lr20 showed infection levels similar to that of the differential cv. Sappo (WBR-3) which carries this gene. Resistance conferred by Lr20 is temperature-sensitive and was overcome by WBRS-01-04 at 25^{o}C in seedling tests. Line Lr23 has a high temperature resistance which was effective against the isolate in seedling tests and in the 2005 field nursery. As in previous years' tests with different isolates of the pathogen, the Thatcher-backcross lines Lr9, Lr17, Lr19 and Lr24 were resistant. Lr17 did, however, show relatively high levels of a mixed, mainly resistant infection type whereas the other lines showed no visible signs of infection.

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Table 10 Percentage flag leaf affected and †reaction types of adult plants of winter and spring wheats to specific isolates of leaf rust at 10°C and 25°C

		ISOLATE							
Cv *[RL rating]	Group	WBRS-05-14 •(WBV-1,2,7)		WBRS-05-35 (WBV-1,2,3,4,7)		WBRS-05-45 (WBV-1-2)		WBRS-05-78 (WBV-2)	
		10	25	10	25	10	25	10	25
Claire [8]	1	20	30	40	35	25MS	35	30MS	25
Alchemy[9]		20	30	50	50	40	35	30MS	35
Zebedee [8]		30	30	30	25	40	35	35MR	40
Piranah [8]		20	25	30	25	30	40	40	40
Richmond [9]		20	40	40	35	30	35	30MS	45
Xi19 [8]		15MS	30	25	25	40	40	15MS	45
Glasgow [8]	2	3	3	40	40	3	20	50	50
Hyperion [9]		25MR	25MR	40MS	40	25MR	25MR	25MS	25
Fastnet [9]	3	10MS	25	40MR	35	25MR	35	1	3
Dover [9]		30MS	25	40	50	25MS	25MS	1	1
Hurley [8]	4	0	25MS	0	20MR	0	20MS	0	10MS
Belvoir [8]		1	30	35MR	40	1	40	1	30
Robigus [9]	5	0	0	0	0	0	0	0	0
Tybalt [9]		0	0	0	0	0	0	0	0
Avalon	6	40	40	40	40	40	35	25	30
Gamin		15	25	35	45	25	25	20	20
Lr10		40	40	45	40	50	45	35	40
Lr13		40	35	40	35	45	40	40	35
Lr26		25	25	45	35	35	40	3	4
Lr37		35R	35	45MS	45	40MR	40	40MS	50
Thatcher	7	40	35	35	35	30	35	30	30

Mean of 2 replicates
†reaction types assessed on a 0-4 scale. Resistant (R:0-2); Susceptible (S: 3-4)
All reaction types susceptible unless stated
When more than one reaction type is expressed by a single cv,
classification is based on the prevalent response
MS = mixed susceptible; MR = mixed resistant
•virulence factors identified in seedling tests
*HGCA Recommended List for 2005/2006

Table 11 †Reaction of winter wheat cvs to specific isolates of *Puccinia triticina* in field isolation nurseries in 2005

				ISOLATE	
Cultivar [1-9]	WBR	Postulated Lr genes	•Resistance type	WBRS-03-11 (WBV-1,2)	WBRS-01-04 (WBV-1,2,7)
Clement	1	26	OR	Trace	9
Fundin	2	17b	OR*	12	14
Huntsman	5	13	APR	17	18
Gamin	6		APR	0	2
Sterna	7	3a+	OR*+ APR	0	3
Ranger	8		APR	0	0
Avalon	9		APR	1	16
Arina	0	13?		21	16
Claire [6]			APR*	0	0
Alchemy [5]			APR	0	0
Zebedee [4]			APR	0	0
Piranah			APR	Trace	0
Hyperion [9]			APR	0	Trace
Glasgow [7]			OR	0	0
Richmond [9]			OR*	0	0
Xil9 [8]			OR	0	1
Malacca [7]		10,13(37?)		0	0
Wizard [8]			OR*	0	0
Robigus [9]			OR	0	0
Nijinsky [6]				0	Trace
Istabraq [5]				0	0
Hurley				0	0
Hereward [6]		10,13		0	0.1
Deben [4]			OR*	Trace	0.7
Option [5]			OR*	1	0.1
Smuggler			*	0.2	0.3
Einstein [6]		(10)		0.2	0.3
Dover [9]				0.2	0.1
Solstice			APR?	0.5	0.1
Dickson			*	0.3	0.8
Cordiale [4]			OR	Trace	10
Riband		13,17b		Trace	7
Soissons [4]		14a	OR	2	22
Tanker		26+	OR	0	13
Kipling		26	OR	0	16
Brompton [8]		26	OR	0	7
Fastnet [8]		26+	OR	0	0
Gladiator		26+	OR	0	13MR
Director [8]		26+	OR	0	6MR
Ambrosia [8]		26+	OR	0	6MR
Gatsby [8]		26+	OR	0	7I
Asagai		26+	OR	Trace	5MR
Welford [7]		26 (10,37)		0	9
Napier [8]		(10,26,37)	APR	0	12MR
Access [8]		(10,26.37)		0	11MR
Savannah		(26,37)		0	4MS
Defender[8]			OR	2MR	4MR
Consort [3]		10,13		0	10MS
Mascot [6]				6MR	9

†Mean of 3 replicates, 2 assessment dates. All reaction type susceptible unless stated
MR = mixed resistant; MS = mixed susceptible; I = intermediate
APR = adults plant resistance; OR = overall resistance; * temperature sensitive resistance
( ) postulated Lr genes based on links to resistances for stripe rust
[1-9] rating: 1 = susceptible; 9 = resistant (HGCA Recommended List for 2006/2007)

Table 12 †Reaction of spring wheat cvs and Thatcher Lr backcross lines to specific isolates of *Puccinia triticinia* in field isolation nurseries in 2005

					ISOLATE
Cultivar [1-9 rating]	Group	WBR-	Postulated Lr genes	▪Resistance type	WBRS-01-04 (WBV-1,2,7)
Sappo	1	3	20	OR*	7
Halberd		4	20	OR*	1
Belvoir [8]	2			OR*	0
Paragon [9]				OR*	0
Tybalt [9]				OR	0
CPBT W111					4
Morph [8]				*	2
Ashby [9]				OR*	2 MR
Chablis [7]			3a+	OR*+APR	18 MS
Lr1	3				5
Lr2a					18
Lr2b					22
Lr2c					40
Lr3					50
Lr3bg					55
Lr3ka					45
Lr9					0
Lr10					48
Lr11					48
Lr13					25
Lr15					50
Lr17					25 MR
Lr19					0
Lr20					8
Lr21					38
Lr23					3 MS
Lr24					0
Lr26					37
Lr28					52
Lr37					5 MS
Thatcher					50

†Mean of 3 replicates, 2 assessment dates. All reaction types susceptible unless stated.
MR = mixed resistant; MS = mixed susceptible
APR = adult plant resistance; OR = overall resistance; * temperature sensitive resistance.
[1-9] rating: 1= susceptible; 9 = resistant. (HGCA Recommended List for 2006/2007)

BROWN RUST OF BARLEY

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As in recent years pathotypes were relatively complex carrying between 7 and 9 virulence factors. 'Simpler' pathotypes, such as those classified as race octal 273, and dominant in the late 1990s, have declined due, in part, to the increased frequency of BBV-10 in recent years. Several of the current HGCA recommended spring barleys, including the 'popular' cv. Optic carry the matching resistance factor. The only other widely deployed major gene resistance in current spring barleys is Rph3 (BBR-3) but where this is combined with additional, partial adult plant resistance it remains effective. None of the current winter barleys appear to have race-specific resistance but carry partial resistance which in some cvs offers good levels of protection. Cultivar Amarena, which has a resistant disease rating (8), and is resistant in field nurseries, is highly susceptible to a range of pathotypes in glasshouse tests.

INTRODUCTION

Brown rust levels in the winter crop were low (Crop Monitor: Winter Barley Survey, provisional data, 2005) and similar to those in 2004. The samples were collected from a range of 38 winter and 4 spring barley cvs (Table1). Twenty samples came from a trial site at Headley Hall, Yorks with the remainder coming from Norfolk (9), Lincs (4), Notts (4), Suffolk (2), Kent (2) and Ceredigion (1).

Table 1 Source cvs of 2005 brown rust samples

Barley cv. *[1-9 rating]	No. of samples	Barley cv. [1-9 rating]	No. of samples	Barley cv. [1-9 rating]	No. of samples
Winter cvs					
Colossus [3]	5	Celebrity	1	Colibri [7]	1
Camion [5]	5	Surtees	1	Pict [7]	1
Saffron [7]	5	Monalisa	1	Unknown	4
Flagon [7]	4	Dolphin	1	**Spring cvs**	
Pearl [7]	2	Boost [4]	1	Midas	1
Sequel [5]	1	Fanfare [7]	1	Cellar [7]	1
Spectrum [5]	1	Regina	1	Chalice [4]	1
Cannock[5]	1	Cypress	1	Riviera [5]	1

*HGCA Recommended List for 2006/07

SEEDLING TESTS WITH 2005 ISOLATES

Methods

Isolates cultured from 26 samples were tested on the standard set of 10 differential cvs which carry different, identified Rph genes for resistance to brown rust (Table 2).

Table 2 Barley genotypes used to identify virulence factors in *Puccinia hordei* and their rankings for octal notation.

	BBR Factor	Gene (Rph)	Ranking for octal notation
Sudan	1	1	1
Peruvian	2	2	2
Estate	3	3	3
Gold	4	4	4
Quinn	5	2+5	5
Bolivia	6	2+6	6
Cebada Capa	7	7	7
Egypt 4	8	8	8
Hord. 2596	9	9	9
Trumpf	10	12	10

Results

Virulences compatible with the resistance factors carried by 9 of the differential cvs were identified (Table 3)

Table 3 Frequencies of individual virulences 1995-2005

	Frequency					
BRV - Year	1995	1997	1999	2001	2003	2005
1	1.00	1.00	1.00	1.00	1.00	1.00
2	1.00	1.00	1.00	1.00	1.00	1.00
3	0.50	0.30	0.36	0.34	0.65	0.42
4	1.00	1.00	1.00	1.00	1.00	1.00
5	0.74	0.88	1.00	0.80	0.90	0.78
6	1.00	1.00	1.00	1.00	1.00	1.00
7	0	0	0	0	0	0
8	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	0.55	0.50	0.61	0.90	1.00
10	0.94	0.88	0.50	0.61	0.90	1.00
No. of isolates	49	33	14	41	29	26

Only resistance conferred by BBR-7, carried by Cebada Capa (Rph7), was effective.This resistance has not been deployed in UK cvs but in some regions, e.g. Eastern Europe, where the gene Rph7 has been deployed in commercial cvs, the matching virulence has been identified. BBV-10, at a high frequency in 2003 (90%) and 2004 (100%), was carried by all the 2005 isolates. Several of the currently

recommended spring barleys, including cv. Optic which is estimated to have occupied about 29% (NIAB 2005) of the spring barley hectarage in 2005, appear to carry BBR-10. However none of the winter barleys, from which the majority of samples are received, are thought to carry this resistance so it is surprising that BBV-10 is at such a high frequency. The other widely used race-specific resistance in recent years is BBR-3, which also has been deployed only in spring barleys. Current recommended cvs with BBR-3 include Static and Cellar. The frequency of the matching virulence BBV-3 remains stable at about 40%.

The pathotypes identified (Table 4) were, as in recent years, relatively complex carrying between 7 (race octal 1653) and 9 (race octal 1677) virulence factors. As in 2004, race octal 273, was not identified even though it was dominant in the late 1990s when it often appeared to infect many winter barleys more severely than more complex races.

Table 4 Races and their frequencies identified from the 2005 isolates compared with representative data from the previous ten years

Race Octal	BBV factors	Frequency					
		1995	1997	1999	2001	2003	2005
273	1,2,4,5,6,8	0	0.06	0.43	0.37	0.06	0
673	1,2,4,5,6,8,9	0.02	0.03	0	0	0	0
277	1,2,3,4,5,6,8	0	0.03	0.07	0.02	0	0
677	1,2,3,4,5,6,8,9	0.02	0	0	0.07	0	0
1273	1,2,4,5,6,8,10	0	0.24	0	0	0	0
1277	1,2,3,4,5,6,8,10	0	0.18	0	0	0	0
1653	1,2,4,6,8,9,10	0.10	0.09	0	0.12	0	0.10
1657	1,2,3,4,6,8,9,10	0.14	0.03	0	0	0.06	0.12
1673	1,2,3,4,5,8,9,10	0.37	0.28	0.21	0.22	0.29	0.48
1677	1,2,3,4,5,6,8,9,10	0.35	0.06	0.29	0.20	0.59	0.30
No. of isolates		49	33	14	41	29	26

GLASSHOUSE TESTS WITH SPECIFIC ISOLATES OF BROWN RUST

Methods

Adult plant tests: Spring and winter barley cvs were grown in a spore-proofed glasshouse until full emergence of the flag leaf. They included cvs on the HGCA Recommended Lists (RL) of winter and spring barleys, potential new cvs and some of the standard differential cvs. Two replicates of each cv. were inoculated separately with each of the following isolates:

Isolate	BBV-	Race octal	Origin
BRS-03-23	1,2,4,5,6,8.	273	cv. Regina, Cambridgeshire
BRS-03-35	1,2,3,4,6,8,9,10	1657	cv. Angela, Cambridgeshire
BRS-97- 27	1,2,4,6,8,9,10	1653	cv. Fighter, Lincolnshire

The plants were inoculated and incubated using methods described previously (Jones and Clifford, 1996). Plants were assessed by percentage flag leaf area infected as well as by reaction type on the standard 0-4 scale as resistant (R: 0-2) or susceptible (S: 3-4).

Seedling tests: Seedlings of spring and winter barley cvs included in the adult plant tests, plus additional winter and spring barleys, were grown in a spore-proofed glass-house to the second leaf stage. They were inoculated with the same isolates and under the same conditions as the adult plants. Assessments of infection type, classified on the standard 0-4 scale, were made on the first leaf.

Results

Winter barleys (Table 5): All cvs, including those in pre-recommendation trials and not tested as adult plant tests, were seedling susceptible. None of the current winter barleys appear to carry race specific resistance but rely on partial resistances which differ in the levels of protection they confer. Cv. Amarena, which has a disease rating of 8 (resistant), was heavily infected in glasshouse tests in 2004 and was again heavily infected by all 3 isolates in 2005 tests. However in field nurseries at IGER in 2004 and 2005 cv. Amarena showed no visible signs of infection even against isolates to which it was susceptible in the glasshouse.

Spring barleys (Table 6): In Table 6, cvs are grouped on the basis of similarities in their adult plant x isolate interactions. Grouping does not necessarily imply that cvs within a group carry a common resistance factor(s).

Group 1: These cvs were susceptible as adult plants and seedlings. They include cv Cocktail which was heavily infected but which in 2003 adult plant tests cv. was resistant to 3 isolates including BRS-03-35 to which it is susceptible in 2005 tests. Further tests are needed to explain this apparent inconsistency. Cv. Vada carries partial resistance and continues to confer some adult plant protection.
Group 2: Cultivars responded similarly to the isolates as the differential cv. Simon which carries resistance factor BBR-3 (Rph3). They were either resistant to, or infected at low levels, by isolates BRS-03-23 and BRS-97-27 but susceptible to BRS-03-35 which carries virulence factor BBV-3. Cv. Cellar has previously expressed adult plant resistance to BBV-3 pathotypes including isolate BRS-03-35 to which, like Cocktail in Group 1, it was resistant in 2003. It appears that the isolate now carries additional virulence(s) capable of overcoming the previously effective adult plant resistance of cv. Cellar.
Group 3: The seedling reactions of these cvs suggest that, like those cvs in Group 2, they carry BRR-3. They differ however in that they possess additional resistance(s) effective at later growth stages to pathotypes carrying BBV-3. As stated in previous years, although the disease ratings of cvs in Groups 2 and 3 are similar, it is expected that cvs in Group 3 would be much more resistant than Group 2 cvs if exposed to BBV-3 pathotypes.
Group 4: Cultivars were susceptible as seedlings and adults to isolates BRS-03-35 and BRS-97-27 but resistant to isolate BRS-03-23 to which, as adult plants, they expressed high levels of a resistant reaction type. BRS-03-23 is the only one of these isolates lacking virulence factors BBV-9 and BBV-10, which are usually found in association. Virulence to BBR-10 has been at a high frequency in recent years and was identified in all the 2005 isolates

Group 5: The seedling reactions of the cvs, including the newly recommended cv. Appaloosa, suggest that they, like those in Group 4, carry resistance factor BBR-10. However they differ from Group 4 cvs in that they were resistant as adults to all the isolates suggesting that they carry additional adult plant resistance effective against these BBV10 isolates. Cvs Power and Decanter have previously shown similar patterns of responses to BBV-10 pathotypes.
Group 6: The differential cv. Quinn (BBR-5) was susceptible to the only isolate (BRS-03-23) carrying the matching virulence, BBV-5. This virulence remains at a high frequency in the pathogen population (78% in 2005) although resistance factor BBR-5 has not been identified in commercial cvs in recent years.

ADULT PLANT FIELD ISOLATION NURSERIES

Methods

Winter and spring barleys were sown during the 2004-2005 season. They included cvs on the HGCA Recommended Lists of winter and spring barleys, some members of the standard set of differential cvs, outmoded cvs and potential new cvs. Spores of isolate BRS-03-23 (race octal 273), ex cv. Regina, Cambridgeshire, were introduced artificially into the winter barley nursery and of isolate BRS-03-25 (race octal 1677), ex cv. Pict, Cambridgeshire into the spring barley nursery. These isolates were tested on adult plants in 2004 glasshouse tests.
Plants were assessed on percentage leaf area infected and on reaction type using the standard 0-4 scale.

Results

Winter barleys (Table 7): All infected cvs were classified as susceptible based on reaction type although in some this was of a mixed type. High levels of disease developed on the cvs Colossus (40%), which has a disease resistance rating of 3 (susceptible) and the outmoded Vanessa (35%). The remainder showed a range of susceptibility with cv. rankings generally confirming their disease ratings. Some, including cvs Haka and Flagon, expressed good levels of partial resistance as they have done previously. The outmoded cv. Monalisa was infected at very low levels. As mentioned previously, cv. Amarena, although highly susceptible in glasshouse tests to a range of pathotypes including BRS-03-23 (Table5), was free of visible disease as it also was in the 2004 a field nursery.

Spring barleys (Table 8): Cultivars varied in their quantitative resistance and reation type to the introduced pathotype. They are grouped on the basis of similarities in their responses to the pathogen in these and other field and glasshouse tests.
Group 1: Cultivars were susceptible although some, e.g. Cocktail and Doyen, showed reasonable levels of partial resistance. Cv. Cocktail was, however, highly susceptible to different isolates in the glasshouse (Table 6).
Group 2: The seedling reactions of these cvs suggest they carry resistance factor BBR-3 (Table 6). All were susceptible in the 2005 field nursery to a pathotype carrying the matching virulence, BBV-3, although they showed differing levels of disease.
Group 3: Cultivars within this group are, like those Group 2, thought to carry BBR-3 but possess additional genetic factors conferring partial adult plant resistance.

Although some of the cvs showed fairly high levels of disease they gave a mainly resistant reaction type.

Group 4: Glasshouse tests have identified these cvs as carrying BBR-10. They were susceptible to the introduced isolate, BRS-03-25, which carries virulence factor BBV-10 although there were quantitative differences in the levels of rust infection.

Group 5: The cvs are thought to carry BBR-10 plus additional adult plant resistance which appears to be highly effective in cv. Power and the newly recommended cv. Appaloosa as they showed low levels of a mixed, mainly resistant reaction type. The resistance of cv. Decanter, however, was not as effective as it developed slightly more disease and showed a more susceptible infection type.

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Table 5. Percentage flag leaf affected and †reaction types of adult plants and seedlings ( ) of winter barley cvs inoculated with specific isolates of *Puccinia hordei* in glasshouse tests.

Cultivar *[1-9 rating]	Isolate					
	BRS-03-23 (BBV-1,2,4,5,6,8) Race octal 273		BRS-97-27 (BBV-1,2,4,6,8,9,10) Race octal 1653		BRS-03-35 (BBV-1,2,3,4,6,8,9,10) Race octal 1657	
Colossus [3]	45	(S)	35	(S)	30	(S)
Amarena [8]	38	(S)	35	(S)	28	(S)
Boost [4]	28	(S)	35	(S)	40	(S)
Cannock [5]	35	(S)	30	(S)	25	(S)
Spectrum [5]	38 MS	(S)	30	(S)	25 MS	(S)
Colibri [7]	25	(S)	30	(S)	28	(S)
Celebrity	25	(S)	30	(S)	40	(S)
Carat [5]	35	(S)	23	(S)	35	(S)
Surtees	30	(S)	30	(S)	30	(S)
Monalisa	25	(S)	40	(S)	25 MS	(S)
Fanfare [7]	30	(S)	28	(S)	10	(S)
Saffron [7]	25	(S)	25	(S)	20	(S)
Pearl [7]	20	(S)	9 MS	(S)	25	(S)
Fahrenheit	10	(S)	15	(S)	25	(S)
Cypress	20	(S)	10	(S)	25 MS	(S)
Dolphin		(S)		(S)		(S)
Accent		(S)		(S)		(S)
Bronx [5]		(S)		(S)		(S)
Shangrila[8]		(S)		(S)		(S)
Retriever [6]		(S)		(S)		(S)
Marado [6]		(S)		(S)		(S)
Suzuka		(S)		(S)		(S)
Pelican [8]		(S)		(S)		(S)
Cassata [8]		(S)		(S)		(S)
Blythe [7]		(S)		(S)		(S)

All adult plant reactions susceptible unless stated.
† (S) susceptible = 3-4 type reaction
When more than one reaction type is expressed by a single cv.,
classification is based on the prevalent response.
MS = mixed susceptible
*HGCA Recommended List for 2006/07

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Table 6. Percentage flag leaf affected and †reaction types of adult plants and seedlings ( ) of spring barley cvs inoculated with specific isolates of *Puccinia hordei* in glasshouse tests.

Cultivar *[1-9 rating]	Group	Isolate BRS-03-23 (BBV-1,2,4,5,6,8) Race octal 273		BRS-97-27 (BBV-1,2,4,6,8,9,10) Race octal 1653		BRS-03-35 (BBV-1,2,3,4,6,8,9,10) Race octal 1657	
Vada	1	23	(S)	23	(S)	23	(S)
Centurion		33	(S)	28	(S)	25	(S)
Cocktail [7]		25	(S)	20	(S)	33	(S)
Simon BBR-3	2	0	(R)	5	(MR)	38	(S)
NFC Tipple [8]		0	(R)	3	(MR)	38	(S)
Cribbage		0	(R)	5 MR	(MR)	35	(S)
Oxbridge [6]		0.2	(R)	4 MR	(MR)	35	(S)
Putney		0	(R)	5	(MR)	35	(S)
Kirsty [8]		0.1	(R)	5	(MR)	25	(S)
Wicket [7]		0	(R)	5	(MR)	25	(S)
Cellar [7]		0	(R)	20 R	(R)	25	(S)
Static [7]	3	10 R	(R)	23 R	(R)	33 R	(MS)
Carafe		0	(R)	25 R	(R)	38 MR	(MS)
Waggon [8]		20 R	(R)	20 R	(R)	25 R	(MS)
Trumpf BBR-10	4	5 R	(R)	15	(S)	30	(S)
Spire [5]		20 R	(R)	30	(S)	30	(S)
Beatrix		23 R	(R)	40	(S)	40	(S)
Optic [6]		20 R	(R)	30	(S)	28	(S)
Tocada [4]		18 R	(R)	25	(S)	25	(S)
Westminster [5]		12 R	(R)	15 MS	(S)	30 MS	(S)
Power [6]	5	15 R	(R)	25 MR	(S)	18 R	(S)
Decanter [5]		15 R	(R)	20 MR	(S)	23 R	(S)
Appaloosa [6]		15 R	(R)	7 R	(S)	30 R	(S)
Quinn BBR-5		30	(S)	3 R	(R)	3 R	(R)

All adult plant reactions susceptible unless stated.
† (S) susceptible = 3-4 type reaction
When more than one reaction type is expressed by a single cv., classification is based on the prevalent response.
MS = mixed susceptible; MR = mixed resistant.
*HGCA Recommended List for 2006/07

Table 7 *Mean total percentage leaf area affected and reactions type† of winter barley cultivars to brown rust in a field nursery in 2005.

Cultivar [1-9 rating]	% Infection BRS-03-23 (Race 273)	Reaction type†
Colossus [3]	40	S
Vanessa	35	S
Camion [5]	33	S
Aquarelle	33	S
Siberia [5]	31	S
Cannock [5]	30	S
Fahrenheit	30	S
Carat [5]	29	S
Celebrity	28	S
Boost[4]	25	S
Spectrum [5]	25	S
Fanfare [7]	25	S
Jewel	25	S
Regina	24	S
Colibri [7]	21	S
Scylla [6]	21	S
Sequel [5]	19	S
Pearl [7]	19	S
Dolphin	19	S
Cypress	16	S
Saffron [7]	12	MS
Surtees	12	MS
Pict [7]	11	S
Haka [7]	8	MS
Flagon [7]	6	MS
Monalisa	Trace	S
Amarena [8]	0	

*Mean of 4 replicates, final assessment date

†0-2 type reaction – resistant (R) 3-4 type reaction – susceptible (S)
When more than one reaction type is expressed by a single cultivar, classification is based on the prevalent response.
MS = mixed susceptible; MR = mixed resistant
[ ] Resistant rating: 1 = susceptible; 9 = resistant

Table 8. *Mean total percentage leaf area affected and reactions type† of spring barley cultivars to brown rust in a field nursery in 2005.

Cultivar [1-9 rating]	Group	% Infection BRS-03-25 (Race 1677)	Reaction type†
Riviera [5]	1	36	S
Hydra		29	S
Chalice [4]		28	S
Centurion		25	S
Poker		24	S
Troon [5]		21	MS
Rebecca [5]		19	S
Vada		14	S
Doyen [6]		12	S
Cocktail [7]		7	S
Wicket [7]	2	35	S
Simon BRR-3		30	S
Prestige		30	S
NFC Tipple [8]		28	S
Cribbage		18	S
Putney		13	MS
Oxbridge [6]		12	S
Cellar [7]	3	22	MR
Static [7]		16	MR
Waggon [8]		14	MR
Kirsty [8]		8	MR
Carafe		5	MR
Trumpf BRR-10	4	29	S
Westminster [5]		19	MS
Tocada [4]		12	MS
Spire [5]		12	S
Optic [6]		6	S
Beatrix	5	10	MR
Decanter [5]		9	MS
Appaloosa [6]		6	MR
Power [6]		3	MR
Quinn BRR-5	6	21	S

*Mean of 4 replicates, final assessment date

†0-2 type reaction – resistant (R) 3-4 type reaction – susceptible (S)
When more than one reaction type is expressed by a single cultivar, classification is based on the prevalent response.
MS = mixed susceptible; MR = mixed resistant
[ ] Resistant rating: 1 = susceptible; 9 = resistant

CROWN RUST OF OATS

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Several lines carrying single genes (Pc) for crown rust resistance were resistant to the 2005 isolates.Cvs Mascani, Brochan and Penderi appear to carry the same resistance as cv. Millennium. The resistance of the spring oat SW Argyle remains effective.

INTRODUCTION

Five samples of crown rust were received in 2005 (Table1).All were infected at low levels.

Table 1. Source cvs and geographic origins of 2005 oat crown rust samples.

Cv. *[1-9 rating]	Geographic origin.
Winter oat	
Mascani [8~]	Crossnacreevy, Belfast
Millennium [8~]	Crossnacreevy, Belfast
SW Dalguise [4]	Crossnacreevy, Belfast
Spring oat	
Drummer [4]	Crossnacreevy, Belfast
Firth [5]	Crossnacreevy, Belfast

*HGCA Recommended List for 2006/07

SEEDLING TESTS WITH 2005 ISOLATES

Methods

Isolates were cultured from the samples and inoculated onto seedlings of the revised set of test differentials comprising 21 near–isogenic (Pc) lines (Jones, 2005). Also included in tests were cvs on the HGCA Recommended Lists (RL) of winter and spring oats, potential new cvs and outmoded cvs. Post-inoculation plants were incubated at approximately 15^{o}C in the glasshouse and after 14 days were assessed for reaction type on the standard 0-4 scale as resistant (0-2) or susceptible (3-4).

Results

The Pc lines (Table2) and additional cvs (Table3) were classified as susceptible (S), resistant (R) or intermediate (I) based on the infection type expressed to each of the isolates.

Table 2 Seedling [†]reactions of Pc lines to 2005 crown rust isolates

	Isolate				
Pc line	CRS-05-01	CRS-05-02	CRS-05-03	CRS-05-04	CRS-05-5
14	R	R	R	I	R
35	R	R	R	R	R
38	R	R	R	R	R
39	R	R	R	R	R
40	S	S	S	S	S
45	I	MR	MR	S	R
46	R	MR	R	MS	R
47	S	S	S	S	S
48	R	R	R	R	R
50	S	S	S	S	R
54	I	S	MR	S	S
55	R	R	R	R	R
56	I	I	MR	MR	I
58	R	R	R	R	R
59	R	R	R	R	R
60	MR	MR	MR	R	R
61	I	MR	R	I	R
62	R	I	S	S	I
63	R	R	R	R	R
68	R	R	R	S	R
96	R	R	R	R	R

[†]Reaction types assessed on a 0-4 scale. Resistant (R:0-2); Susceptible (S:3-4)
When more than one reaction type is expressed by a single line, classification is based on the prevalent response
MR = mixed resistant; MS = mixed susceptible

Thirteen of the twenty one (61%) Pc lines gave a resistant or intermediate reaction to all the isolates. Lines carrying genes Pc35, 38, 39, 48, 55, 58, 59, 60, 63 and 96 were resistant and lines Pc14, 56 and 61 expressed a resistant or intermediate reaction. Genes Pc38,Pc48 and Pc68 are found in modern North American cvs and offer good scope for resistance. Line Pc68 was however overcome by isolate CRS-05-04 as was Line Pc46. Other lines differentiating the isolates were Pc45, 50, 54 and 62 suggesting that these genes may be carried by some commercial cvs.

Three of the five isolates were virulent on all the winter and spring oat cvs with the exception of SW Argyle. The majority of the winter oat cvs (Table3) included in the tests were susceptible. Cv. Millennium, which has a race specific resistance, was resistant to isolates CRS-05-01 and CRS-05-05. Also resistant to these two isolates were cv Mascani, the potential new cv. Brochan and the outmoded cv. Penderi suggesting they carry the same resistance. Previous tests have shown cvs Millennium and Mascani to have additional partial, adult plant resistance effective against some isolates which infected them as seedlings. However isolates overcoming the resistance of Millennium at later growth stages have been identified indicating that this resistance is unlikely to be durable.

Of the spring oats, the resistance of cv. SW Argyle remains effective.

Table 3 Seedling [†]reactions of winter and spring oats to 2005 crown rust isolates

	Isolate				
Cv* [1-9] rating	CRS-05-01	CRS-05-02	CRS-05-03	CRS-05-04	CRS-05-05
Winter oat					
Millennium [8~]	R	S	MS	S	R
Mascani [8~]	R	S	S	S	R
Penderi	R	S	MS	S	R
Brochan	R	S	MS	S	R
Buffalo	S	S	S	S	R&S
Gerald [5]	S	S	S	S	S
Dalguise [4]	S	S	S	S	S
Ayr [6]	S	S	S	S	S
Jalna [5]	S	S	S	S	S
Expression [5]	S	S	S	S	S
Hendon [4]	S	S	S	S	S
Grafton [5]	S	S	S	S	S
Racoon	S	S	S	S	S
Icon	S	S	S	S	S
Lexicon	S	S	S	S	S
Kynon	S	S	S	S	S
95-140Cn	S	S	S	S	S
Spring oat					
Winston [5]	S	S	S	S	S
Emotion [4]	S	S	S	S	S
SW Argyle [8]	R	R	R	R	R
Firth [5]	S	S	S	S	S

[†]reaction types assessed on a 0-4 scale. Resistant (R:0-2); Susceptible (S:3-4)
When more than one reaction type is expressed by a single line, classification is based on the prevalent response
MR = mixed resistant; MS = mixed susceptible
*HGCA Recommended List Rating for 2006/07

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RHYNCHOSPORIUM OF BARLEY

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As in 2004 the frequencies of virulence factors BRV-1, BRV-2 and BRV-7 were lower than in recent years. This was again probably due to the higher proportion of tested isolates coming from recommended spring barleys none of which carry the matching race specific resistances. BRV-5 and BRV-6 remain at low levels in the population but are likely to increase in frequency should BRR-5 carrying cvs such as Westminster and the potential new winter barley cv. Accent become more widely grown. Likewise, virulence to BRR-8, currently only carried by one recommended barley, cv.Doyen, is at a low frequency. Several of the current recommended winter barleys carry BRR-2 but also appear to have additional partial adult plant resistance. Of the potential new winter barley cvs, Suzuka, Retriever, Pelican, Cassata, Blythe and Bronx appear to carry BRR-2 and the resistance of Shangrila was effective against isolates carrying a range of virulences.

INTRODUCTION

Leaf blotch in commercial crops of winter barley was at its least severe since 1995. Recorded levels were less than half those in 2004 and well below the ten year mean. This continues the gradual decline in the severity of the disease since 2000 (Crop Monitor, Winter Barley Survey, 2005). Infected leaf samples were received from 61 winter (Table1) and 34 spring (Table2) barley crops/plots. Geographically, 29 samples were from two test sites in Northern Ireland. The remainder were collected across a wide area of the UK (Table3).

Table 1 Source winter barley cultivars of 2005 leaf blotch samples

Cv. *[1-9 rating]	No. of samples	Cv. [1-9 rating]	No. of samples	Cv. [1-9 rating]	No. of samples
Pearl [7]	10	Fahrenheit	4	Regina	2
Cannock[8]	7	Pict [8]	3	Surtees	1
Colibri [8]	6	Colossus [8]	3	Flagon [8]	1
Sequel [8]	5	Antonia	2	Otter	1
Amarena[8]	4	Camion [7]	2	Unknown	6
Boost [8]	4				

*HGCA Recommended List for 2006/07

Table 2 Source spring barley cultivars of 2005 leaf blotch samples

Cv. [1-9 rating]	No. of samples	Cv. [1-9 rating]	No. of samples	Cv. [1-9 rating]	No. of samples
Optic [4]	5	Spire [4]	1	Static [5]	1
Power [6]	4	Kirsty [4]	1	Carafe	1
Doyen [8]	4	Troon [4]	1	Tocada [4]	1
Cellar [4]	3	Tipple [4]	1	Cribbage	1
Oxbridge[7]	3	Poker	1	Waggon [4]	1
Chalice[5]	2	Riviera [5]	1	Cockail [5]	1
Westminster[8]	1				

*HGCA Recommended List for 2006/07

Table 3 Geographic origins of 2005 leaf blotch samples

County of origin	No. of samples	County of origin	No. of samples	County of origin	No. of samples
Co.Down	18	Shrops	5	Cornwall	1
Tayside	16	Kent	5	Wilts	1
Co.Tyrone	11	Fife	4	Lincs	1
Yorks	9	Notts	4	Ceredigion	1
Gwent	8	Cambs	1	Unknown	4
Devon	6				

SEEDLING TESTS WITH YEAR 2005 ISOLATES

Methods

Isolates cultured from 27 samples were inoculated onto seedlings of the standard set of differential cultivars carrying different, specific resistant genes (Table4). Post-inoculation plants were incubated and assessed as described previously (Jones and Newton,2004)

Table 4 Differential test cultivars for *Rhynchosporium secalis* and their rankings for octal notation.

BRR Factor	Cultivar	Octal rank
0	Maris Mink	-
1	Armelle	1
2	Astrix	2
3	Athene	3
4	Igri	4
5	La Mesita	5
6	Osiris	6
7	Pirate	7
8	Digger	8

Results

Table 5 compares the frequencies of individual virulences identified from the 2005 isolates with those of previous years. BRV-1 and BRV-2, which appear to be associated as their frequencies have been identical over many years, were found in 33% of the isolates and were at similar levels to 2004 (25%). They have however declined in frequency since 2002 and this is probably because the majority of the samples tested in 2004 and 2005 were from spring barleys, none of which are thought to carry the matching resistance factors, BRR-1 and BRR-2. BRV-7, that overcomes the resistance of the differential cv. Pirate, showed a further decline in frequency in 2005 which, in part, is also due the lower number of winter samples tested. Also the matching resistance BRR-7, postulated to be carried by the currently recommended cv. Flagon, is not thought to have been deployed in many cvs in recent years.

BRV-4, which has been at a high frequency since it was first identified in the early 1980s, was found in 96% of the 2005 isolates. The matching resistance BRR-4 is carried by cv. Pearl which is estimated to have occupied 44% of the winter barley hectarage in 2005 (NIAB, 2005).

Virulence to the differential cv. La Mesita (BRR-5) remains at a low frequency and only two of the 2005 isolates carried virulence factor BRV-5. Virulence to cv. Osiris (BRR-6), which is usually found in association with BRV-5, was found in the same two isolates. Current recommend spring barleys thought to carry BRR-5 and /or BRR-6 are cvs Westminster and Rebecca which are estimated to have occupied just under 8% of the area sown to spring barley in 2005 (NIAB, 2005).

BRV-8, capable of overcoming the matching resistance BRR-8 carried by the differential cv. Digger, was identified in isolates cultured from 3 samples. Two of these were from a spring barley trial in Devon and the other from a plot of cv. Doyen grown in Cambridgeshire. Few cvs have carried BRR-8 and none have been widely grown, and consequently BRV-8 has remained at a low frequency. Currently cv. Doyen, estimated to have occupied 4.6% of the spring barley area in 2005 (NIAB, 2005), is the only recommended barley carrying BRR-8

Table 5 Frequencies of individual virulences, 1995-2005

	BRV-								No. of
Year	8	7	6	5	4	3	2	1	isolates
2005	0.11	0.07	0.07	0.07	0.96	*1.00	0.33	0.33	27
2004	0.02	0.27	0.05	0.05	0.93	1.00	0.25	0.25	44
2003	0	0.62	0.05	0.05	1.00	0.95	0.67	0.67	21
2001	0.04	0.80	0.02	0.04	0.94	0.99	0.89	0.89	85
1999	0	0.32	0.16	0.20	0.64	1.00	0.76	0.76	25
1997	0.02	0.37	0.02	0.02	0.96	1.00	0.31	0.31	45
1995	-	0.26	0.13	0.30	0.65	0.91	0.26	0.26	23

(*1 represents 100%)

The virulence combinations present in 2005 isolates are shown in Table 6. The 'simple' race octal 14 (BRV-3, 4), which replaced race octal 117 (BRV-1, 2, 3, 4, 7) as the prevalent race in 2004, was again dominant in 2005. The decline in frequency of race octal 117 is probably due to the greater proportion of spring barley samples tested and

consequently the reduced frequency of resistance factors BRR-1, BRR-2 and BRR-7 deployed in cvs from which samples were received.
One isolate, Rs-05-01 (race octal374), cultured from cv. Doyen grown in Cambridgeshire, carried BRV-5 and BRV-8. These virulences, which are generally at a low frequency, have not previously been found in combination.

Table 6 Virulence factor combinations identified from 2005 isolates

No. of isolates	Differential cultivars in linear order								Race octal
	Digger	Pirate	Osiris	LaMesita	Igri	Athene	Astrix	Armelle	
1	0	0	0	0	0	1	0	0	4
12	0	0	0	0	1	1	0	0	14
2	0	1	0	0	1	1	0	0	114
1	0	0	1	1	1	1	0	0	74
7	0	0	0	0	1	1	1	1	17
1	1	0	0	0	1	1	0	0	214
1	0	1	0	0	1	1	1	1	117
1	1	0	0	0	1	1	1	1	217
1	1	1	1	1	0	0	0	0	374

1 – susceptible; 0 = resistant

GLASSHOUSE ADULT PLANT AND SEEDLING TESTS WITH SPECIFIC ISOLATES OF *RHYNCHOSPORIUM*

Methods

Adult plant tests: Spring barleys were grown in a spore-proofed glasshouse until full emergence of the flag leaf. Cvs included those on the HGCA Recommended Lists of winter and spring barleys, potential new cvs and members of the standard differential set. Two replicates of each cv. were inoculated separately with each of the following isolates whose BRV (race octal) characteristics were identified in previous seedling tests:

Isolate	BRV (race octal)	Origin
RS-04-30	1,2,3,4 (17)	cv. Siberia, Co.Londonderry
RS-04-76	3,4,5,6 (74)	cv. Rebecca, Co.Tyrone
RS-04-90	3,4,8 (214)	cv. Doyen, Aberdeen

Plants were inoculated using methods described previously (Jones, Clifford and Newton, 1996) and assessed on percentage leaf area affected.

Seedling tests: Cvs tested were those included in adult plant tests, some potential new winter and spring barleys and members of the differential set. Plants were grown to the second leaf stage when they were inoculated with the same isolates and incubated under the same conditions as the adult plants. Seedling reactions were assessed by infection levels on the second leaf and classified as resistant (R), susceptible (S) or intermediate (I) (approx.4%-9% infected leaf area).

Results

Cultivars are grouped within Table 7 and Table 8 on the basis of similarities in the patterns of their responses to the isolates and their known resistance factors. Grouping does not necessarily imply that cvs within a group carry a common resistance factor(s). The levels of disease seen on some cvs in glasshouse tests are generally greater than those seen on the same cvs in field tests.

Winter barleys (Table 7):

Group 1: Cultivars were seedling susceptible to the 3 isolates. Prior to 2004 it was thought that cvs Spectrum and Carat carried BRR-2 but this appears not to be the case as they were susceptible to the non-BRR-2 isolates Rs-04-76 and Rs-04-90 in 2005. In 2004, however, cv. Spectrum also showed susceptibility as a seedling and adult plant to these isolates, while cv. Carat gave an intermediate reaction as a seedling

Group 2: These cvs were resistant to isolates Rs-04-76 and Rs-04-90 but were susceptible, or showed an intermediate type reaction, to Rs-04-30, the only one carrying BRR-1 and BRR-2. Cv. Cannock consistently shows high levels of resistance to non-BRR-2 isolates as a seedling but its responses to BRV-2 isolates are inconsistent. In 2002 it was resistant to 2 such isolates, susceptible to 2 different isolates in 2003 and 2004, and gave and intermediate reaction to isolate Rs-04-30 in 2005. It may be that it carries resistance in addition to BRR-2 that is effective against some isolates carrying BRV-2. A large number of recommended and potential new cvs carry BRR-2 and the matching virulence BRV-2 is generally found at a high frequency in sample populations. The test results shown in Table 7 indicate that seedlings of these Group 2 cvs generally showed high susceptibility to RS-04-30 (carrying BRV-2), but as reported below, this is not true in the field where the majority of the cvs show good levels of resistance and have high (resistant) disease ratings. It may be that they have additional genetic factors governing resistance.

Group 3: The differential cv. Pirate (BRR-7), whose resistance is more readily expressed as an adult, gave an intermediate reaction to isolates RS-04-30 and RS-04-76. Cv. Flagon showed a similar pattern of responses although it gave an intermediate rather than resistant reaction to isolate RS-04-90. Similar tests in 2004 suggested that cv. Flagon, like cv. Pirate, carries BRR-7.

Group 4: The responses of the potential new cv. Accent suggest it carries BRR-5 and/or BRR-6 which are usually associated. The matching virulence factors have generally decreased in frequency in recent years. This follows the decline in the winter barley area sown since the latter half of the 1990s as cv. Pipkin became outmoded (the only BRR-5 to have been widely grown). However, it is likely that if cv. Accent comes to occupy a significant area there will be an associated increase in the frequency of BRV-5 and /or BRV-6, and resistance conferred by this cv. could be of little long term value.

Group 5: The potential new cv. Shangrila was seedling resistant against all isolates. It may, however, carry race specific resistance genes that are not matched by virulence combinations present in the pathotypes tested here.

Group 6: Virulence to the differential cv. Igri (BRR-4) was carried by all the isolates. Based on pedigrees, BRR-4 is thought to have been deployed in several popular cvs over the last 20 years, but many have shown good levels of adult plant resistance.

Spring barleys (Table 8):

Group 1**:** The cvs tested as adult plants were highly susceptible to the 3 isolates. The majority have disease resistance ratings of 4 or 5 (susceptible) but cv. Oxbridge, which has a more resistant rating of 7, was generally infected at lower levels. Seedlings of other Recommended List cvs, which have previously been heavily diseased in similar adult plant tests, were also susceptible.

Group 2: As seedlings the differential cvs La Mesita (BRR-5) and Osiris (BRR-6) were susceptible to isolate Rs-04-76, the only one carrying the matching virulence factors BRV-5 and BRV-6 which are usually associated. The recommended cv. Westminster showed a similar pattern of responses. The adult plant reactions of cvs Osiris and Westminster to the isolates confirmed those of their seedlings but cv. La Mesita was susceptible as an adult plant to all isolates. It is, however, characteristic of the differential cv. La Mesita, and some other BRR-5 cvs, that it is susceptible at the later growth stages to isolates which do not appear to carry the matching virulence in seedling tests.

Group 3: The differential cv. Armelle (BRR-1) was susceptible only to the isolate carrying the matching virulence BRV-1 (RS-04-30). Although very few recommended spring barleys have been identified as carrying BRR-1, BRV-1 virulence has been at a high frequency in the population over several years. This is probably because BRR-1 is associated with BRR-2 which has been widely deployed in winter barley cvs.

Group 4: The resistance conferred by BRR-8 in cvs Digger and Doyen was overcome by one isolate, RS-04-90 (BRV-3, 4, 8). As seedlings they were also infected at low levels by isolate RS-04 76 which also induced low levels of disease on adult plants of cv. Doyen. Virulence factor BRV-8 has remained at a low frequency since it was first identified in 1990, but the matching resistance has been deployed in very few recommended cvs, none of which were widely grown.

ADULT PLANT FIELD ISOLATION NURSERIES

Methods

Winter and spring barley nurseries were grown at a site conducive to the development of leaf blotch. Cultivars comprised those on the HGCA Recommended Lists of winter and spring barleys, potential new cvs, outmoded cvs and cvs carrying known specific resistances and used as differentials in seedling tests. Disease developed on the susceptible cvs from endemic inoculum.

Results

Winter barleys (Table 9):

Disease levels on the susceptible cvs were generally low and similar to those in 2004. Cultivars showed a range of quantitative responses with the majority showing low levels of infection. Several of these, including the newly recommended cvs Colibri and Boost, are postulated to carry a race specific resistance, BRR-2. Many of these BRR-2 cvs however, appear to carry additional resistance(s) which confer different levels of protection at the later growth stages. The seedling differential cv. Igri (BRR-4) was, as in

2004, the most heavily infected although it has expressed good levels of adult plant resistance to the majority of isolates against which it has been exposed in glasshouse tests. Other cvs postulated as carrying BRR-4, on the basis that they have cv. Igri in their ancestry, are cvs. Haka, Pearl and Camion. Cv. Haka was again one of the most heavily infected cvs, as it also was in field nurseries in the previous two years. Cvs Pearl and Camion, however, showed lower levels of infection.

Spring barleys (Table 10):
Cultivars differed in the levels of disease they developed with high levels building up on the most susceptible cvs. Several cvs, including Poker, Oxbridge and Cribbage, showed relatively low levels of disease although they were heavily infected in glasshouse tests (Table8) where cv Cribbage was one of the most susceptible. Cv. Oxbridge also showed relatively low levels of infection in a similar nursery in 2004, supporting its disease resistance rating of 7. It may carry partial adult plant resistance that is more readily expressed in the field. The BRR-5 carriers cv. Rebecca and the differential cv. La Mesita were both infected although tests showed that the endemic pathotypes which infected the nursery did not carry the matching virulence. However, as noted earlier, adult plant susceptibility to some non-BRV-5 isolates is characteristic of cv. La Mesita and some other BRR-5 cvs. Nevertheless, cv. Westminster which also carries resistance factor BRR-5 was infected at lower levels.

ADULT PLANT FIELD NURSERY AT SCRI

Methods

A nursery, comprising cvs from the 2005 HGCA Recommended List of spring barleys, together with winter and spring barleys carrying known specific resistances, was sown during the spring of 2005. Disease was allowed to build up naturally.

Results (Table11).

High levels of disease built up on the susceptible cvs although cv.rankings did not always confirm their Recommended List disease resistance ratings. Cv. Oxbridge,which showed low levels of infection in a nursery at IGER(Table 10) and which is not thought to carry a major gene resistance, was among the least heavily infected of the commercially grown cvs. Those cvs identified as carrying race specific resistances were infected at generally low levels suggesting that the endemic pathotypes which infected the nursery were relatively ‘simple’.

ACKNOWLEDGMENTS

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Jones, E.R.L.,and Newton, A.C. (2004). *Rhynchosporium* of barley. *UK Cereal PathogenVirulence Survey 2003 Annual Report*, pp. 57-68.

Table 7 †Reactions of seedlings of winter barley cultivars to specific isolates of *Rhynchosporium secalis* in glasshouse tests

Cultivar/isolate *[1-9 rating]	Group	RS-04-30 BRV- 1,2,3,4 (Race octal 17)	RS-04-90 BRV-3,4,8 (Race octal 214)	RS-04-76 BRV-3,4,5,6 (Race octal 74)
Saffron [6]	1	S	S	S
Pearl [7]		S	S	S
Surtees		S	S	S
Dolphin		S	S	S
Carat [7]		S	S	S
Spectrum [6]		S	S	S
Athene (BRR-3)		S	S	S
Colibri[8]	2	I	R	R
Marado [8]		I	R	R
Fahrenheit		I	R	R
Cannock [8]		I	R	I
Astrix (BRR-2)		S	R	R
Cypress		S	R	R
Celebrity		S	R	R
Monalisa		S	R	R
Colossus [8]		S	R	R
Amarena [8]		S	R	R
Boost [8]		S	R	R
Fanfare [7]		S	R	R
Suzuka		S	R	R
Retriever [9]		S	R	R
Pelican [8]		S	R	R
Cassata [8]		S	R	R
Blythe [5]		S	R	R
Bronx [8]		S	R	R
Pirate (BRR-7)	3	I	R	I
Flagon [8]		I	I	I
Accent	4	R	R	S
Shangrila [8]	5	R	R	R
Igri (BRR-4)	6	S	S	S

†Seedlings assessed on 2nd leaf and classified as resistant (R); susceptible (S) or intermediate (I)
*Disease resistance rating: 1 = susceptible; 9 = resistant
HGCA Recommended List for 2006/07

Table 8 †Percentage flag leaf affected and reaction types of seedlings ( ) of spring barley cultivars inoculated with specific isolates of *Rhynchosporium secalis* in glasshouse tests.

Cultivar/Isolate *[1-9 rating] Group	RS-04-30 BRV- 1,2,3,4 (Race octal 17)	RS-04-90 BRV-3,4,8 (Race octal 214)	RS-04-76 BRV-3,4,5,6 (Race octal 74)
Cribbage	65 (S)	80 (S)	80 (S)
NFC Tipple [4]	70 (S)	75 (S)	80 (S)
Beatrix	70 (S)	75 (S)	60 (S)
Optic [4]	60 (S)	70 (S)	70 (S)
Centurion	60 (S)	60 (S)	65 (S)
Poker	50 (S)	75 (S)	60 (S)
Chalice [5]	55 (S)	70 (S)	55 (S)
Appaloosa [4]	45 (S)	75 (S)	55 (S)
Putney	45 (S)	50 (S)	60 (S)
Cellar [4]	45 (S)	50 (S)	45 (S)
Cocktail [5]	50 (S)	55 (S)	50 (S)
Oxbridge [7]	30 (S)	25 (S)	50 (S)
Power [6]	- (S)	- (S)	- (S)
Decanter [6]	- (S)	- (S)	- (S)
Spire [4]	- (S)	- (S)	- (S)
Tocada [4]	- (S)	- (S)	- (S)
Static [5]	- (S)	- (S)	- (S)
Kirsty [4]	- (S)	- (S)	- (S)
Waggon 4]	- (S)	- (S)	- (S)
Carafe	- (S)	- (S)	- (S)
Wicket [6]	- (S)	- (S)	- (S)
Riviera [5]	- (S)	- (S)	- (S)
Troon	- (S)	- (S)	- (S)
La Mesita BRR-5	75 (R)	65 (R)	65 (S)
Westminster [8]	0 (R)	0 (R)	70 (S)
Osiris BRR-6	1 (R)	0 (R)	50 (S)
Armelle BRR-1	40 (S)	0 (R)	0 (R)
Digger BRR-8	0 (R)	80 (S)	0 (I)
Doyen [8]	0 (R)	80 (S)	7 (I)

†Adult plants assessed on percentage area of flag leaf infected
Mean of 2 plants.
Seedlings assessed on 2nd leaf and classified as
Resistant(R), susceptible (S) or intermediate (I)
*[ ] Disease resistance rating: 1 = susceptible; 9 = resistant
HGCA Recommended List Rating for 2006/07

Table 9 †Mean percentage total leaf area of winter barley cultivars affected by *Rhynchosporium secalis* in a field isolation nursery in 2005

Cultivar *[1-9 rating]	Postulated BRR factor	% total leaf area infected
Igri	4	20
Haka [5]	4	15
Carat [7]	2	10
Spectrum [6]		10
Scylla [7]		10
Pirate	7	10
Saffron [6]		8
Flagon [8]		8
Regina	7?	8
Otter	2	7
Aquarelle	0	7
Camion [6]	2	6
Cypress	4	5
Fanfare [7]	2	5
Siberia [8]	2	5
Fahrenheit	2	5
Sequel [8]	2	4
Astrix	2	3
Athene	2	3
Pearl [7]	3	2
Pict [8]	4	2
Vanessa	2	2
Jewel	2	2
Colibri [8]		2
Celebrity	2	2
Monalisa	2	2
Amarena [8]	2	0.5
Dolphin	2	0.5
Surtees		0.5
Cannock [8]	2+?	0.5
Boost [8]	2	0.2
Colossus [8]	2	0.2

†Mean of 4 replicates, 2 assessment dates

* [ ] Disease rating: 1 = susceptible; 9 = resistant

HGCA Recommended List for 2006/07

Table 10 †Mean percentage total leaf area of spring barley cultivars affected by *Rhynchosporium secalis* in a field isolation nursery in 2005

Cultivar *[1-9 rating]	BRR factor	% total leaf area infected
Beatrix		37
Putney		33
Static[5]		30
Kirsty [4]		22
Waggon [4]		20
Rebecca[7]	5	18
Prestige		15
Carafe		14
Riviera [5]		14
Decanter[6]		13
Cocktail [5]		13
Chalice [5]		12
Appaloosa [4]		12
Spire [4]		12
Troon [4]		12
Cellar		11
Hydra		11
La Mesita	5	10
Optic [4]		10
NFCTipple [4]		10
Tocada [4]		8
Cribbage		8
Oxbridge [7]		6
Westminster[8]	5	3
Poker		1
Doyen [8]	8	1
Armelle	1	0.2
Osiris	6	0.1
Digger	8	0.1

†Mean of 4 replicates, 2 assessment dates
*[ ] Disease rating: 1 = susceptible; 9 = resistant
*HGCA Recommended List for 2006/07

Table 11 Disease levels on spring barleys infected with endemic inoculum in a field nursery at SCRI

Cultivar *[1-9 rating]	BRR factor	% total leaf area infected
Tocada [4]		671.8
Prestige		624.5
Carafe		609.1
Beatrix		606.3
Waggon [4]		429.9
Riviera [5]	5	416.2
Chalice [5]		410.5
Static [5]		402.3
Power [6]		393.2
Cellar [4]		380.9
Spire[4]		367.6
CSBC4433-22		323.9
Cocktail [5]		322.7
Putney		285.6
Optic [4]		277.4
Appaloosa [4]		255.5
Rebecca [7]	5	253.9
Troon [4]		253.3
Poker		251.3
Oxbridge [7]		236.1
Decanter [6]		235.5
Kirsty [4]		233.9
Cribbage		231.0
NFC Tipple [4]		211.2
Wicket [6]		161.9
Doyen [8]	8	140.0
Hydra		126.7
Westminster[8]	5	118.7
Digger	8	114.5
La Mesita	5	97.5
Igri	4	27.6
Astrix	2	18.7
Pirate	7	9.5
Athene	3	5.9
Armelle	1	3.5
Osiris	6	1.8

SED = 73.00

†Mean of 4 replicates, 7 assessment dates

*[ ] Disease rating: 1 = susceptible; 9 = resistant

*HGCA Recommended List for 2006/07

NET BLOTCH OF BARLEY

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INTRODUCTION

Net blotch levels in winter barley were the same as in 2004 (Crop Monitor: Winter Barley Survey 2005) which, although higher than any year since 2000, were well below the 10 year mean. QoI fungicides have offered effective control of the disease in recent years but this may change as low levels of fungicide resistance have been detected in some isolates collected in south east England and parts of mainland Europe. Net blotch, however, remains locally damaging and unsprayed crops are threatened: this is especially true for the susceptible cv. Pearl which occupied around 44% of the area sown to winter barley in 2005 (NIAB,2005).

Fifty-seven samples, the highest number since 1997, were received from a range of winter barley cvs (Table1) and their geographic origins are given in Table 2.

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Table 1 Source winter barley cultivars of 2005 net blotch samples

Cv *[1-9 rating]	No of samples	Cv [1-9 rating]	No of samples	Cv [1-9 rating]	No of samples
Pearl [5]	10	Sequel [7]	4	Colibri [8]	2
Regina	8	Carat [6]	4	Saffron [8]	2
Colossus[7]	6	Siberia [7]	3	Scylla [8]	1
Surtees	5	Camion [6]	3	Unknown	1
Boost [8]	5	Amarena[8]	3		

*HGCA Recommended List disease rating for 2006/2007

Table 2 Geographic origins of 2005 net blotch samples

Origin	No of samples	Origin	No of samples	Origin	No of samples
Yorks	11	Kent	3	W Midlands	1
Norfolk	10	Shrops	2	E England	1
Co Down	9	Suffolk	2	Wilts	1
Dorset	8	E Midlands	2	Notts	1
Tayside	5	Cornwall	1		

METHODS

Samples were not tested individually but a mixed inoculum was prepared from all the samples.

Adult plant tests

Barley cvs were grown in a spore-proofed glasshouse until full emergence of the flag leaf. They included those cvs on the HGCA Recommended List (RL) of winter barleys, some outmoded cvs and the winter cvs from the set of seedling differentials. Two replicates of each cv. were sprayed with the mixed inoculum and then placed in dew chambers in the dark at 15^{o}C for 24 hrs. They were then placed in the glasshouse at approximately 15^{o}C for 12 days. Assessments were made of percentage flag leaf area infected.

Seedling tests

Seedlings of some of the RL cvs, potential new cvs, as well as the standard set of differential cvs were grown to the second leaf stage. They were inoculated with the same mixed inoculum and incubated under identical conditions to the adult plants. Seedling reactions were assessed on the second leaf and classified on a 0-4 scale (Clifford and Jones, 1981) as resistant (R: 0-2) or susceptible (S: 3-4).

RESULTS (Table 3)

Disease symptoms on the adult plants were mainly of a striping or blotching type whereas those on the seedlings were generally of a netting type.

The inoculum mixture infected seedlings of only 2 of the differential cvs, Proctor (susceptible check) and CI 9518 which was also adult plant susceptible. Based on the differential code numbers (Table 3) the isolate mixture carried virulence factors 9 and 11, both of which have previously been identified frequently in the pathogen population. Seedlings of cvs Sequel, Colibri and Amarena were resistant, as they have been in previous years when exposed to different isolate mixtures. Of thepotential new cvs tested only as seedlings, cv. Marado showed no visible signs of infection and cvs Shangrila and Pelican gave an intermediate response.

As adult plants, cvs expressed a range of quantitative responses with several showing good levels of resistance. Cv. Amarena, resistant in 2004 tests, and cvs Colibri, Fahrenheit and Cypress showed very little or no disease. The responses of cvs Amarena and Colibri suggest they carry effective race specific resistance since they were resistant as both seedlings and adult plants, but in cvs Fahrenheit and Cypress resistance was expressed only in the adult plant. The reaction of cv. Sequel is difficult to classify. It has been consistently resistant as a seedling but its adult plant response has fluctuated between years; it showed moderate disease in 2005.

REFERENCE

Clifford, B.C. & Jones, D. (1981). Net Blotch of Barley, *UK Cereal Pathogen Virulence Survey 1980 Annual Report*, pp.71-77.

Table 3 *Percentage flag leaf area infected and seedling reaction types of winter barley cultivars to a mixture of net blotch isolates in glasshouse tests

Cultivar [1-9 rating]	Differential code number	Flag leaf % infection	Seedling reaction	Cultivar	Differential code number	Seedling reaction
Monlisa		20	S	Accent		S
Boost [8]		15	S	Bronx [8]		S
Dolphin		13	-	Shangrila [7]		I
Pearl [5]		10	S	Retriever [8]		S
Pict [6]		10	S	Marado [9]		R
Camion [8]		10	S	Suzuka		S
Scylla [8]		9	S	Pelican [7]		I
Surtees		8	S	Cassata [5]		S
Sequel [7]		8	R	Blythe [8]		S
Flagon [6]		8	S			
Cannock [8]		7	S	CI 5401	1	R
Siberia [5]		6	S	CI 6311	2	R
Celebrity		5	S	CI 9820	3	R
Fanfare		5	S	CI 739	4	R
Saffron [8]		4	S	CI 1243	5	R
Carat [6]		4	S	CI 4795	6	R
Colossus [7]		4	S	CI 4502	7	R
Spectrum [6]		3	S	CI 4979	8	R
Fahrenheit		1	S	Proctor	9	S
Colibri [8]		1	R	CI 9214	13	R
Amarena [8]		0	R			
Cypress		0	S			
Code 65	10	0	R			
CI 9518	11	10	S			
Tenn.61-119	12	3	R			

* mean of 2 plants
Seedlings assessed on reaction type on a 0-4 scale
0-2 type reaction - resistant (R), 3-4 type reaction - susceptible (S)