



**PROJECT REPORT No. 300**

**THE PERFORMANCE OF WINTER BARLEY VARIETIES IN  
THE PRESENCE OF BARLEY YELLOW MOSAIC VIRUS  
(BaYMV) AND BARLEY MILD MOSAIC VIRUS (BaMMV)**

MARCH 2003

Price £4.50

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THE PRESENCE OF BARLEY YELLOW MOSAIC VIRUS  
(BaYMV) AND BARLEY MILD MOSAIC VIRUS (BaMMV)**

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This is the final report of a 50-month project which started in September 1998 with a grant of £57,860 from HGCA (Project No. 2075).

The Home-Grown Cereals Authority (HGCA) has provided funding for this project but has not conducted the research or written this report. While the authors have worked on the best information available to them, neither HGCA nor the authors shall in any event be liable for any loss, damage or injury howsoever suffered directly or indirectly in relation to the report or the research on which it is based.

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## Abstract

In four seasons from 1998/9 to 2001/2, a number of winter barley varieties were sown at two sites uniformly infected with barley yellow mosaic virus, and barley mild mosaic virus respectively. The levels of virus infection, in both resistant and susceptible varieties, were monitored, along with the grain yield, which was then related to the infection levels recorded.

Levels of infection in susceptible varieties varied from one season to the next, although symptoms were never recorded in resistant varieties.

Throughout the project the highest yields tended to come from the resistant varieties, although some susceptible varieties gave yields comparable to these despite showing relatively high levels of infection. Examples were Fanfare, Intro, Opal and Haka.

There were no consistent interactions between the susceptible varieties and the individual virus present. Previous work had shown that mild mosaic tends to be more serious than yellow mosaic virus on malting varieties and *vice versa* for feed varieties. However, in this trial series the relative yields of susceptible varieties were often similar for both virus sites and were not related to variety type.

Vanessa, a feed variety, showed no symptoms in the mild mosaic trials, but did in the yellow mosaic trials. However, the levels in the latter trials were not high enough for such differences to be shown in yield.

This project has highlighted the importance of variety choice in controlling barley mosaic viruses, although the relative performance of resistant varieties was different to that seen in conventional, non-infected trials. Therefore, reference to these may not always give an indication of the likely performance of a resistant variety on infected land, although any resistant variety will still be expected to outyield a susceptible variety in the same situation.

In addition the project has identified varieties that are susceptible and show virus symptoms, yet do not appear to suffer the same yield reductions typically seen in susceptible varieties. Such varieties could widen the choice available to a grower with virus-infected land.

## **Part 1**

## **Summary**

### **Introduction**

Barley mild mosaic virus (BaMMV) and barley yellow mosaic virus (BaYMV) are soil-borne viruses carried by a soil fungus. This is present in soils to varying degrees in most areas of the UK, and in virtually every county where barley is grown. Infection of barley plants is via the fungal vector, which is a common non-pathogenic coloniser of barley roots. The yield effects of virus infection vary from year to year, but may be as high as 40-50%.

Extensive research, mainly HGCA-funded, has consistently shown that the damage from the virus cannot be offset by agronomic measures, although delayed drilling has been seen to offset infection in the autumn. However, since delayed drilling itself has significant negative effects on barley yield, the only practicable remedy available to the grower with BMV-infected land is the use of resistant varieties.

Evaluation of barley varieties, both MV-resistant and MV-susceptible, is well covered in HGCA Recommended List trials, though these have traditionally been on non-infected soil. This project has provided the unique opportunity to test a range of winter barley varieties on soil infected with either barley mild mosaic virus or barley yellow mosaic virus. This has allowed the performance of resistant varieties in particular to be evaluated in the situation in which they would be grown. It has also allowed a comparison of the performance of susceptible varieties when affected by the virus(es).

This project continues the work of an earlier levy-funded project (HGCA Project Report 203), which also looked at variety performance on infected soils, along with the interaction with sowing date.

### **Methods**

Using fully replicated, small plot (21m<sup>2</sup>) trials, the core list of varieties in HGCA Recommended List trials, including resistant and susceptible varieties, were planted at each of two locations near Fairford in Gloucestershire. One location, Hatherop, was known from earlier trials to be uniformly infected with barley mild mosaic virus, whilst the second site, Eastleach, was uniformly infected with barley yellow mosaic virus.

Trials were run at both sites in 1998/9 and 1999/2000. In 2000/2001, only Hatherop (BaMMV) was planted, due to difficult sowing conditions in autumn 2000, and in 2001/2 two trials were sown with the BaYMV site moving from Eastleach to a similarly-infected site near Cirencester. Husbandry of the trials involved routine inputs of fungicides, nitrogen, etc. to best farm practice.

Virus infection was assessed by Rothamsted Research by enzyme-linked immunosorbent assay (ELISA) to confirm the identity of the virus, and visual assessment of the percentage of plants in each trial plot exhibiting symptoms.

The trials were then harvested, and the yield figures compared to the infection levels as appropriate.

### Key results

Assessment of infection levels showed that resistant varieties consistently showed no symptoms, but infection of susceptible varieties did vary. In particular, one variety (Vanessa) showed symptoms in the yellow mosaic trial in 1999, but none in the mild mosaic trial. The trials in 1999 (the first year of the project) showed some of the highest infection levels, and therefore a clear difference between resistant and susceptible varieties:

#### 1. Virus infection levels, spring 1999

Susceptible varieties.	% of plants infected		Resistant varieties	BaMMV	BaYMV
	BaMMV	BaYMV			
Artist	98	57	Angela	0	0
Fanfare	90	43	Antonia	0	0
Flute	97	53	Avenue	0	0
Halcyon	97	60	Epic	0	0
Hanna	90	63	Gleam	0	0
Heligan	77	90	Jewel	0	0
Intro	80	80	Leonie	0	0
Pearl	98	73	Muscat	0	0
Regina	77	63	Siberia	0	0
Rifle	80	87			
Vanessa	0	23			
Vertige	90	70			

Infection was higher at the mild mosaic site, a feature commonly seen in trials of this nature.

Barley mild mosaic has also been associated with greater yield effects.

## 2. Yields (1999)

	Susceptible varieties						Resistant varieties			
	BaMMV		BaYMV				BaMMV		BaYMV	
	t/ha	% site mean	t/ha	%			t/ha	%	t/ha	%
Artist	6.33	90	5.99	76		Angela	6.49	92	7.69	98
Fanfare	7.51	107	8.10	103		Antonia	7.07	101	7.75	99
Flute	6.99	100	7.39	94		Avenue	7.25	103	7.21	92
Halcyon	6.12	87	7.01	89		Epic	6.84	97	8.06	103
Hanna	6.33	90	8.69	111		Gleam	7.39	103	7.85	100
Heligan	6.41	91	8.40	107		Jewel	8.08	115	8.96	114
Intro	7.97	113	8.79	112		Leonie	7.12	101	8.28	106
Pearl	6.20	88	6.43	82		Muscat	7.80	111	7.47	95
Regina	6.91	98	6.09	78		Siberia	7.40	105	8.36	107
Rifle	6.98	99	7.06	90						
Vanessa	6.99	100	8.66	111						
Vertige	5.38	77	8.24	105						

Generally the resistant varieties were higher yielding, though there was variation in the yield of susceptible varieties. Fanfare and Intro in particular stand out as varieties that showed reasonable infection levels but at both sites have given yields comparable to some of the resistant varieties, apparently tolerant of the infection in some way. Vanessa has also yielded well at the mild mosaic site, reflecting its lack of symptoms here, but has also yielded well at the yellow mosaic site.

Previous trials have shown that mild mosaic tends to be more damaging to malting varieties, and yellow mosaic more damaging to feed varieties. However there is little evidence of this here, with Fanfare, Halcyon and Pearl in particular showing little or no difference in relative yield at either site. Generally yields of susceptible varieties were more affected at the mild mosaic site, irrespective of the variety type.

Of the resistant varieties, Jewel was the highest yielding, followed by the six-row varieties Muscat and Siberia in the mild mosaic trial, and Leonie and Siberia in the yellow mosaic trial. This also reflects a trend seen in other work, that even the resistant varieties can perform differently when grown on infected soils, Jewel being a relatively lower yielding variety in conventional, non-infected trials.

In 2000/01, symptoms were again fairly high in susceptible varieties (only the mild mosaic site was drilled in this year).

**Virus symptoms (% of plants infected)**

Susceptible varieties.

Resistant varieties

Chamomile	50	Angela	0
Diamond	83	Antonia	0
Fanfare	80	Avenue	0
Flute	73	Carat	0
Haka	60	Jackpot	0
Heligan	87	Jewel	0
Milena	58	Leonie	0
Opal	70	Muscat	0
Pearl	68	Pict	0
Regina	63	Siberia	0
Scylla	57	Whisper	0
Sumo	67		
Vanessa	0		
Vertige	78		

Vanessa again showed no infection at this site

**Yields (2001)**

	Susceptible varieties			Resistant varieties	
	t/ha	% site mean		t/ha	%
Chamomile	5.41	95	Angela	6.43	113
Diamond	5.09	89	Antonia	6.26	110
Fanfare	5.36	94	Avenue	5.72	100
Flute	5.07	89	Carat	6.85	120
Haka	6.06	106	Jackpot	5.84	103
Heligan	5.18	91	Jewel	6.22	109
Milena	5.37	94	Leonie	5.24	92
Opal	6.20	109	Muscat	6.11	107
Pearl	5.61	98	Pict	5.77	101
Regina	4.96	87	Siberia	6.44	113
Scylla	5.54	97	Whisper	5.96	105
Sumo	4.60	81			
Vanessa	5.36	94			
Vertige	5.34	94			

In this trial, Opal and Haka stood out as varieties with high infection levels but with yields similar to resistant varieties, in the way Fanfare and Intro had in the 1999 trial. Carat was the highest yielding resistant variety, outyielding the six-row varieties, and Jewel again performed well relative to other resistant varieties.



Leonie was the only resistant malt variety, but its performance here was disappointing.

### **Conclusions and implications**

Throughout the trial series MV-resistant varieties tended to give considerably higher yields than susceptible varieties, underlining the importance of genetic resistance as the main control measure against the disease. Yield differences between the best resistant variety and the worst susceptible variety were as high as 5 t/ha in one trial. However, there were differences in performance within each group which appeared to be unique to the virus-infected situations in which they were grown. Susceptible varieties showing reasonably high levels of infection produced yields similar to resistant varieties (e.g. Opal, Haka, and in the early years of the project, Fanfare and Intro). This apparent tolerance of the disease effectively widens the variety choice for growers with virus-infected land. Such susceptible varieties as these could still be grown on infected land should the grower wish, at least until the area of infection grew to the extent that a switch to a resistant variety becomes necessary. Since these varieties will still show symptoms, they will allow the spread of the virus in the field to be monitored, whilst the yield of the infected areas might not be much different to that in the rest of the field. It remains to be seen if any more recent varieties have the same properties.

There was little consistent evidence of differences in susceptibility or yield effects between the two viruses, an effect reported in earlier work. Generally the yellow mosaic trials showed smaller yield effects than the mild mosaic trials, but the effects on individual varieties tended to be similar at both sites. One exception was Vanessa, a feed variety which showed no symptoms in the mild mosaic trials, indicating differential resistance to this strain, although the infection levels in the yellow mosaic trials were not always high enough for these differences to be shown in yield.

Of the resistant varieties, six-row types tended to give higher yields as they would be expected to in conventional, non-infected trials. However, on occasion a two-row variety gave the highest yield in the resistant group. In particular Jewel frequently gave a yield, relative to other varieties, superior to that which it has given in conventional trials. Therefore

even resistant varieties can behave differently when grown on infected soils, and it cannot be assumed that resistance eliminates all effects of the virus(es) such that the varieties will perform as if no virus were present.

Variety choice in the resistant group is now fairly wide, and a resistant variety can now be found to suit a wide range of grower's requirements. The exception is still the malting market, as there is still little choice for a grower wishing to grow malting barley on virus-infected land. Historically Gleam was the only variety to fill this niche, which was superseded by Leonie during the course of this project. However the latter has been fairly low yielding compared to other malt varieties, and although new varieties are appearing now which might fill this niche, the choice is likely to remain restricted.

## Technical Report

### Introduction

*Barley yellow mosaic virus* (BaYMV) and *Barley mild mosaic virus* (BaMMV) are important pathogens of barley, causing large yield losses in susceptible crops and persisting in infected soils for many years. Separately or together, they cause the very widespread mosaic virus disease, with infected fields recorded in all areas of the UK, and in virtually every county where barley is grown (HGCA Topic Sheet No.23, 1999)

The virus is transmitted to the roots of barley by a soil-borne fungus *Polymyxa graminis*, and therefore spread of the disease is related to any form of soil movement either within a field or from one field to another.

The severity of the disease in an infected area varies from year to year, but yield losses resulting from infection can be as high as 50% (Adams, M.J., 1992).

Earlier HGCA-funded research has shown that the disease is not affected by agronomic inputs (Adams et al 1992), though later sowing, with associated lower soil temperatures, reduces the opportunities for infection by the fungus and hence viral infection (Overthrow, Carver & Adams 1999). However, since delayed sowing itself can lead to significant yield reductions in winter barley crops, the value of this as a means of control is limited.

Genetic resistance therefore remains the main method of control, and resistance to mosaic viruses is a significant part of the breeding programme of many plant breeders. As more and more growers find their land infected with the virus, this cultivar resistance will become more important, and comparative evaluation of variety performance is therefore essential. In particular, since resistant varieties are most likely to be grown on infected land, it is important to test new resistant varieties on similarly infected land.

This project involved growing a number of barley varieties, both resistant and susceptible, in replicated, small plot trials on land infected with mosaic virus. The levels of infection in susceptible varieties were monitored, along with the grain yield.

It is known that susceptible varieties can differ in their susceptibility to the two viruses, and therefore the trials were run at two sites each believed to be uniformly infected with either BaMMV or BaYMV. In this way the differential susceptibility, in terms of virus symptoms and yield, could be assessed.

## **Materials and Methods**

Fully replicated, small plot (21m<sup>2</sup>) trials, containing the core list of varieties in HGCA Recommended List trials, including resistant and susceptible varieties, were planted at each of two locations near Fairford in Gloucestershire. One location, Hatherop, was known from earlier trials to be uniformly infected with Barley mild mosaic virus, whilst the second site, Eastleach, was believed to be uniformly infected with Barley yellow mosaic virus.

Trials were run at both sites in 1998/9 and 1999/2000. In 2000/2001, only Hatherop (BaMMV) was planted, due to difficult sowing conditions in autumn 2000, and in 2001/2 two trials were sown, but the BaYMV site was moved from Eastleach to a similarly-infected site near Cirencester.

Husbandry of the trials involved routine inputs of fungicides, nitrogen, etc. to best farm practice.

Virus infection was assessed by IACR Rothamsted by enzyme-linked immunosorbent assay (ELISA) to confirm the identity of the virus, and visual assessment of the percentage of plants in each trial plot exhibiting symptoms.

The trials were then taken to yield, and the yield figures compared to the infection levels as appropriate.

## Results

1998/9

**Table 1: Virus infection levels, spring 1999.**

Susceptible varieties.	% of plants infected		Resistant varieties	BaMMV	BaYMV
	BaMMV	BaYMV			
Artist	98	57	Angela	0	0
Fanfare	90	43	Antonia	0	0
Flute	97	53	Avenue	0	0
Halcyon	97	60	Epic	0	0
Hanna	90	63	Gleam	0	0
Heligan	77	90	Jewel	0	0
Intro	80	80	Leonie	0	0
Pearl	98	73	Muscat	0	0
Regina	77	63	Siberia	0	0
Rifle	80	87			
Vanessa	0	23			
Vertige	90	70			

In most cases infection levels in susceptible varieties were higher at the BaMMV site. Exceptions are Rifle and Intro, where symptoms were equally severe in both trials, and Heligan and Vanessa, with slightly worse symptoms at the BAYMV site. Vanessa actually exhibited no symptoms in the ‘mild’ trial, and this variety, although classed as ‘susceptible’, has shown some tolerance to the disease in earlier trials.

No symptoms were recorded in any of the resistant varieties at either site.

**Table 2: Yields (1999)**

	Susceptible varieties					Resistant varieties			
	BaMMV		BaYMV			BaMMV		BaYMV	
	t/ha	% site mean	t/ha	%		t/ha	%	t/ha	%
Artist	6.33	90	5.99	76	Angela	6.49	92	7.69	98
Fanfare	7.51	107	8.10	103	Antonia	7.07	101	7.75	99
Flute	6.99	100	7.39	94	Avenue	7.25	103	7.21	92
Halcyon	6.12	87	7.01	89	Epic	6.84	97	8.06	103
Hanna	6.33	90	8.69	111	Gleam	7.39	103	7.85	100
Heligan	6.41	91	8.40	107	Jewel	8.08	115	8.96	114
Intro	7.97	113	8.79	112	Leonie	7.12	101	8.28	106
Pearl	6.20	88	6.43	82	Muscat	7.80	111	7.47	95
Regina	6.91	98	6.09	78	Siberia	7.40	105	8.36	107
Rifle	6.98	99	7.06	90					
Vanessa	6.99	100	8.66	111					
Vertige	5.38	77	8.24	105					

Mild Mosaic trial: LSD (0.95) 1.32 t/ha, CoV 11.5%. Yellow Mosaic trial: LSD 1.78 t/ha, CoV 13.9%

Despite showing high levels of infection, both Fanfare and Intro produced, at both sites, relatively high yields for susceptible varieties, indicating some level of tolerance despite no true resistance. Hanna and Vanessa also gave a relatively high yield at the yellow mosaic site.

At the mild mosaic site, with the exception of Intro and Fanfare the resistant varieties gave the highest yields, with Jewel giving the highest, though Angela and Epic were by contrast surprisingly low yielding considering the levels of infection at this site.

At the yellow mosaic site, the infection levels were lower and there is less of a clear separation in yield rankings between susceptible and resistant varieties. Jewel and Muscat gave high yields, but other varieties produced yields at similar levels to the susceptible varieties at this site.

### 1999/2000

**Table 3: Virus symptoms (spring 2000)**

Note no significant symptoms were recorded at the yellow mosaic site

Susceptible varieties.	% of plants infected	Resistant varieties	
	BaMMV		BaMMV
Artist	52	Angela	0
Fanfare	65	Antonia	0
Flute	67	Avenue	0
Haka	83	Gleam	0
Halcyon	97	Jackpot	0
Heligan	72	Jewel	0
Intro	37	Leonie	0
Opal	27	Muscat	0
Pearl	63	Siberia	0
Regina	4		
Sumo	77		
Vanessa	0		
Vertige	42		

Halcyon was the most affected variety, with Haka and Sumo also showing high levels of virus infection.

Vanessa and Regina showed little or no symptoms, despite being susceptible varieties, though in Vanessa's case this was also noted in the 1999 trial. No symptoms were observed in any of the resistant varieties.

**Table 4: Yields (2000)**

	Susceptible varieties				Resistant varieties				
	BaMMV		BaYMV		BaMMV		BaYMV		
	t/ha	% site mean	t/ha	%	t/ha	%	t/ha	%	
Artist	6.90	92	6.17	102	Angela	8.70	116	6.96	115
Fanfare	7.31	97	6.24	103	Antonia	8.42	112	5.98	99
Flute	7.14	95	5.82	96	Avenue	7.81	104	6.10	101
Haka	7.22	96	5.59	93	Gleam	8.42	112	6.39	106
Halcyon	5.77	77	5.12	85	Jackpot	8.08	108	6.49	107
Heligan	6.79	90	6.04	100	Jewel	7.63	102	5.69	94
Intro	7.24	96	5.96	99	Leonie	7.37	98	5.69	94
Opal	7.90	105	6.20	103	Muscat	8.58	114	6.08	101
Pearl	7.14	95	5.82	96	Siberia	8.44	112	6.71	111
Regina	7.27	97	5.77	96					
Sumo	6.37	85	5.93	98					
Vanessa	7.71	103	5.88	97					
Vertige	7.13	95	5.72	95					

Mild mosaic trial: LSD (0.95) 0.59 t/ha, CoV 4.8%. Yellow mosaic trial: LSD 0.65 t/ha, CoV 6.6%

Despite the lack of symptoms at the yellow mosaic site, the resistant varieties still tended to produce the higher yields, though the best in this respect, Angela, Jackpot and Siberia, are all six-row varieties which tend to give higher yields anyway. (There were no six-row varieties among the susceptible varieties).

In the mild mosaic trial the resistant varieties were more clearly higher yielding, with the exception of Leonie, though again there are susceptible varieties which have given similar yields to resistant varieties. Opal showed fairly high levels of infection but has still returned a relatively high yield. Vanessa's yield was also high, but in this case reflecting the lack of virus infection seen in this variety.

**2000/01**

In this year no Yellow mosaic trial was sown

**Table 5: Virus symptoms, spring 2001**

Susceptible varieties.		% of plants infected	Resistant varieties	
Chamomile		50	Angela	0
Diamond		83	Antonia	0
Fanfare		80	Avenue	0
Flute		73	Carat	0
Haka		60	Jackpot	0
Heligan		87	Jewel	0
Milena		58	Leonie	0
Opal		70	Muscat	0
Pearl		68	Pict	0
Regina		63	Siberia	0
Scylla		57	Whisper	0
Sumo		67		
Vanessa		0		
Vertige		78		

Symptom levels were again high at this site with Heligan, Fanfare and the new variety Diamond showing the highest levels. Once again Vanessa showed no sign of virus infection at this site. No symptoms were observed in any of the resistant varieties.

**Table 6: Yields (2001)**

Susceptible varieties			Resistant varieties		
	t/ha	% site mean		t/ha	%
Chamomile	5.41	95	Angela	6.43	113
Diamond	5.09	89	Antonia	6.26	110
Fanfare	5.36	94	Avenue	5.72	100
Flute	5.07	89	Carat	6.85	120
Haka	6.06	106	Jackpot	5.84	103
Heligan	5.18	91	Jewel	6.22	109
Milena	5.37	94	Leonie	5.24	92
Opal	6.20	109	Muscat	6.11	107
Pearl	5.61	98	Pict	5.77	101
Regina	4.96	87	Siberia	6.44	113
Scylla	5.54	97	Whisper	5.96	105
Sumo	4.60	81			
Vanessa	5.36	94			
Vertige	5.34	94			

Mild Mosaic trial: LSD (0.95) 0.69 t/ha, CoV 7.5%.

As in the 2000 trial Opal has given a fairly high yield despite showing relatively high levels of infection. In this trial Haka has shown the same effects. Again, however, the resistant varieties have in



most part given the higher yields, particularly Carat in its first year in trial, outyielding the six-row resistant varieties. Leonie, the only resistant malt variety in trial, was disappointing as in 2000.

## 2001/02

**Table 7: Virus symptoms, (% plants infected)**

	Susceptible varieties.		Resistant varieties		
	BaMMV	BaYMV	BaMMV	BaYMV	
Cannock	92	98	Angela	0	0
Fanfare	95	97	Antelope	0	0
Haka	87	33	Antonia	0	0
Heligan	70	100	Avenue	0	0
Opal	95	98	Carat	0	0
Pearl	93	90	Clara	0	0
Pedigree	85	27	Jewel	0	0
Regina	62	47	Kestrel	0	0
Sumo	92	62	Leonie	0	0
Swallow	97	98	Muscat	0	0
Vanessa	1	63	Pict	0	0
Vertige	97	100	Saigon	0	0
			Sequel	0	0
			Siberia	0	0

Virus levels were high at both sites, though more variable between the susceptible varieties in the Yellow Mosaic trial. In particular, Pedigree, Sumo, Haka and Regina showed lower infection levels in the Yellow Mosaic trial, whilst the levels on Opal, Pearl, Swallow, Fanfare and Vertige were similarly high in both trials. Once again Vanessa showed little or no infection in the Mild Mosaic trial, but fairly high levels in the Yellow Mosaic trial. Again no symptoms were recorded in resistant varieties.

**Table 8: Yields (t/ha), (2002)**

	Susceptible varieties				Resistant varieties				
	BaMMV		BaYMV		BaMMV		BaYMV		
	t/ha	% site mean	t/ha	%		t/ha	%	t/ha	%
Cannock	3.21	56	-	-	Angela	7.20	126	5.68	134
Fanfare	5.11	90	3.34	79	Antelope	7.57	133	5.32	125
Haka	3.75	66	2.49	59	Antonia	6.11	107	4.71	111
Heligan	4.05	71	2.49	59	Avenue	5.33	94	6.44	152
Opal	6.46	113	3.16	74	Carat	5.86	103	4.34	102
Pearl	4.20	74	2.40	57	Clara	6.29	110	4.22	99
Pedigree	4.11	72	2.19	52	Jewel	5.67	100	4.69	110
Regina	3.43	60	1.46	34	Kestrel	5.79	102	4.28	101
Sumo	2.77	49	3.00	71	Leonie	4.72	83	4.08	96
Swallow	4.78	84	4.55	107	Muscat	7.10	125	6.43	151
Vanessa	7.73	136	3.97	94	Parasol	7.65	134	4.28	101
Vertige	3.58	63	3.45	81	Pict	7.80	137	5.44	128
					Saigon	7.24	127	4.60	108
					Sequel	8.18	144	6.86	162
					Siberia	8.28	145	4.81	113

Mild Mosaic trial: LSD (0.95) 1.93 t/ha. CoV 20.5%. Yellow Mosaic trial: LSD 1.61 t/ha, CoV 22.7%

It should be noted that both trials were subject to high levels of blackgrass, which was controlled reasonably well in plots of resistant varieties. However the lack of vigour shown by susceptible varieties carrying high levels of virus infection allowed the blackgrass to flourish in these plots, despite a comprehensive herbicide programme at both sites, and this effect exaggerated the yield differences between resistant and susceptible varieties at this site. This was particularly true with Cannock, from which a representative yield could not be recorded in the Yellow Mosaic trial due to heavy blackgrass infestation.

This has also led to considerable variation in yield across the trials and high statistical errors. Results should therefore be treated with caution.

In the Yellow Mosaic trial the six-row resistant varieties gave the highest yield, though a two-row (Avenue) was also among them in the yield rankings. In the Mild Mosaic trial the six-rows Sequel, Siberia and Pict gave the highest yields, though the new two-row inclusions Parasol and Antelope were not far below, and again Vanessa has given a yield comparable to the higher yielding resistant varieties, reflecting its lack of symptoms at this site.

In this year Opal again showed its 'tolerance' of high virus levels, giving a relatively high yield despite high infection levels, but only in the Mild Mosaic trial. In the Yellow Mosaic trial this effect was not seen, though interestingly it was seen in the new variety Swallow, though in this case only in the Yellow Mosaic trial.

## Discussion

Throughout the four years of this project the MV-resistant varieties outyielded susceptible varieties in the majority of cases. Whilst this is not surprising, it does underline the fact, as found in previous HGCA funded work, that varietal resistance to the Barley Mosaic Viruses is by far the most important tool available to the grower to overcome this disease.

The range in yield (from lowest to highest yielding) in a variety trial is an indication of the potential yield penalty from choosing the 'wrong' variety. In these trials the susceptibility or resistance to mosaic virus was an added factor, and yield ranges were greater than would be expected from conventional cultivar evaluation trials. These were highest in 2002, being 5.07 t/ha (8.28-3.21) in the mild mosaic trial, and 5.40 t/ha (6.86-1.46) in the yellow mosaic trial. Therefore it is clear that where virus is present, variety choice is even more important. These high ranges in yield have also been recorded in earlier work (Overthrow, Carver, Adams 1999).

In other years this yield range was smaller and it is clear that the yield penalty from mosaic virus infection will vary from year to year depending on the severity of symptoms in that season. However it was consistent in each year and each site that the highest yielding variety was resistant, and the lowest yielding susceptible.

As well as separating resistant and susceptible varieties, this trial series also highlighted the performance of resistant varieties as differing from that seen in non-infected trials. Jewel is a good example of this, a variety that, during the course of this project, was 'outclassed' by other varieties in conventional Recommended List trials. However in this trial series, particularly in 1999 and 2001, it gave a better yield relative to other resistant varieties than would be expected from its Recommended List trials performance. In particular, in 1999 Jewel gave the highest yields in trial at both sites. It would appear that even resistant varieties can behave differently when grown on infected land.

In addition, the performance of susceptible varieties was not always straightforward. Occasionally resistant varieties gave yields lower than susceptible varieties, despite clear differences in virus infection. This appeared to be as much due to the variation in susceptibility in susceptible varieties, than to other yield influences between resistant varieties. Several susceptible varieties exhibited high levels of virus infection, but their yields appeared to be unaffected, being comparable to those of resistant varieties. Another variety, Vanessa, showed high levels of infection in the presence of yellow mosaic, but little or no symptoms when exposed to BaMMV.

This suggests that variety selection for a grower with MV-infected land may not be restricted to resistant varieties. Some varieties without recognised genetic resistance may be more tolerant of virus

infection than other susceptible varieties, this effectively widening the choice for growers should resistant varieties not match their requirements.

Examples of such varieties include Opal, Fanfare, Intro and Haka. Fanfare and Intro are no longer mainstream varieties but have consistently given high yields in these trials, and in earlier similar projects, despite high levels of infection. Opal and Haka have shown similar effects, though less consistently. Both varieties were in trial from 2000-2002 (the final three years of the project) i.e. in five trials in total. Haka gave a high yield despite high virus levels in one trial (2001), whereas Opal did so at both sites in 2000, the one site (Mild Mosaic) established in 2001, and at the Mild Mosaic site again in 2002 (i.e. in four out of five trials in which it was grown).

Opal in particular would therefore be an example of a susceptible variety with sufficient 'tolerance' of mosaic virus infection to allow it to be grown on infected land should the grower wish. Such varieties have been highlighted in the past as having a value where the area of infection in a field is not large, and does not warrant switching to a resistant variety for the whole field should the grower have a particular desire not to grow such a variety. Susceptible varieties, which do not suffer as great a yield penalty as others, could be grown, if suitable to the grower's needs, until the infected area, (which could still be monitored since the susceptible variety would show the spread of the virus) became large enough to justify switching to a resistant variety.

That said, the number of resistant varieties currently available is considerably larger than in previous years, with breeding for resistance now an important factor in many plant breeders' objectives. Hence most requirements of a barley grower could be met with the range of resistant varieties that is now available.

The exception is malting barley. For many years now the combination of malting quality and MV resistance has been scarce, with the variety Gleam being the only option for many years. This variety is now outclassed, and Leonie is currently the only available variety with both attributes. However its yield has been poor in trials irrespective of its MV resistance, and it is the area of malting barley growing on MV-infected land where a wider choice of varieties is needed. If susceptible malt varieties could be identified which do not suffer severe yield penalties when infected, this would help in this respect. (Fanfare was such a malt variety with good tolerance of MV infection).

This project has shown the potential yield loss from incorrect variety selection, which is far greater where mosaic virus is present than when it is not. It has also identified varieties that have no recognised resistance to the viruses, yet still give yields comparable to resistant varieties, thereby extending variety choice for the grower with infected land.

In addition, resistant varieties which do not perform well in conventional, uninfected trials, have yielded relatively better in this trial series, even compared to other resistant varieties, (e.g. Jewel) indicating that even resistant varieties perform differently on infected land compared to non-infected land. The importance of variety trials on MV-infected land is therefore clear, even where resistant varieties are being evaluated.

## References

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The researchers involved in this project express their gratitude to the HGCA for providing funding from the R&D levy.

We also acknowledge the help and co-operation given by the host farmers involved in the trials, James Hart, David Jenkinson and Richard Knight.