BARLEY YELLOW DWARF VIRUS SURVEY IN CANADA, 1961[1]

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Abstract

Tests with detached leaves from cereals and grasses showed that Rhopalosiphum padi (L.) was the most efficient vector of barley yellow dwarf virus (BYDV) in samples from Quebec, Manitoba, and Saskatchewan. Both R. padi and Macrosiphum avenae (F.) were efficient vectors of BYDV from Ontario, New Brunswick, and Alberta. R. maidis (F.) was of minor importance as a vector of BYDV in Canada. It was occasionally effective on samples from New Brunswick, Ontario, Manitoba, and Saskatchewan.

No true vector-specific isolates of BYDV were found for R, padi or R, maidis. Vector-specific isolates of BYDV for M. avenae were common only in Ontario, where they occurred mainly in autumn-sown cereal crops. In all cases they were less virulent than isolates transmitted by R. padi. This is probably because of the winter-killing of cereals infected with virulent isolates of BYDV. Aphids were noted in half of the crops surveyed but were abundant in only a quarter of the crops.

The incidence of BYDV was moderate (over 10 per cent) in ten per cent of the crops and, in only one crop, in Quebec, was there a serious loss in yield (over 50 percent). The predominance of yellowing on infected barley and wheat and reddening on infected oats was confirmed in the survey. Leaf purpling was recorded on one Brome grass and two barley samples. The main sources of BYDV infection in the spring, in Ontario, are perennial grasses for R. padi, and wheat, rye and barley for M. avenae.

Introduction

As part of an investigation on the variability of the BYDV disease of cereals, a survey was undertaken with the co-operation of officers of the Canadian Department of Agriculture at different Research Stations and Experimental Farms across Canada. The primary aims of the survey were: (1) to determine the incidence of BYDV; (2) to obtain representative isolates for further study; and, (3) to compare the relative efficiency of the three main vectors, Rhopalosiphum padi (L.), (the bird cherry-oat aphid), Macrosiphum avenae (F.) (=M. granarium), the English grain aphid); and R. maidis (F.) (the corn leaf aphid), in transferring the disease.

Methods

Survey forms, plastic bags, and filter paper for wrapping leaf and stem samples were posted from Ottawa on June 29 to most Experimental Farms and Research Stations in Canada, Ten samples of fresh leaves and stems, from

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cereals and grasses showing stunting, yellowing or reddish-purple leaf discoloration, were requested from each Station. The sample requested was 2 to 3 inches of shoot and base of the uppermost leaf, from one tiller of each plant, The samples were wrapped in moist filter paper and placed in the plastic bags before posting. They all arrived in good condition except for two packages which were delayed more than 10 days before delivery.

Each sample was cut and placed in three plastic dishes containing moist filter paper and healthy individuals of one of the three main vectors; R. padi, (R.P.), M. avenac (M.A.) or R. maidis (R.M.). The aphids were allowed an acquisition feed in the refrigerator at about 15°C for 2 or 3 days. Mature aphids were individually transferred to young (1-to 2-leaf) seedlings of Clintland 60 oats which had been grown in an insect-free greenhouse. Five plants, growing in a 4-inch clay pot, were used for the test with each aphid species. The aphids were placed on the plants which were then immediately covered with either a glass tumbler or a 2-inch diameter cellulose cage. After an infection-feeding period of from 2 to 5 days the covers were removed and the aphids killed by spraying with "TEPP" or nicotine sulphate insecticide, The greenhouses were screened and kept free of aphids by weekly spraying with insecticide. Check plants tested with the stock aphid cultures remained free of BYDV infection.

The severity of infection was first recorded after 17 days and again 20 to 25 days after inoculation. The four grades of infection shown in Tables 1 to 3 were as follows:

0 = No symptoms
t = Mild infection on one or two plants
++ = Mild infection on more than two, or severe infection on one or two plants.
ttt = Severe infection on three or more plants,

Results

ONTARIO: The results of tests to transmit BYDV from leaf samples from various sources in Ontario are given in Tables 1 and 2.

Grasses: The most significant feature of the results with grasses was the superiority of R. padi as a vector. It transmitted efficiently from 8 of the 39 grass samples. M. avenae transmitted from only two samples and then less efficiently than R. padi. These results showed that Dactylis glomerata, Phleum pratense, Festuca pratensis, and Poa pratensis were probably the most important pasture grass sources of BYDV in Ontario and confirmed the findings of Slykhuis et al (10) in 1959 that R. padi was the most efficient vector of BYDV from infected perennial grasses at Ottawa.

In the samples labelled "C.E.F. Roadside" (Table 1), the grasses, were growing alongside a crop of oats which showed severe barley yellow dwarf adjacent to the grasses but much less towards the centre of the field, Of the grasses tested tested next to the affected oats, Agropyron repens, Phleum pratense, Echinochloa crusgalli, and Setaria viridis were not infective, but Dactylis glomerata and Poa pratensis were. The only aphid species found regularly on grasses during the summer was R, padi and this aphid was the only vector of BYDV from these grasses. Tests on the oat plants at this location (Table 1) suggested that D. glomerata and P. pratensis were the main sources of virus infection because

Table 1. Barley Yellow Dwarf Virus Survey-1961. Incidence in Ontario

GRASSES						OATS (Spring Sown)					
			Vectors						Vectors		
SPECIES	Locality	Date	RP**	MA	RM	Variety	Locality	Date	RP	MA	RM
Lolium perenne (2)*	C.E.F. ***	17/4	0	0	-	-	C.E.F. Plots	7/6	+	++	-
Lolium perenne	C. E. F. Greenhouse	28/4	++	0	0	Garry	Harrow	4/7	0	++	0
Festuca arundinacea(2)	C.E.F. Plots	17/4	0	0	-	Fundy	Harrow	4/7	0	0	0
Festuca rubra (3)	C.E.F. Plots	17/4	0	0	-	Tioga	Harrow	4/7	0	++	0
Festuca elatior	C.E.F. Plots	17/4	+++	++	-	Bonham	Harrow	4/7	0	0	0
Phleum pratense (2)	C.E.F. Plots	17/4	0	0	-	-	Merrickville	13/7	++	-	0
Phleum pratense	Norwood	12/5	0	0	-	-	Guelph	13/7	++	-	0
Phleum pratense	C. E. F. Greenhouse	28/5	+	0	-	-	Guelph	13/7	++	0	0
Phleum pratense	C. E. F. Greenhouse	28/5	+++	0	-	-	Appleton	13/7	0	++	0
Phleum pratense	C. E. F. Roadside	15/9	0	0	-	-	Lancaster	31/7	0	+++	0
Phleum pratense	Ridgetown	13/7	0	0	0	-	C.E. F. Field	14/9	++	0	0
Poa pratensis (2)	C.E.F. Plots	17/4	0	0	-	-	C.E.F. Field	14/9	++	0	0
Poa pratensis	C.E.F. Roadside	15/9	++	0	0	-	C.E. F. Field	14/10	++	++	+
Agropyron repens	Lindsey	12/4	0	0	0	- (3)	C. E. F. Field	14/10	0	++	++
Agropyron repens	Harrow	12/4	0	0	-	- (2)	C.E.F. Field	14/10	0	0	+
Agropyron repens	C.E.F. Plots	31/7	0	0	-	- (5)	C.E.F. Roadside	14/10	+++	+++	+++
Agropyron repens	C. E. F. Roadside	15/9	0	0	0	- (2)	C.E. F. Roadside	14/10	0	++	-
Dactylis glomerata 2)	C.E.F. Plots	17/4	0	0	-	- (2)	C.E.F. Roadside	14/10	++	0	-
Dactylis glomerata	C. E. F. Roadside	15/9	++	0	0	-	C.E.F. Plots	14/10	++	0	++
Bromus inermis (3)	C.E.F. Plots	17/4	0	0	-	-	C.E.F. Plots	14/10	+++	0	0
Bromus sterilis	Ridgetown	13/7	++	+	-	-	C.E.F. Plots	14/10	0	+++	+
Echinochloa crusgalli	C.E.F. Plots	27/6	0	0	0	-	C.E.F. Plots	14/10	0	0	++
Echinochloa crusgalli	Ridgetown	13/7	++	0	0	-	Z.E.F. Plots	14/10	0	++	++
Echinochloa crusgalli	Z.E.F. Plots	31/7	0	0	-	- (4)	Z.E.F. Plots	14/10	0	0	0
Echinochloa crusgalli	C.E. F. Roadside	15/9	0	0	0						
Setaria viridis	Z.E.F. Plots	31/7	0	0	-						
Setaria viridis	C.E. F. Roadside	15/9	0	0	0						
Panicum capillare	C.E.F. Plots	31/7	0	0	-						
Phalaris arundinacea (2)	Z.E.F. Plots	17/4	0	0	-						

* Number of samples tested

** RP=Rhopalosiphum padi, MA=Macrosiphum avenae, RM=R. maidis.

*** C.E. F.=Central Experimental Farm, Ottawa.

Table 2. Barley Yellow Dwarf Virus Survey-1961. Incidence in Ontario

WHEAT (Autumn Sown)				Vectors		BARLEY (Autumn Sown)				Vectors	
Variety	Locality	Date	RF	MA	RM	Variety	Locality	Date	RP	MA	RM
-	Lindsey	12/4	0	0	-	Hudson	C.E.F. Plots	7/6	+	+++	-
-	Barrie	12/4	0	+	-	Hudson	C.E.F. Plots	7/6	0	+++	-
-	Barrie	12/4	0	0	-	-	Guelph	7/6	+	+++	-
-	Windsor	12/4	++	+	-	182	C.E.F. Plots	7/6	0	+++	0
-	Harrow	12/4	0	0	-	52	C.E.F. Plots	7/6	0	0	-
	Orono	12/4	0	0	-						
-	C.E.F. Plots	25/4	0	++	-	BARLEY (Spring Sown)					
Capelle desprez	C.E.F. Plots	25/4	+	++			Merrickville	13/7	0	-	0
Hybrid 46	C.E.F. Plots	25/4	0	+++			Guelph	13/7	++	0	0
Richmond	C.E.F. Plots	25/6	+	+++			Guelph	13/7	0	0	0
Kent	C.E.F. Plots	25/4	+	++t			Guelph	13/7	+	0	0
Genesee	C.E.F. Plots	25/4	+	tt+			Guelph	13/7	++	0	0
CD 1569	C.E.F. Plots	25/4	+	ttt			Ridgetown	13/7	++	+	0
-	C.E.F. Plots	25/4	+	+++		(Autumn Sown)					
CD 1569	C.E.F. Plots	7/6	+	tt			C.E.F. Plots	20/4	0	++	-
Richmond	C.E.F. Plots	7/6	+t+	++			C.E.F. Plots	20/4	0	++	-
Kent	C.E.F. Plots	7/6	0	0	-		Madoc	12/5	0	tt	-
	Guelph	7/6	0	ttt	-		Holland	12/5	0	0	-
Ross	Guelph	7/6	++	++	-		Hanover	12/5	0	0	-
-	Ridgetown	7/6	0	t++	-		Norwood	12/5	0	tt	-
Pembina	Merrickville	13/7	t	-	0		C.E.F. Plots	25/5	t	tt	-
-	Guelph	13/7	++	-	0		C.E.F. Plots	7/6	0	++	-
-	Ridgetown	13/7	++	0	0						
Ross	Ridgetown	13/7	0	0	0						
Kent	Ailsa Craig	13/7	0	0	0						

there was a much higher proportion of transmission by R. padi here than in samples from other adjadent oat crops with uniform BYDV infection.

Greenhouse tests on the survival of R. padi and M. avenae on grasses showed that R. padi readily colonized and multiplied on Lolium perenne, Phleum pratense, Agrostis palustris, Alopecurus pratensis, Poa annua, and Poa pratensis, whereas M. avenae survived and multiplied only on Poa annua.

Wheat, Barley and Rye (Autumn-sown crops): When these crops were tested during April and May there was a high rate of transmission of **BYDV** by M. avenae. Later tests during June and July in the wheat plots at the Central Experimental Farm, Ottawa and in southern Ontario showed an increasing efficiency of transmission by R. padi. These results suggest that autumn-sown cereals provide the main over-wintering source of BYDV which is transmitted by M. avenae in the spring, and confirm the records of Slykhuis et al. (9) who also found M. avenae to be the only vector from autumn-sown wheat and barley in early-season tests, The M. avenae-specific isolates obtained were identical to the EGV-1 isolate described by Rochow (7), and were invariably less virulent than the isolates transmitted by R. padi.

Observations on the incidence of aphid vectors in the field at Ottawa showed that, as in 1959 (10), M. avenae was the first cereal aphid seen. It was first seen in oats and wheat on June 1. R. padi was the first aphid found in wheat and rye, on 18 June; and R. maidis was found about the middle of July. Metapolophium dirhodum, Schizaphis graminium, and Sipha agropyri were not found until late in July on wheat and oats. These observations support the hypothesis that M. avenae is the first vector of BYDV in the spring, obtaining the virus from winter wheat, rye and barley. R. padi probably first infects grasses after leaving its winter host (choke cherry) and brings BYDV infection from the perennial grasses to the cereal crops later in the spring. R. maidis and other vectors multiply later in the season and are able to transmit BYDV brought to the cereal crops by R. padi.

Oats and Barley: (Spring-sown crops) The main feature of the tests with spring oats and barley was the fairly clear cut vector-specificity during June and July in contrast to fall tests. Either M. avenae or R. padi alone transmitted from the samples tested in June and July. In October, however, when R. padi, M. avenae, and R. maidis were all abundant in oats, transmission of BYDV from single plants was commonly obtained by both R. padi and M. avenae, and occasionally by all three vectors'. In subsequent greenhouse tests only the vector-specificity of the M. avenae isolates was maintained.

QUEBEC: The results of transmission tests with samples from Quebec are given in Table 3.

Wheat, oats and barley: The main vector of BYDV in 18 of the 21 samples was R. padi. M. avenae gave only poor transmission from two samples which were both efficiently transmitted by R. padi. These results are similar to those obtained with grasses in Ontario. This indicates that the main vector of BYDV in Quebec was R. padi and its source, perennial pasture grasses.

NEW BRUNSWICK: (Table 3)

Oats and Barley: Both R. padi and M, avenae readily transmitted BYDV from the samples received, M. avenae appeared to transmit more efficiently than R. padi from the oat samples but R. maidis transmitted BYDV from only

Table 3. Barley Yellow Dwarf Virus Survey-1961. Incidence in Manitoba, Saskatchewan, Quebec, Alberta, and New Brunswick.

Crop	Variety	Locality	Date	Vectors RP	MA	RM
Wheat	Durum	Winnipeg	27/6	++t	0	-
Wheat	-		20/7	t	0	0
Wheat	-		20/7	++	0	0
Wheat	Thatcher	Swift Current	12/7	++	0	+
Wheat	Pelissier	Swift Current	12/7	++	0	0
Oats	-	Winnipeg	27/7	+	0	0
Oats	Rodney	Swift Current	12/7	0	0	0
Barley	-	Winnipeg	20/7	+	0	0
Barley	-	Brandon	23/7	0	0	t
Barley	-	Brandon	23/7	+	0	+
Barley	Atlas 57	Swift Current	12/7	+++	0	0
Barley	Bonneville	Swift Current	12/7	0	0	t
Quebec						
Wheat	Thatcher	Lennoxville	8/7	+++t	t	0
Oats	Victory	Lennoxville	8/7	+++	0	0
Oat	Garry	Lennoxville	8/7	0	0	0
Oats	00.3.2	Lennoxville	8/7	t	0	0
Oats	-	St. Anne (2)	27/7	++	0	0
Oats	-	St. Anne	27/7	0	0	0
Oats	-	St. Anne	27/7	++	+	0
Oats	-	St. Anne	15/9	t++	0	0
Barley	Keystone	Lennoxville	8/7	++	0	0
Oats	Roxton	Lennoxville	8/7	++	0	0
Barley	Montcalm	Lennoxville	8/7	+++	0	0
Barley	Brant	Lennoxville	8/7	++	-	-
Barley	00591	Lennoxville	8/7	+++	0	0
Barley	Len. 30	Lennoxville	8/7	0	0	0
Barley	Le -	St, Anne	27/7	++	0	0
Barley	-	St. Anne (5)	27/7	+	0	0

Alberta Crop	Variety	Locality	Date	Vectors RP	MA	RM
Wheat	Jones Fife	Fort McLeod	22/6	++	++	-
Wheat	-	Welling	22/6	+++	++	-
Wheat	Kharkov	Whiskey Gap	22/6	+++	++	-
Wheat	-	Magrath	22/6	++	++	-
Wheat		Lethbridge	27/6	++	++	-
Wheat	-	i ethbridge	27/6	+	0	-
Oats	-	Magrath	22/6	ti	++	-
Oats	-	Lacombe	12/7	++	++	++
Barley	-	Magrath	22/6	++	++	-
Grass	Bromus	Fort Vermillion	27/7	t	0	0
New Brunswick						
Oats	Fundy	Fredericton	11/7	0	-+	+
Oats	Rodney	Fredericton	11/7	tt	0	t
Oats	CH 5612	Fredericton	11/7	0	0	0
Oats	CH 5612-27	Fredericton	11/7	+++	t+t	0
Oats	5246-6	Fredericton	11/7	+++	t+t	0
Oats	Fundy	Fredericton	22/7	0	++	0
Oast	Garry	Fredericton	22/7	0	+	0
Oats	Russell	Fredericton	22/7	+t+	t++	0
Oats	Shield	Fredericton	22/7	0	t++	0
Oats	Glen	Fredericton	22/7	0	+++	0
Barley	Montcalm	Fredericton	11/7	0	t	0
Barley	Fort	Fredericton	11/7	+t+	0	0
Balrye	Herta	Fredericton	11/7	0	0	0
Barley	4675CH1	Fredericton	11/7	++	+	0
Barley	B2M57754	Fredericton	11/7	0	++	0
Barley	Montcalm	Fredericton	22/7	0	t	0
Barley	Fort	Fredericton	22/7	++	0	0
Barley	Carlsberg	Fredericton	22/7	0	0	+
Barley	Chitton	Fredericton	22/7	0	++	++
Barley	Keystone	Fredericton	22/7	0	0	0

two samples of oats and two of barley. In addition to R. padi, M. avenae and R. maidis, Orlob (4) found what S. graminum (Rond.) and Metopolophium dirhodum (Wlk.) were vectors of BYDV in New Brunswick.

MANITOBA and SASKATCHEWAN: (Table 3).

Wheat, oats and barley: (spring-sown) M. avenae did not transmit BYDV from any sample and is therefore probably of little importance as a vector in the field in these provinces. R. padi was an effective vector from 10 of the 13 samples and R. maidis from only 4 of 12 samples tested. As in Quebec, the main overwintering sources of BYDV are probably the perennial grasses and the main vector, R. padi.

ALBERTA: (Table 3)

Wheat (autumn-sown), oats and barley: R. padi and M. avenae were both important vectors of BYDV from Alberta samples. R. maidis gave good transmission from the one sample tested. The first record of BYDV in Canada was from barley in Alberta in 1955 (2), when a species of Rhopalosiphum was found to be the vector,

Grass: R. padi transmitted BYDV from the one sample of Brome grass tested.

The cereal virus situation in Alberta resembles that in Ontario and New Brunswick where perennial grasses and winter wheat are the main overwintering sources of BYDV for R. padi and M. avenae respectively.

Discussion

Vector-specificity has been widely studied as a possible basis of distinguishing between strains of BYDV. The stability of this characteristic in some isolates was first shown by Toko and Bruehl (12). Rochow (6, 8) subsequently found that the bulk of the BYDV isolates from oats in New York were vector-specific to M. avenae, the English grain aphid, and a very few isolates were readily transmitted by R. padi.

As Bruehl (1) has pointed out, the bulk of the isolates in many other areas of the United States were, however, non-specific and could be readily transmitted by both R. padi and M. avenae. Most vector studies with BYDV have shown that R. padi (also called R. fitchii F. in error *(3)*) was a more efficient vector of BYDV than M. avenae and produces a more severe disease (9, 12). The only reference to M. avenae-specific isolates (MGV) causing severe infection is that of Smith (11) who found that Saia and Fulghum oats were more severely infected in seedling tests. Field tests, however, showed that these varieties recovered in the adult stage and suggested that the more severe seedling infection was probably due to more efficient transmission of MGV by M. avenae, which is probably better adapted to feeding on Saia and Fulghum than R. padi.

The vector-specificity of MGV isolates was found to be more complete than that of other isolates (7, 13). This could be explained on the basis that M. avenae changes the virus slightly and transmits the less virulent isolates more effectively, but is unable to transmit the less virulent MGV isolates, particularly from oats which are not the best host for R. padi. This hypothesis is supported by transmission experiments using various Canadian isolates of BYDV. In all cases, the

MGV isolates were of reduced virulence and R. padi was rarely able to transmit them from oats or rye, although it did so quite consistently when they were first isolated from wheat, Thus the M. avenae vector-specificity of BYDV appears to have resulted from continuous transmission of the virus between autumn- and spring-sown cereals by one vector, M. avenae. The main reason for the mild or attenuated nature of the MGV isolates in Canada is probably that infection with the more virulent isolates results in winter-killing of infected cereals and hence they can only survive in perennial grasses, The MGV isolates were found mainly in Ontario in autumn-sown wheat, barley and rye, as previously reported by Slykhuis et al. (7).

Isolates transmitted by R. padi were much less specific than the MGV isolates when tested in the greenhouse and were much more virulent when transmitted by either R. padi or M. avenae. They were found predomiantly in Quebec, Manitoba and Saskatchewan on cereals but they were also found in Ontario where they were particularly associated with perennial grasses. Later in the spring, when R. padi became more abundant, they were found more readily on oats and wheat.

Isolates that were transmitted with equal facility by R. padi or M. avenae were found mainly in New Brunswick and Alberta and, in late summer, in Ontario, These isolates had probably resulted from mixed field infections of BYDV when both infective R. padi and M. avenae occurred on the same plant. In some cases, MGV isolates were obtained from these mixed infections, as first suggested by Watson and Mulligan (13).

No true R. maidis-specific isolates were obtained in this survey and all isolates which were originally transmitted efficiently by R. maidis were subsequently transmitted more efficiently by R. padi in greenhouse tests.

Vector-specific strains of BYDV appear to be rare except in Ontario and New York where there is a continuous association of M. avenae as a vector of attenuated strains of BYDV in autumn-sown cereals.

A general conclusion from this survey would be that the most efficient vector or vectors of BYDV in any locality or crop depend primarily on the source of overwintering virus infection and, secondly, on the predominating aphids in each area previous to the samples being taken,

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