IS BARLEY YELLOW DWARF VIRUS A PREDISPOSING FACTOR IN THE COMMON ROOT ROT DISEASE OF WHEAT IN CANADA? [1]

Harvey C. Smith [2].

Abstract

Investigations of cereal root-rot diseases in New Zealand in the past five years have led to the conclusion that root-rotting fungi in the genera Fusarium and Rhizoctonia become pathogenic predominantly on wheat plants that have been previously infected with barley yellow dwarf virus (BYDV). It is suggested that a similar situation may exist in regard to common root rot of wheat in the Prairie Provinces of Canada where BYDV has been shown to be widely distributed. This hypothesis does not apply to diseases caused by Ophiobolus graminis and Cercosporella herpotrichoides, both of which cause root diseases of wheat independently of BYDV infection in New Zealand.

Introduction

This paper is presented primarily to suggest avenues of investigation which are likely to yield information on the complex disease known as common root rot of wheat. Information assembled from two widely different environments, New Zealand and Ottawa, Canada, appears to give support to a hypothesis that could have a very wide application wherever wheat crops, BYDV and the aphid vectors occur together,

The lack of distinctive virus symptoms on wheat has been the main reason for the failure of .plant pathologists to recognize barley yellow dwarf infection in this crop, Most wheat varieties are relatively tolerant of BYDV infection and the principal symptoms produced are readily confused with those associated with nutritional deficiencies and the attack of root-rot pathogens. The typical symptoms of BYDV infection in wheat are:

1. Slight stunting of growth (Fig. 1).
2. Yellowing of the edges of leaves often not apparent on leaves before the flag leaf (Fig, 2).
3. Secondary fungal attack on the glumes, especially after moist weather conditions (Fig. 3).

---

1. The substance of this paper was presented as an address to the 30th Annual Meeting of the Associate Committee on Plant Diseases, Winnipeg, Man., 20-22 Feb. 1962.
2. National Research Council Post-doctorate Fellow, Plant Research Institute, Canada Department of Agriculture, Ottawa, Ont. Present address: Crop Research Station, Private Bldg, Christchurch, New Zealand.

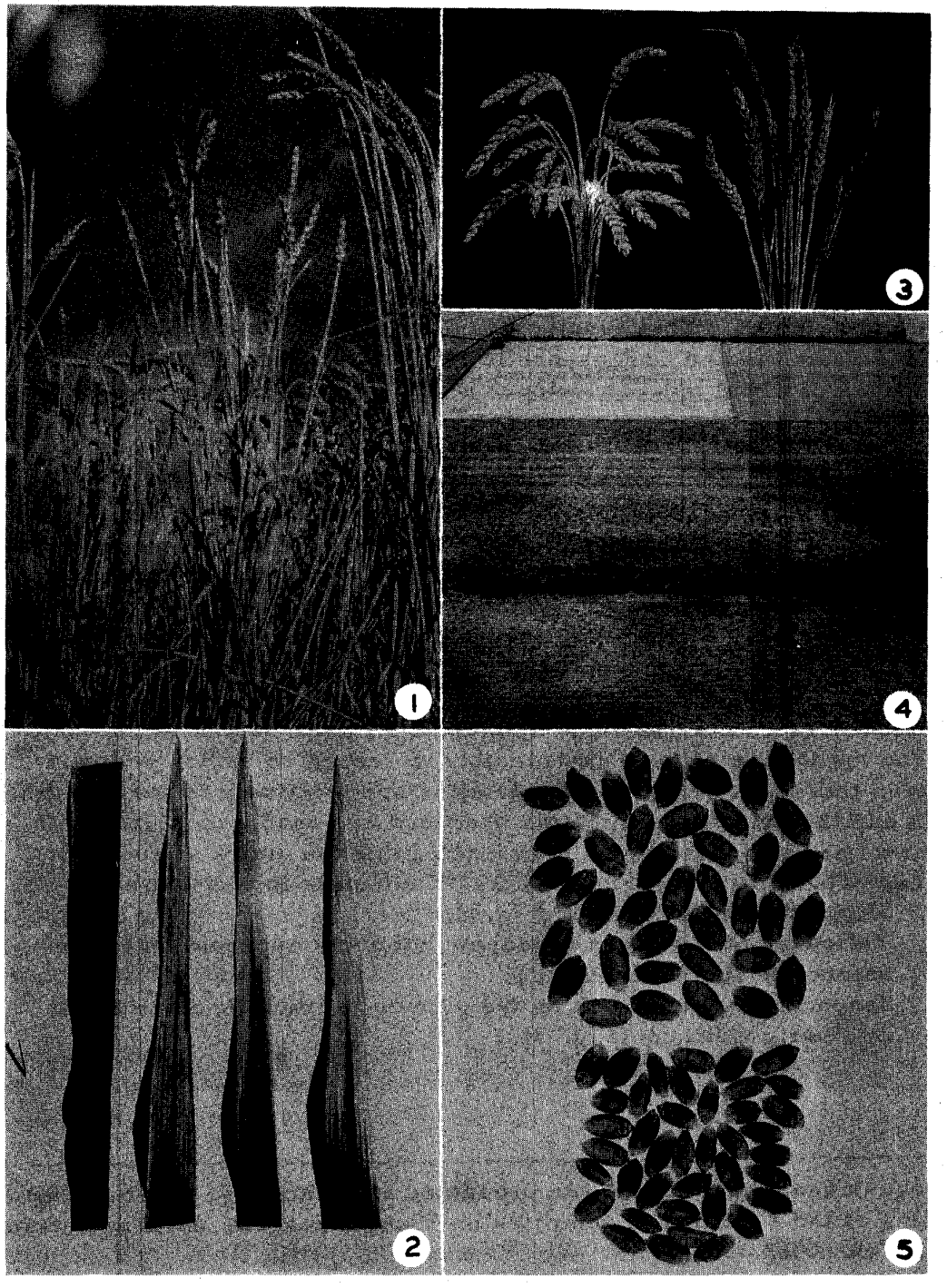

FIG. 1. WHEAT PLANTS STUNTED BY BARLEY YELLOW DWARF VIRUS. FIG.2. WHEAT LEAVES WITH YELLOWING SYMPTOMS TYPICAL OF BARLEY YELLOW DWARF VIRUS. FIG.3. LEFT: BLACKENED ERECT EARS OF WHEAT FROM BARLEY YELLOW DWARF VIRUS INFECTED PLANTS. RIGHT: HEALTHY WHEAT EARS. FIG.4. INSECTICIDE SPRAYED STRIPS WHERE BARLEY YELLOW DWARF VIRUS WAS CONTROLLED IN WHEAT, FIG.5. BARLEY YELLOW DWARF VIRUS EFFECT IN GRAIN SIZE OF WHEAT (STRAIN V34 ON MARQUIS).

Proof of BYDV infection in wheat can be established only through experiments involving the use of virus-free aphid vectors (Rophalosiphum padi). The aphids must be allowed to feed on the living leaf and stem tissues of suspect plants for at least 2 and preferably 3 days before transfer to test seedlings for an infection feeding of 2 days. The seedlings must then be incubated under high light intensity and moderate temperatures (60 - 75°F) for 15 to 25 days in an aphid-free greenhouse or insectary.

The Evidence

Wheat crops in New Zealand may be either autumn- or spring-sown and, every few years, there has been an outbreak of a disease that has resulted in a serious reduction of yield in the autumn- sown crops. The cause of the disease has perplexed plant pathologists and several hypotheses have been advanced regarding its etiology. Following such an outbreak in 1956, a five-year survey of wheat crops was conducted and isolations were made from plants showing "crown rot" or "brown root rot" symptoms. No fungus was consistently isolated from the affected plants, A wide variety of-species of Fusarium and Rhizoctonia were isolated. Inoculation trials with the various isolates were being planned when it was noted that the plants that showed "crown rot" or "black root rot symptoms" were those that also showed symptoms of BYDV infection.

Similarly, an examination of samples of spring wheat, variety Gabo, infected with scab (Gibberella zeae) confirmed the almost complete association of BYDV symptoms and infection by Gibberella. Evidence that the blackening of heads of wheat plants infected with BYDV was due to a susceptibility induced by the virus infection was obtained by greenhouse inoculations of both healthy and BYDV-infected plants. Wheat heads kept under conditions of high humidity were sprayed with spores of Alternaria and Cladosporium species, The glumes of the virus-infected plants were more severely blackened than those of healthy plants.

The Effect of BYDV Infection on Yield.

Field investigations of BYDV in New Zealand over a period of three years failed to demonstrate any practical means of reducing BYDV incidence either by cultural practices or preventative insecticide spraying. In the spring of 1960 a situation arose in which all early autumn-sown wheat fields in the arable district carried moderate to heavy infestations of Rophalosiphum padi, the principal vector of BYDV in New Zealand. Insecticide trials were laid down in an attempt to measure the degree of aphid control, virus control, and the effect on yield.

The results were quite spectacular (Table 1). The best insecticidal treatment, dimethoate (Rogor 40), gave a 38 per cent increase in yield. All treatments, besides giving excellent control of aphids, gave a considerable degree of control of the spread of BYDV as illustrated in Figure 4.

Table 1. Control of BYDV in winter wheat in New Zealand by one application of insecticide

Treatment	Spray Application 6/10/60 Dose oz/ac.	Active Ingredient oz/ac.	R. Aphid Counts per plant 7/10/60	19/10/60	27/10/60	Yield Bu/ac	percent increase over Check
Rogor 40%	12	4.8	1	0	0	69	38
Metasystox 50%	16	8	0	0	0	64	29
DDT 20% E.C.	80	16	11	0	0	63	26
Lindane 20% E.C.	80	16	4	0	0	58	17
Sayfos 80%	4	3.2	67	0	0	55	11
Check	-	-	200	80	20	50	--

It was apparent, from estimates of BYDV infection in the different plots and the relatively complete control of aphids, that the increases in yield were attributable to a reduction in virus incidence rather than to the elimination of feeding damage by the aphid. However, it was deemed adviseable to carry out further trials comparing the effects of virus-free and virus- infective aphids on yield.

A greenhouse trial was carried out at Ottawa using four oat varieties that differed in their tolerance to BYDV and seven wheat varieties. Different numbers of infective and virus-free aphids were given 2-day infection feeding periods on each variety, The plants were then sprayed with an insecticide and kept insect-free in the greenhouse and later in a cold frame outdoors until they had reached maturity. The yields of grain were measured and the effect of BYDV infection was calculated by a comparison of the yields of plants inoculated with infective aphids and the yields of those inoculated with virus-free aphids, The results of this trial are presented in Table 2. Yields of varieties inoculated with infective aphids are expressed as a percentage of yields of the same varieties inoculated with virus-free aphids. Because there were no apparent differences in the relative tolerance to BYDV among the seven wheat varieties, Cascade, Selkirk, Thatcher, Marquis, Red Fife and Huron, their average yield was used in the results shown in Table 2.

'Table 2. Effect of the number of infective aphids on resistance of oats and wheat to BYDV

	RVP strain, ex grass				MGV t RPV strains, ex cereals			
	Aphids per plant				Aphids per plant			
	1-5	10-20	100-200	Mean	1-5	10-20	100-200	Mean
Oat Variety								
Saia C. I 186606	70*	62	33	55	44	28	44	39
Fulghum C.I. 3067	100	100	77	92	73	41	59	58
Albion C. I. 792	36	9	--	23	14	18	--	16
Clintland 60	7	4	4	5	44	25	18	29
Wheat								
Mean, 7 Varieties	100	91	66	86	48	43	35	42

This trial confirmed the fact that the feeding by virus-free aphids for a 2-day period had no measurable effect on yield and that the four oat varieties differed greatly in their relative resistance to BYDV. The resistance of all seven wheat varieties tested was nearly equivalent to that of the most resistant oat variety, Fulghum C. I. 3067. Despite this relatively high degree of resistance they suffered a 50 percent reduction in yield when inoculated with some isolates of BYDV.

A field trial to test the effect on yield of a relatively late inoculation of BYDV into spring-sown wheat and oats was carried out at Ottawa, Two varieties of wheat, Marquis and Cascade, and two of oats, Clintland 60 and Rodney were each incoulated with (1) virus- free aphids, (2) aphids carrying the RPV strain of BYDV and (3) aphids carrying the MGV strain of BYDV. Check plots were provided by spraying plants of the same varieties with an insecticide. The results of this trial are presented in Table 3.

Table 3. Yield of spring oats and wheat inoculated 22 June with 2 strains of BYDV.

	Yield as percent of sprayed check			Symptoms of BYDV		
Variety	Unsprayed "virus- free" aphid inoc.	RPV	MGV	Unsprayed	RPV	MGV
Oats						
Clintland 60	90	49	115*	1**	4	2
Rodney	98	72	72	1	2	2
Wheat						
Marquis	80	42	39	trace	1	2
Cascade	85	47	48	trace	1	1

* The apparent increase in yield is due to the protective action of this strain against severe strains of BYDV from grasses in the locality.

** Severity of symptoms rated on a 0-4 scale.

Clintland 60 was only mildly affected by the MGV strain arid infection with this strain apparently protected it from subsequent natural infections of the more prevalent BYDV strain from grasses. This strain, which occurred even in sprayed plots caused severe symptoms on Clintland 60. The protective effect of the MGV strain against some other strains of BYDV on Clintland 60 oats was subsequently confirmed in three greenhouse trials. Rodney was apparently more tolerant to BYDV infection than Clintland 60.

The symptom8 of BYDV on wheat were very mild and consisted mainly of a premature yellowing of the flag leaf and a slight stunting, The grain harvested from the inoculated plots, however, had a marked shrivelled appearance (Fig, 5). Despite a mild expression of visible symptoms, even the late inoculations with BYDV resulted in a severe reduction in yield,

These trials have confirmed that symptom expression in Canadian wheat varieties infected with BYDV is poor, even though yields may be severely reduced, They also suggest the value of sowing oats along with the wheat in similar trials to give a readily identifiable measure of the prevalence of BYDV in the crops or plots. They have also shown that certain insecticides can give excellent control of BYDV by reducing the aphid population, This is especially true with wheat due to the relatively high degree of tolerance to BYDV which necessitates a higher population of aphids per plant to achieve the same degree of infection as caused by a small population on the more susceptible oats.

PLANT RESEARCH INSTITUTE,
RESEARCH BRANCH, CANADA AGRICULTURE,
OTTAWA, ONTARIO