EFFECTS OF CEREAL HOST, INSECTICIDE AND LOCALITY ON THE INCIDENCE OF BARLEY YELLOW DWARF VIRUS IN THE SOUTH ISLAND

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SUMMARY

In field trials incidence of barley yellow dwarf virus (BYDV) symptoms was less in wheat and rye than in barley and oats. Serological assay showed that symptomless BYDV infection was also present, particularly in wheat and rye. In all cereals, except wheat, yield reduction was prevented by insecticide treatment. Among spring barley cultivars, incidence of BYDV symptoms and yield responses to insecticide were greater in Triumph than in Coracle and intermediate in Magnum and Fleet. Surveys in 1986-1988 showed that incidence of BYDV symptoms was high in Marlborough and mid-Canterbury, low in south Canterbury and north Otago, and negligible in Southland.

INTRODUCTION

Early work on the incidence of barley yellow dwarf virus (BYDV) in the South Island was concerned with wheat; BYDV was not considered to be a problem in barley (Close 1969). More recently, BYDV infection has been slight in winter wheat but was widespread in barley during late 1985 in Canterbury (Stufkens and Farrell 1986). In 1986, up to 5% BYDV infection occurred in winter barley at Lincoln and grain yields were increased by 9% in plots treated with insecticide at the seedling and tillering stages (Stufkens and Farrell 1987). The incidence of BYDV symptoms was significantly lower in Fleet than in Triumph spring barley in recent trials at Lincoln (Stufkens and Farrell 1986, 1987). No recent information is available on regional variation in BYDV incidence in the South Island.

In this paper field trials and surveys are reported which examine the effects of host plants, insecticide and locality on the severity of BYDV disease in South Island cereals during 1986-1988.

MATERIALS AND METHODS

Field trials

In 1987 two field trials at the DSIR research farm, Lincoln, used split-plot designs. Trial 1 comprised four main treatments (Illia barley, Makuru oats, Rongotea wheat and Rapaki rye), in six replicates, sown at a rate of 120 kg/ha on 4 May. Main plots were split into two 30 m^2 (10 × 3 m) subplots, a) sprayed with permethrin (Ambush) and pirimicarb (Pirimor) on 21 August, and b) untreated. Tillers showing symptoms of BYDV (Smith 1963) were counted in one randomly chosen quarter (7.5 m^2) of each subplot on 29 September, and tiller counts were made in a 0.1 m^2 quadrat in each untreated sub-plot on 6 October. Crop canopy height was measured at six points in each barley subplot on 14 October, but these measurements were not made in other cereals.

Trial 2 comprised four main treatments, Triumph, Magnum, Fleet and Coracle barley, in five replicates, sown at a rate of 150 kg/ha on 20 September 1987. Main plots were split into two 25 m^2 (18 × 1.4 m) subplots, a) sprayed with permethrin on 19 October and with pirimicarb on 5 November and b) untreated. Tillers showing symptoms of BYDV were counted in whole subplots on 25 November, and tiller counts were made in a 0.2 m^2 quadrat in each untreated sub-plot on 2 December.

Both trials received superphosphate (200 kg/ha) at sowing and urea (100 kg N/ha) at tillering. Chlorsulfuron (Glean) was applied at tillering. Propiconazole (Tilt) was applied on three occasions during the spring. Cereal growth stage (GS) was recorded on the decimal scale (Tottman 1987) at 1 or 2 week intervals during growth. Grain yields were recorded from subplots at harvest.

Serology

Tillers with and without BYDV symptoms were collected from both trials, crushed in liquid nitrogen, and then ground in a mortar with potassium phosphate buffer (0.5 M, pH 6). The resulting extract was diluted further with phosphate buffer (0.5 M, pH 6). The resulting extract was diluted further with phosphate buffered saline containing 0.05% Tween-20 and 2% polyvinyl pyrrolidone. After centrifuging at 8000 rpm, the samples were assayed by double antibody sandwich ELISA (Clark and Adams 1977) using a rabbit antiserum against a Canterbury isolate of BYDV (J.W. Ashby, pers. comm.).

Survey

Cereal tillers showing symptoms of BYDV were counted in 10-30 m² areas of commercial crops inspected during road transects through cereal-growing areas of the South Island in 1986-1988. Details are given in Tables 4 and 5.

RESULTS

In Trial 1, BYDV symptoms appeared in barley and oats during July, in wheat in August and in rye in September. Counts of infected tillers at late stem extension (29 September) were significantly ($P<0.001$) greater in barley and oats than in other cereals, and had not been affected by insecticide treatment at tillering (21 August) (Table 1). Total tillers/m² (Table 1) indicated that the proportion of tillers showing BYDV symptoms on 29 September was >10% in barley and oats, compared with approximately 4% in wheat and <1% in rye. Subsequently, considerable spread of BYDV occurred and there were visible differences in the incidence of symptoms between treated and untreated plots. Mean barley crop height on 14 October was significantly ($P<0.05$) less in untreated (0.61 m), than in treated (0.67 m). At flowering (mid-November), BYDV incidence was estimated at >90% in untreated, and <50% in sprayed subtreatments of barley and oats, and at <20% and <5% in untreated wheat and rye plots respectively.

Table 1 shows that yield responses to spray were positive and highly significant ($P<0.001$) overall. Significant ($P<0.05$-0.01) yield responses to insecticide (20-30%) were found in barley, oats and rye, but not in wheat. Wheat was severely affected by take-all and stripe rust in two replicates, and this treatment was therefore excluded from split-plot analysis.

TABLE 1: Numbers of cereal tillers showing BYDV symptoms on 29 September (n/m²), grain yields (t/ha) and tiller counts (n/m²) in untreated and insecticide subtreatments of Trial 1. Wheat yields excluded from analysis are in parentheses.

Crop	n/m² tillers	n/m² BYDV tillers untreated	treated	mean	t/ha grain untreated	treated
Barley	870	105.8	76.5	91.2 a	5.00	6.50*
Oats	620	70.3	68.9	69.6 a	4.46	5.38*
Wheat	760	35.8	25.7	30.8 b	(3.81)	(3.83)
Rye	780	1.5	1.3	1.4 c	4.60	5.46**
Mean		53.4	43.1 ns		4.69	5.78***

ns non-significant, * $P<0.05$, ** $P<0.01$, *** $P<0.001$ for comparison within rows, Means bearing different letters are significantly ($P<0.001$) different, for comparison within columns.

In Trial 2, BYDV symptoms appeared in late October. At flagleaf (25 November) counts of infected tillers were greatest in Triumph and Magnum barley, significantly lower ($P<0.01$) in Fleet and least in Coracle. BYDV response to insecticide was negative and highly significant ($P<0.001$) over all cultivars (Table 2). Tiller counts of approximately 830/m² indicated that the proportion of tillers showing BYDV symptoms in Triumph barley was < 3% at the flagleaf stage (GS 41).

The grain yield response to spray was positive and highly significant ($P<0.001$). The interaction between cultivar and insecticide effects was also significant ($P<0.05$), indicating that the yield response to spray varied between cultivars. Analysis of the differences between treated and untreated yields in each main plot showed that the effect of insecticide on Coracle was negligible and significantly ($P<0.05$) less than that in Triumph (Table 2).

TABLE 2: Numbers of barley tillers showing BYDV symptoms (n/m²) on 25 November and grain yields (t/ha) in untreated and insecticide subtreatments of Trial 2.

Cultivar	n/m² BYDV tillers			t/ha grain yield		
	untreated	treated	mean	untreated	treated	Spray yield increase
Triumph	26.2	3.9	15.1 a	5.38	6.42	1.04 a
Magnum	19.6	4.1	11.9 a	6.89	7.42	0.53 a
Fleet	7.7	1.9	4.8 b	6.77	7.39	0.62 a
Coracle	2.1	0.7	1.4 c	5.77	5.82	0.05 b
Mean	13.9	2.7***		6.20	6.76***	

*** $P<0.001$ for comparison within rows. Values bearing different letters are significantly ($P<0.05$-0.001) different, for comparison within columns.

Serology

Table 3 shows that a high proportion of cereal tillers showing BYDV symptoms in both trials were positive for BYDV by ELISA. Symptomless BYDV infections were present in a significantly greater (X^2 = 37.8, df 3, $P<0.001$) proportion of wheat and rye tillers (20-30%) than in barley tillers (5%) in Trial 1. No symptomless infections were detected in spring barley (Trial 2).

TABLE 3: Positive tests /total ELISA tests for BYDV in cereal tillers showing symptoms (+) or symptomless (−). Sampling dates: 21-30 September in Trial 1, 26 November (+) and 8 December (−) in Trial 2.

	Trial 1				Trial 2			
	Barley	Oats	Wheat	Rye	Triumph	Magnum	Fleet	Coracle
+	20/20	20/21	27/28	14/19	10/10	9/10	10/10	10/10
−	1/19	3/19	8/40	13/40	0/30	0/0	0/15	0/15

Survey

BYDV incidence recorded in surveys during 1986 and 1987 was significantly less in wheat than in oats or barley in mid Canterbury, and was similar in oats and barley surveyed in south Canterbury. Average cereal growth stage at sampling was flag leaf extension (1986) or ear emergence (1987) (Table 4). Regional variation in BYDV infection in barley crops during the 1987-88 season is shown in Table 5. Up to 50% infection levels were seen near Blenheim, Marlborough, and near Ashburton, mid Canterbury. BYDV was less severe in south Canterbury and north Otago, and negligible in Southland. Average barley growth stage was at booting in December, and at heading in January.

TABLE 4: Mean ± standard error of n/m² cereal tillers showing symptoms of BYDV, mean growth stage (GS) and number of sites sampled (in parentheses) in mid Canterbury (MC) and South Canterbury (SC).

Area	Date	GS	Barley	Wheat	Oats
MC	31 Oct 86	41	—	<0.1 ± 0.1 (43)	1.1 ± 0.4 (9)
MC	27 Nov 87	47	11.5 ± 4.7 (23)	1.0 ± 0.8 (12)	—
SC	15 Dec 87	51	8.0 ± 1.9 (16)	—	6.6 ± 1.7 (8)

TABLE 5: Mean ± standard error of n/m² spring barley tillers showing symptoms of BYDV; number of sites sampled (in parentheses) and mean barley growth stages in different areas of the South Island on three dates in 1987-88.

Area	2-7 Dec 87	15-18 Dec 87	1-2 Jan 88
Marlborough	89.6 ± 22.9 (14)	—	—
Mid Canterbury	20.9 ± 9.5 (22)	61.5 ± 22.2 (11)	—
South Canterbury	—	6.6 ± 1.5 (33)	7.3 ± 1.8 (16)
North Otago	—	1.3 ± 0.2 (22)	4.3 ± 1.6 (16)
Southland	—	<0.1 ± 0.1 (31)	<0.1 ± 0.1 (28)
Growth stage	45	43	55

DISCUSSION

The incidence of visible BYDV infection was least in rye and significantly lower in wheat than in barley or oats. The presence of symptomless infections in wheat and rye (Table 3) suggests that symptom expression, rather than the extent of virus infection, varied between cereal species. The similarity in yield response to insecticide treatment in rye, barley and oats (20-30%) is consistent with this view. Insecticide treatment did not increase the yield of wheat, where the effects of virus infection may have been masked by stripe rust and take -all infections. Among spring barley cultivars, BYDV incidence and yield response to insecticide treatment were greatest in Triumph, intermediate in Fleet as shown previously (Stufkens and Farrell 1987), and least in Coracle, where resistance to the virus is conditioned by the *Yd2* gene (Parry and Habgood 1986).

There was considerable regional variation in BYDV incidence in the South Island (Table 5). Further monitoring of high-risk areas is required so that BYDV control measures can be adequately implemented.

Two control measures were shown to be effective against BYDV in the present work. Firstly, insecticide treatment of cereals at the tillering stage, recommended by Smith (1963), controlled the spread of BYDV by two vectors; the rose grain aphid (RGA) *(Metopolophium dirhodum* Walker) and the cereal aphid (CA) *(Rhopalosiphum padi* L.) (Stufkens and Farrell, unpublished). Feeding damage by RGA populations of >100 aphids per tiller may also cause loss of yield in barley and oats (Stufkens and Farrell 1985). Reduction of feeding damage may have contributed to the yield response to insecticide in Trial 1, where up to 40 aphids per tiller were recorded in untreated plots (Farrell and Stufkens in press a, b). However, < 1 aphid per tiller was recorded in Trial 2 and yield loss varied with BYDV incidence (Table 2).

Side effects of insecticide on the natural enemies of the predominant species, RGA, may bring disadvantages. Populations of RGA have declined steeply since 1984, coincident with an increase in numbers of the brown lacewing *(Micromus tasmaniae* Walker) and the parasitoid *Aphidius rhopalosiphi* de Stefani-Perez (Farrell and Stufkens in press b). The release of predator pressure on aphid populations by widespread insecticide use could allow outbreaks of RGA with an associated yield loss as was found in 1984 (Stufkens and Farrell 1985).

The second effective control measure was plant resistance in Coracle barley which was associated with a tenfold reduction in BYDV incidence compared with Triumph.

The *Yd2* gene has been incorporated into existing commercial barley cultivars such as Proctor and California Mariout, yielding the new cultivars Shannon (Vertigan 1980) and CM7 (Skaria *et al* 1985) respectively, that are 'near-isogenic' with the parent. Similar work is in progress in Victoria, Australia (Sward in press). The development of virus-resistant cultivars appears to be an appropriate strategy for BYDV control in New Zealand.

BYDV disease was relatively severe at Lincoln and elsewhere in the South Island in the 1987-88 season, compared with a low incidence of the disease in 1983 (Stufkens and Farrell 1986). Increasing BYDV incidence during the period 1983-1987 may be linked with two factors. Firstly, autumn flights of CA and RGA, and their colonization of winter cereals, has increased by a factor of 20 during this period (Farrell and Stufkens, in press a, b). Secondly, RGA, which appeared in the South Island in 1982 (Stufkens and Farrell 1985), comprised 97-100% of aphid immigrants into spring barley at Lincoln in 1986 and 1987 (Farrell and Stufkens, unpublished). The recent increase of BYDV in spring barley, compared with the low incidence in earlier years (Close 1969), may be associated with the presence of this vector.

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