THE TIMING OF SPRAY APPLICATIONS AGAINST POWDERY MILDEW AND LEAF RUST IN BARLEY

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SUMMARY

In late-sown spring barley trials, early infection by powdery mildew and the initial stages of a late epidemic of leaf rust caused significant yield losses, mostly as reductions in the number of ear-bearing tillers. There was no evidence for compensation in the later determined components. Though the late phase of the leaf rust epidemic had greatest effect on grain weight, there were also significant effects on grain number per ear and on tiller survival. Early spraying to control epidemic development is recommended for those crops which are pre-disposed to mildew and rust infection.

INTRODUCTION

In New Zealand, powdery mildew of spring sown barley caused by *Erysiphe graminis* DC f.sp. *hordei* is generally regarded as a disease of little economic significance though in other countries it is significant, and in the United Kingdom it is regarded as the most serious disease problem (Jenkins and Storey 1975). In the Canterbury area, in some years infection levels may be high, especially in late-sown crops and yield increases have been demonstrated (Gaunt, unpublished) when crops were sprayed before the appearance of the disease with a mildew specific fungicide. Leaf, or brown rust, caused by *Puccinia hordei* reduced yields significantly in several investigations (e.g. Arnst and Fenwick 1973). Most loss was induced by the disease in crops which became heavily infected after anthesis, with a resultant loss in individual grain weight due to constraints during the grain filling period (Teng 1978).

In view of the lack of information on the potential yield losses induced by these diseases, and the crop growth stages at which protection should be provided, a series of trials were conducted at Lincoln. The objectives of the trials were to assess the relative importance of the two diseases in late sown barley crops, and to identify the time of constraint, based on an analysis of individual yield components.

MATERIALS AND METHODS

A trial was sown on 7 December 1977 at Kimihia Research Centre. Four cultivars (Manapou, Georgie, Zephyr and Hassan) were sown in a randomised split plot design with four replicate blocks. Fungicides were used to regulate disease levels in different treatment combinations (Table 1). The plots (12 x 1.5 m) were sown adjacent to each

TABLE 1: Experimental treatments applied to field grown plots of barley.

Designation	Early disease ¹	Late disease ²
Nil Disease (N)	+	+
Mildew only (E)	—	+
Rust only (L)	+	—
Mildew plus rust (F)	—	—

1. Triadimenol (22.5 g/100 kg seed) seed treatment plus benodanil (0.75 kg/ha) 36 days after sowing.
2. Triadimefon (125 g/ha) 48 and 59 days after sowing.

Proc. 34th N.Z. Weed and Pest Control Conf.

Cereals

other, with a border strip of barley around the edge of the experimental area.

During crop growth, whole plants were sampled randomly at five growth stages, and analysed for the degree of disease development. Ten main stems per plot were assessed for the percentage area occupied by mildew and rust pustules and the associated chlorotic area (James 1971 a, b). Assessments were recorded for all leaves that had at least some green tissue remaining in the control plots (i.e. healthy plants). From this data, a weighted mean disease severity was calculated, taking into account the size of individual leaves (Lim and Gaunt 1981). At the same times, plants were analysed for the growth stage (Zadoks *et al* 1974) and degree of apical development.

Final harvest was carried out on 16 March 1978, when grain moisture was 18%. Five quadrat samples (0.1 m² each) were removed from each plot, and the total number of plants and ear-bearing tillers recorded. Twenty five sub-sampled plants were analysed for the total number of spikelets and the number of grain-bearing spikelets. The whole quadrat sample was then threshed and analysed for grain number and grain weight. Subsequent to quadrat sampling, the plots were harvested mechanically and the total grain yield determined.

RESULTS

Powdery mildew was first seen 14 days after sowing, and the level of infection increased rapidly to reach a peak when assessed 27 days after sowing at G.S. 31 (Fig. 1). Thereafter the disease declined to low levels of infection by G.S. 65. Hassan and Georgie showed a high and moderate level of resistance respectively, whereas Manapou and Zephyr were susceptible. The leaf rust epidemic developed rapidly after its first appearance at G.S. 31, though high levels of infection were not reached until G.S. 45, after which the epidemic increased till maturity. All cultivars were susceptible to varying

Fig. 1: The development of powdery mildew and leaf rust epidemics in field plots of four cultivars of spring barley.

Cereals

Fig. 2: Influence of fungicide treatments on disease development in spring barley (mean of four cultivars).

degrees to leaf rust, in the order Zephyr ► Manapou ► Hassan ► Gorgie.

The fungicide treatments had similar effects on all four cultivars tested and the results are therefore presented as a mean value for all the cultivars (Fig. 2). Powdery mildew was successfully controlled by the seed treatment with triadimenol, and there was little difference within the pairs of treatments receiving similar treatment up to 36 days after sowing. The control of leaf rust was initiated too late for full control of the early phase of the epidemic, and thus there was little difference between treatments till after G.S. 31, and even at G.S. 45 the differences were not as large as anticipated. Thereafter control was successful in reducing the epidemics in the nil and mildew only plots to low levels relative to the mildew plus rust plots. Since the rust only plots received the benodanil spray at G.S. 31, the epidemic in these plots was reduced relative to the mildew plus rust plots. The resultant treatment combinations enabled comparisons between early combined infections by mildew and leaf rust and high levels of leaf rust at later growth stages. Thus the treatments are more accurately referred to as "early", "late", "full" and "nil" epidemics.

Yield, expressed as the mean of all four cultivars, was reduced equally by the early and late epidemic treatments, and the combined disease effects on yield were additive in the full disease plots (Table 2). Yield reductions in the diseased plots were examined as individual yield components, and are presented in Table 2 for early and late epidemic

TABLE 2: The influence of disease on total yield and yield components in four barley cultivars.

Treatment	Mean yield t/ha	Percentage reduction relative to nil disease		
		Tillers/m ²	Grain No./ear	Grain wt
Nil disease	5.30 a	-	-	-
Early epidemic	4.06 b	14.0	9.7	3.7
Late epidemic	4.21 b	5.7	6.1	11.1
Full epidemic	2.95 c			

Cereals

treatments as percentage losses relative to the nil disease treatment. The major effect of the former was on the number of ear-bearing tillers per unit area, with a lesser effect on the number of grain per ear and a non-significant reduction on individual grain weight. Conversely, the late epidemic treatment mainly influenced the individual grain weight, with lesser effects on the other two components.

DISCUSSION

In this trial, reported in detail elsewhere (Lim 1981), it was shown that early disease epidemics of powdery mildew and leaf rust had a severe effect on the yield of four barley cultivars. Yield was affected by a reduction in the number of ear-bearing tillers, mostly as a result of an effect on tiller survival. The number of grain per ear was also reduced, due to effects on spikelet survival prior to anthesis (Lim 1981). The late phase of the leaf rust epidemic mostly influenced grain weight, but there were also significant effects on the number of ears and grain per ear. These results indicated that disease may influence potential yield from an early stage of plant growth and there was no evidence of compensation for these effects in the later determined components. It is frequently stated that the grain-filling stage of plant growth is the most important to consider in relation to the presence of disease. Our results suggest that greater attention should be given to earlier effects on yield potential in view of the lack of compensation in this crop system.

Jenkins and Storey (1975) showed that a single spray of tridemorph was most effective in increasing yield by controlling mildew epidemics in British spring barley crops when applied before there was more than 10% of leaves 3 and 4 (from the top of the plant) occupied by the disease. Their data suggested that this may have been due in part to the effect on the amount of inoculum available for further development of the epidemic. However, a part of the success could be attributed to the elimination of effects of the early part of the epidemic on yield potential (Teng and Gaunt 1981). We believe that the apparent lack of response to control of powdery mildew in cereals in New Zealand may in part be explained in terms of the lateness of application of control measures.

For late-sown crops, suitable fungicides should be applied as soon as powdery mildew is present in the crop on the lower leaves. Similarly, for leaf rust it has been shown that the best yield response is achieved if crops are sprayed soon after appearance of the disease, especially for late-sown crops (Teng 1978).

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