

EFFECTS OF FUNGICIDE RATES AND TIMING ON CONTROL OF STRIPE RUST IN WHEAT

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ABSTRACT

A field trial was conducted to evaluate control options of stripe rust in a 1997/98 crop of spring sown Otane wheat near Methven. Three fungicides were evaluated for disease control, at half and label recommended application rates and at three timings. Disease levels were assessed at five dates. Plots were harvested and yield components recorded. In this trial where stripe rust appeared relatively early, the first spray had the greatest effect on disease severity. All three fungicides reduced disease severity compared to the untreated plots but azoxystrobin reduced disease more than epoxiconazole or tebuconazole. A full application of any of the three fungicides at application time 1 gave similar disease control to two half rate applications (Time 1 plus Time 2 or Time 3). Yield was significantly increased by both azoxystrobin and epoxiconazole at application Time 1.

Keywords: *Puccinia striiformis*, fungicide timing, fungicide rates, disease control.

INTRODUCTION

Stripe rust of wheat (*Triticum aestivum* L.), caused by *Puccinia striiformis* Westend. f. sp. *tritici* Erriks., was first detected in New Zealand in November 1980, causing yield losses of up to 60% in the susceptible cultivars which prevailed in New Zealand at the time (Beresford 1982). Fungicides were a very important method for control of stripe rust in wheat crops. Seed treatment with an appropriate fungicide provided up to eight weeks protection from stripe rust and regular foliar application of fungicides, approximately every three to four weeks, maintained a suitable level of control (Cromey *et al.* 1993).

Since the arrival of stripe rust, considerable effort has gone into breeding resistant cultivars (Cromey 1992). However, use of fungicides continues to be an important component of stripe rust control because some cultivars rely on partial (adult plant) resistance and the resistance of others may be eroded with the appearance of new rust pathotypes (Cromey 1992).

It is appropriate to re-evaluate the use of fungicides to control stripe rust because most current New Zealand wheat cultivars have at least a moderate level of stripe rust resistance. This study has compared three fungicides (two currently registered and one under evaluation) at full recommended, or half rates, and at three application timings, for the control of stripe rust in Otane wheat, a cultivar possessing a moderate level of adult plant resistance.

METHODS

Trial sites

A field trial was conducted on the property of Mr David Wright, Darts Road Methven, Mid Canterbury. The trial was in a crop of Otane wheat sown on 25 August, 1997, in a Hororata-Mayfield stony alluvial clay (yellow grey earth).

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Fungicide treatments and applications

Three fungicide treatments (Table 1) were applied at either the manufacturer's recommended rate or half the recommended rate. Treatment plots (11 x 2 m) were sprayed with fungicide treatments on one or more of three occasions: Time 1 (T1), 27 October 1997, Growth stage (GS) 33 (third node just visible, Zadoks *et al.* 1974); Time 2 (T2), 20 November 1997, GS 49 (awns just visible); and Time 3 (T3), 11 December 1997, GS 65 (late flowering). Fungicide treatments were applied using a compressed air back-pack sprayer with a hand-held boom fitted with Spraying Systems 110^P -02 nozzles applying 300 litres/ ha at 300 kPa.

TABLE 1: Fungicides applied to spring wheat.

Common name	Trade name	Active ingredient (%)	Application rate (litres/ha)	
			Half	Full
azoxystrobin	Amistar	25	0.50	1.00
epoxiconazole (proposed)	Opus	50	0.50	1.00
tebuconazole	Folicur 430 SC	43	0.22	0.44

Experimental design

The trial was designed with two replicate blocks. Each replicate block was divided into six sub-blocks, with the three chemicals by two rates randomly allocated to these sub-blocks (one chemical and one rate assigned to each sub-block). Each sub-block consisted of eight plots to which were randomly allocated all possible combinations of nil, one, two or three applications of the following treatments: 1) no applications; 2) - 4) single application at T1, T2 or T3; 5) - 7) two applications (T1 + T2, T1 + T3, T2 + T3); 8) three applications (T1 + T2 + T3).

The trial site was surrounded by a non-irrigated wheat crop which received the standard agronomic treatments of that crop, except for fungicide applications.

Assessment

The trial site was assessed for the incidence of stripe rust infection prior to the first fungicide application. One hundred randomly selected plants were examined for the presence or absence of stripe rust sporulation. On two occasions associated with fungicide applications T2 and T3 (25 November and 9 December, respectively) and five and 12 days following the final fungicide application (16 and 23 December), twenty flag leaves from each trial plot were scored for percent leaf area affected by stripe rust. The trial was mechanically harvested on 28 January 1998. Total yield (t/ha adjusted to 14% moisture) and thousand grain weight (TGW) were recorded. All data were statistically analysed using analysis of variance.

RESULTS

Stripe rust was first detected at GS33, the time of the first fungicide application (T1). Disease continued to develop over a four week period (to GS49). Subsequent disease levels remained similar due to dry weather. Results are presented in Tables 2 and 3. Table 3 examines the main effects of times of fungicide application. The least significant effect (LSEffect) determined whether a change in area under the disease progress curve (AUDPC) or yield was significant. By contrast, the least significant difference (LSD) was used to compare changes in AUDPC or yield between the different fungicide treatments.

All fungicide treatments at recommended rates significantly reduced leaf area senesced due to stripe rust, except for epoxiconazole at T3 (Table 2). Multiple applications of all three fungicides at half recommended rates significantly reduced leaf area senesced. However, results were variable for single applications at half recommended rates.

For each plot, disease assessments were used to calculate the AUDPC. This takes into account changes in disease severity over the duration of the trial (Tables 2 and 3).

Azoxystrobin and tebuconazole significantly reduced disease development at most times and rates of application when compared with the untreated (Table 2). Epoxiconazole applied at the recommended rate significantly reduced disease development when applied at T1, T1+T2 and T1+T2+T3. Irrespective of fungicide or rate, treatments which included a fungicide application at T1 provided the greatest reduction in AUDPC (Tables 2 and 3). A single full-rate application of azoxystrobin at T1 reduced the AUDPC to well under half that of the corresponding untreated (Table 2). In general, multiple fungicide applications (T1+T2, T1+T3 and T1+T2+T3) at recommended rates did not significantly reduce AUDPC further compared to the single application at T1. Single fungicide applications at T2 or T3 did not significantly reduce AUDPC except for tebuconazole at the recommended rate at T3.

Effects of fungicide treatments on yield were generally small, variable and mostly not significant (Tables 2 and 3). Recommended rates of azoxystrobin (T1+T3) and epoxiconazole (T1+T2, T1+T3, and T1+T2+T3) did significantly increase yield (t/ha) when compared to the untreated. Fungicide treatments had little effect on thousand grain weight (data were not presented).

TABLE 2: Percent leaf area senesced by stripe rust, area under the disease progress curve and yield (t/ha) in Otane wheat treated with three fungicides. Treatments which differ from the untreated are marked * = P<0.05; ** = P<0.01; * = P<0.001.**

Treatment	azoxystrobin		tebuconazole		epoxiconazole	
	0.5	1.0	0.5	1.0	0.5	1.0
Percent leaf area senesced						
Untreated	18.9	20.4	20.5	16.7	15.3	17.8
Time 1 (T1)	10.9*	8.1**	12.7*	11.0**	13.5	4.3**
Time 2 (T2)	9.2*	6.2**	14.3	9.5**	10.7	4.7**
Time 3 (T3)	12.7	11.7*	16.3	8.4***	18.6	12.4
T1+T2	6.2**	3.0***	8.0**	6.8***	4.5*	8.5*
T1+T3	6.8*	4.6***	11.7*	9.2***	6.9*	7.1**
T2+T3	13.3	5.1***	13.9*	5.3***	7.0*	6.0**
T1+T2+T3	3.3**	4.3***	5.6**	8.8***	7.6*	4.0**
LSD 5%	7.7	6.4	6.5	3.2	8.1	6.7
Area under the disease progress curve						
Untreated	873	822	840	886	741	807
Time 1 (T1)	460***	334***	625*	600*	629	546*
Time 2 (T2)	759	725	752	757	680	751
Time 3 (T3)	738	833	846	704*	779	789
T1+T2	295***	273***	559**	537**	543	509**
T1+T3	321***	291***	608**	642*	526	637
T2+T3	589*	635*	822	627*	678	667
T1+T2+T3	318***	318***	640**	518**	531	509*
LSD 5%	147	166	123	180	230	222
Yield (t/ha)						
Untreated	5.8	6.0	6.0	5.9	5.7	5.4
Time 1 (T1)	6.0	6.4	6.4	5.8	6.3	5.5
Time 2 (T2)	5.9	6.3	6.1	6.2	5.7	5.9
Time 3 (T3)	5.6	6.1	6.2	5.7	6.1	5.5
T1+T2	6.1	6.8	6.5	5.9	5.9	5.9*
T1+T3	5.9	7.0*	6.4	6.2	6.1	6.0**
T2+T3	5.8	6.6	6.8*	6.0	5.6	5.7
T1+T2+T3	6.1	6.8	6.6	6.3	6.0	5.9*
LSD 5%	0.4	0.9	0.8	0.4	0.8	0.5

Few treatments significantly increased yields in comparison with untreated (Table 2), although the mean yield for a single application of fungicide at T1 was 6.1 t/ha, compared with 5.8 for the untreated, suggesting a yield increase of 5%. Multiple fungicide applications gave a better yield response than a single application.

Table 3 examines the main effects of times of fungicide application. The least significant effect (LSEffect) in Table 3 determines whether a change in AUDPC or yield is significant. By contrast, the LSD is used to compare changes in AUDPC or yield between the different fungicide treatments. Treatments including an application at T1 reduced the AUDPC most, compared with treatments not including an application at T1. Smaller reductions were recorded for application at T2 or T3. Treatment with azoxystrobin resulted in greater reduction in AUDPC than treatment with tebuconazole or epoxiconazole, which were similar in response. Overall, the effect of application rate on AUDPC was small.

In general, effects of treatments on yield were small and not significant (Table 3). Treatments including an application at T1 generally resulted in greater yield increases than application at T2 or T3. There were almost no effects of fungicides on thousand grain weight, so these data are not presented.

TABLE 3: Application time effect of fungicides on stripe rust area under the disease progress curve (AUDPC) and yield in a wheat trial. Values presented are changes induced by the fungicides; significant changes are denoted by * = $P < 0.05$; ** = $P < 0.01$; the least significant change is the LSEffect (5%). The LSD (5%) is for comparing changes induced by different fungicide treatments.

Treatments	Rate	Area under the disease progress curve (AUDPC)			Yield (t/ha)		
		Time 1 T1	Time 2 T2	Time 3 T3	Time 1 T1	Time 2 T2	Time 3 T3
azoxystrobin	0.5	-391**	-107	-105*	0.24	0.16	-0.09
	1.0	-450**	-82	-19	0.50**	0.23	0.25
tebuconazole	0.5	-207**	-36	35	0.15	0.23	0.23
	1.0	-169**	-98	-72*	0.09	0.21	0.06
epoxiconazole	0.5	-162**	-61	-20	0.31*	-0.24	0.04
	1.0	-203**	-86	-2	0.19	0.24	0.09
LSEffect 5%		98	124	71	0.19	0.40	0.30
LSD (5%)		139	175	101	0.42	0.56	0.42

DISCUSSION

Time of fungicide application was critical in reducing stripe rust epidemic development in this trial, which used the moderately resistant wheat cultivar Otane. The first application during late stem elongation, when stripe rust was restricted to scattered infections, provided the best control of the disease. Even two full-rate applications made after the disease epidemic had become established did not provide as good overall disease control as a single application in the early stages of disease development.

The critical factor in timing of fungicide application is the presence of disease, rather than growth stage of the crop *per se*. For instance, in another trial in the same season, where stripe rust was first observed after ear emergence, a fungicide application during early flowering was more effective than an application at booting (Cromey unpubl. data). It is not possible to predict the onset and timing of stripe rust epidemics because they are affected by inoculum availability and pathotype, cultivar and environment. It is therefore important to monitor crops for disease, in order to optimise the timing of fungicide applications.

The fungicides investigated here differed in their efficacy of control of stripe rust. The two demethylation inhibitor (DMI) fungicides tebuconazole and epoxiconazole (both currently registered for the control of stripe rust in New Zealand) reduced stripe rust development in this trial. However, azoxystrobin, a fungicide of the newer strobilurin group provided a higher level of control of stripe rust than these DMI fungicides.

The hot dry conditions experienced during the trial were not conducive to the development of a severe epidemic of stripe rust. Otane has a moderate level of adult plant resistance to stripe rust, but can sustain a steady disease epidemic under cooler, wetter conditions (Cromey 1992). While the epidemic was sufficient to provide good differentiation of treatments, seasonal effects on disease and yield meant that treatment effects on yield were mostly small. Nevertheless, the treatments with lowest AUDPCs (two or more applications of azoxystrobin including one at T1) increased yields by an average of 15%, or 0.9 t/ha. Yield responses, especially in terms of t/ha, would have been greater in a season with more normal rainfall.

The cost effectiveness of fungicide applications is important. While three full applications of fungicides provided good disease control and maximised yield increases, yield responses from such high fungicide inputs are unlikely to be economic in a moderately resistant cultivar such as Otane, even in a season more conducive to disease development. In this trial, a single full application of fungicide at T1 would have been economic.

While stripe rust is the most important foliar disease of wheat in New Zealand, it is not the only disease. An application of fungicide is clearly important in the early stages of stripe rust epidemic development, but in this trial, a split application of fungicide, with half rates applied early and late, reduced AUDPCs as much as an early single full application early. In a season with more summer rainfall and a slower ripening period, a late application of fungicide may be beneficial for control of late season pathogens such as *Didymella exitialis* (Mace and Cromey 1996).

Seasonal differences can have a dramatic effect on stripe rust epidemics. It is important that trials such as this one are repeated to provide data for development of stripe rust control guidelines for moderately resistant cultivars which take into account environmental differences between seasons.

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