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THE EFFECTS OF WHEAT RUSTS IN THE MANAWATU

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ABSTRACT

Ten wheats, comprising two susceptible lines to each of the wheat rusts *Puccinia striiformis, P. recondita* and *P. graminis,* plus four standard cultivars, were protected by four different spraying regimes. The trial was grown in the Manawatu with two sowing dates for two seasons. In both seasons moderate to heavy natural infections of stripe and leaf rust occurred, but stem rust was hardly observable and appeared too late to have any clear effect. Significant responses to the spraying treatments were measured and differences between the wheats could be related to which rust was infecting the line, the degree of infection, and the stage of plant development at which infection occurred. There was a maximum response of 305% in the most stripe rust-susceptible line, while other lines showed no significant responses to any of the treatments.

KEYWORDS

Puccinia striiformis, P. recondita, P. graminis, stripe rust, leaf rust, stem rust, rust resistance, rust susceptibility.

INTRODUCTION

Stripe rust (*Puccinia striiformis* West), leaf rust (*P. recondita* f. sp. *tritici*), and stem rust (*P. graminis* f. sp. *tritici*) are common diseases of wheat throughout the world. Since the arrival of stripe rust in New Zealand in 1980, it is not uncommon to find all three rusts in the one area, particularly in the lower North Island. Burnett and McEwan (1982) described notable changes in the presence and epidemology of wheat rusts in the Manawatu during the 1981/82 season after the arrival of stripe rust and new races of leaf and stem rusts.

Leaf and stem rusts have long been recognised as potentially serious diseases in New Zealand wheat crops. In 1930, increases in yield of up to 96% were measured when leaf and stem rusts were controlled in wheat at Palmerston North (Neill, 1931). More recent information on the effect of leaf rust is scarce, but Burnett and McEwan (1982) discuss a significant reduction in yield of 6% in the cultivar Takahe, even though there was a low incidence of disease. In Canterbury, Close (1967) measured increases in yield of up to 40% in small-plot trials when stem rust was controlled in the cultivar Hilgendorf. Burnett and McEwan (1982) estimated yield loss to be up to 60% by comparing crops of Karamu infected with stem rust against uninfected crops.

Recently, stripe rust has also caused severe losses. In Southland a yield loss of 62% in the highly susceptible cultivar Takahe has been measured (Risk and Beresford, 1982), and in Canterbury a loss of 43% was measured in Rongotea (McCloy, 1982). Fungicide control strategies, based upon seed treatment and foliar sprays in relation to infection and epidemic development, have been recommended for all three rusts (Close, 1980; Hedley and McCloy, 1982; Cole and Gaunt, 1984). Gaunt (1982) discussed more long term breeding strategies and Wright and Sanderson (1982) showed that these are likely to be successful relatively quickly since there is a lot of highly resistant material within the New Zealand breeding programmes.

The present study was started in response to the increased incidence of rust in wheat crops of the lower North Island and the scarcity of yield information in relation to disease attack. The study aimed to assess overall yield loss due to each of the three wheat rusts in the Manawatu district; to assess different spraying regimes in the light of Southland experience; and to assess the accuracy of measuring yield loss by visual scoring of each rust.

MATERIALS AND METHODS

Two advanced lines that are susceptible to stripe rust but resistant to leaf and stem rust were selected from the Crop Research Division, Palmerston North, spring wheat breeding programme. Similarly, two other lines were selected in turn for their susceptibility to each of leaf or stem rust and resistance to the others. These six lines, together with two others that are fully resistant to all three rusts and the standard cultivars Karamu and Oroua, were sown for the 1983/84 season in a four replicate split plot trial, with sprays on main plots and genotypes in subplots. The trial was sown on two dates, both at the DSIR Aorangi farm, Palmerston North, to ensure infection by the late season leaf and stem rusts. A similar pair of trials were sown the following season, except that the two resistant lines were replaced by Tiritea, a highly stripe rust susceptible standard cultivar and Otane, a new cultivar moderately resistant to stripe and stem rust and fully resistant to leaf rust.

Table 1. Dates (day.month) and growth stages of spraying, first rust observation and assessment in the early (E) and late (L) trials in 1983/84 and 1984/85.

	Spraying dates			
	83/84 E	83/84 L	84/85 E	84/85 L
Spraying treatments				
1	None	None	None	None
2	2.11 (29)[1]	16.12 (37)	7.11 (30)	27.11 (33)
3	2.11	16.12	7.11	27.11
	7. 1 (80)	24. 1 (77)	19.12 (73)	9. 1 (77)
		9. 2 (84)		
4	2.11	16.12	7.11	27.11
	25.11 (47)	7. 1 (65)	27.11 (55)	19.12 (65)
	16.12 (69)	24. 1	19.12	9. 1
	7. 1	9. 2	9. 1	25. 1
First rust observation				
Stripe	2.11 (29)	15.12 (37)	7.11 (30)	26.11 (33)
Leaf	3. 1 (77)	21. 1 (75)	16.12 (71)	8. 1(77)
Stem	-	1. 2 (80)	15. 1 (87)	-
Disease assessment				
Stripe	6. 1 (80)	19. 1 (75)	7. 1 (83)	20. 1 (83)
Leaf	20. 1 (85)	7. 2 (83)	7. 1 (83)	29. 1 (87)
Stem	-	20. 2 (87)	25. 1 (90)	-

[1] Zadok's growth stages (Tottman *et al.,* 1979).

In 1983 the two trials were sown on 9 September and 28 October, and in 1984 on 4 September and 3 October. Untreated seed was drilled with a cone-seeder into three-row plots with 15 cm between rows and 30 cm between plots, each 5.5 m long. The sowing rate was 1000 seed/plot, approximately equivalent to a sowing rate of 200 kg/ha. A post emergent herbicide was applied at 200 g/ha dichloroprop, 50 g/ha MCPA, and 6.2 g/ha dicamba (Trident) to control broadleaf weeds.

The main spraying treatments were separated by a buffer strip consisting of a mixture of three lines each highly susceptible to one of the three rusts. A propane operated sprayer was used to apply 125 g/ha triadimefon (Bayleton) following four spraying regimes:

1. no spraying,
2. spraying at first sign of stripe rust,
3. spraying at first sign of stripe rust plus a second spraying when leaf rust appeared,
4. spraying about every three weeks to give complete protection.

The plots were assessed for each rust after natural infection on a scale of 0 (no visible symptoms) to 9 (fully susceptible) at the stage of maximum disease development. This system of scoring is commonly used to assess material in New Zealand cereal breeding programmes (Munro and Sanderson, 1985). Table 1 gives the spraying dates, crop development stages and dates when the rusts were first observed in each of the trials. The plots were harvested with a small self-propelled combine and the grain yields recorded at 15% moisture.

RESULTS AND DISCUSSION

The levels of rust infection in the four trials are given in Tables 2 and 3. The overall severity of stripe rust and leaf rust was similar in both years, although the relative levels within the early and late trials in each year were different. During the 1983/84 season a second stripe rust race (106E139A⁻) appeared in the Manawatu (C.R. Wellings, pers. comm.), causing relatively more damage in the late trial. The increased stripe rust scores for Lines 7, and 8, and for Oroua, which were selected for resistance to the only race (104E137A⁻) present previously, shows they are susceptible to the new race. In 1984/85 the two 'resistant' lines were replaced by Tiritea and Otane. In contrast to the previous season, the 1984/85 late trial showed decreased stripe rust infection. The leaf rust scores indicate a similar trend, very little difference between the trials in 1983/84, but decreased infection in the late trial in 1984/85. There was very little stem rust found in any plot, except in Line 6 in the 1983/84 late trial. The other stem rust susceptible lines also showed a moderate level only in this trial.

The overall effect of the four spraying treatments on yield and the differences between the early and late trials are given in Table 4. In spite of moderately good control by the treatments, there were no significant yield responses in the 1983/84 early trial. All other trials gave significant responses, although multiple spraying (Treatment 4) did not always boost yields over one or two sprays. As expected, there was little overall difference between Treatments 2 and 3, since Treatment 3 was expected to

Table 2. Stripe, leaf, and stem rust scores in the early (E) and late (L) trial in 1983/84.

Line	Rust susceptibility	Rust scored	83/84 E Spraying treatments 1	2	3	4	83/84 L Spraying treatments 1	2	3	4
		Stripe								
1	Stripe		5.5	3.2	3.0	1.2	5.7	3.5	3.5	3.5
2	Stripe		4.0	3.2	2.7	1.2	6.2	3.7	3.7	3.7
3	Leaf		1.2	1.0	1.0	-	1.7	1.5	1.5	1.2
4	Leaf		0.5	0.2	0.5	-	1.5	1.0	0.5	0.7
5	Stem		-	-	-	-	1.5	0.5	1.0	0.5
6	Stem		-	-	-	-	1.0	0.7	0.7	0.5
7	None		0.5	0.5	-	-	4.5	3.0	2.2	2.7
8	None		0.7	0.7	0.5	-	3.5	2.0	2.2	2.0
Karamu	Leaf/stem		-	-	-	-	-	-	-	-
Oroua	None		1.5	1.0	1.0	-	4.0	2.7	2.2	2.7
		Leaf								
1			-	-	-	-	-	-	-	-
2			-	-	-	-	-	-	-	-
3			4.7	5.0	3.5	2.7	4.5	4.5	3.0	0.5
4			5.2	5.5	3.7	2.0	5.5	5.5	3.0	-
5			-	-	-	-	-	-	-	-
6			-	-	-	-	-	-	-	-
7			-	-	-	-	0.2	0.2	0.2	-
8			-	-	-	-	-	-	-	-
Karamu			5.2	5.2	4.0	2.7	6.0	5.7	3.0	0.5
Oroua			-	-	-	-	-	-	-	-
		Stem								
1			(None in 83/84 E)				-	0.2	-	-
2							0.5	0.7	-	-
3							1.0	1.5	0.7	0.5
4							1.0	1.2	0.7	0.2
5							3.5	3.7	2.7	1.0
6							6.5	6.2	5.0	2.0
7							0.5	0.2	-	-
8							-	-	-	-
Karamu							3.2	3.0	2.2	0.7
Oroua							0.7	1.0	-	-

cause a response in the leaf and stem rust susceptible lines only. The inclusion of the highly susceptible Tiritea in 1984/85 caused the overall responses to be larger that season than in the previous year.

There was a highly significant difference in overall yield between the early and late trials in both years, but a reversal in direction between the seasons. This can partially be explained by the different levels of rust observed in the trials; relatively more in the 1983/84 late trial and relatively less in the 1984/85 late trial. However, the two seasons were also climatically quite different (Table 5) allowing higher overall yields in the 1983/84 season and, by different genotypic responses, contributing to the relative difference between the two sets of trials. The spraying x season x site interaction was also highly significant, with the yield responses being greatest in the lowest yielding trial (84/85E), nonsignificant in the highest yielding trial (83/84E) and very similar in the two other intermediate yielding trials. This result contrasts with autumn sown Rongotea in Canterbury, where McCloy (1982) measured the greatest responses in the highest yielding site. More results are needed before this difference between autumn and spring responses can be confirmed, but it emphasises the large seasonal influence upon the effects of rust diseases and therefore the difficulty in making generalised protection recommendations.

Table 6 gives the genotype x spraying treatment means in the 1983/84 trials. There were no clear trends in the early trial and rust incidence does not explain the high response to Treatment 2 by Lines 1 and 2. The high response by Line 6 to all three spraying treatments is probably because of a lower than expected yield in Treatment 1. The patterns are much clearer in the late trial. The two stripe rust susceptible lines (1 and 2) both responded to the spraying treatments. Line 1 showed no difference between the sprayings, just as the rust levels would predict, whereas Line 2 showed a stepwise response in spite of there being no difference in rust recorded. Lines 7, 8, and Oroua (susceptible to the new

Table 3. Stripe, leaf, and stem rust scores in the early (E) and late (L) trial in 1984/85.

Line	Rust susceptibility	Rust scored	84/85 E Spraying treatments 1	2	3	4	84/85 L Spraying treatments 1	2	3	4
		Stripe								
1	Stripe		3.7	2.5	2.7	-	2.0	1.0	-	-
2	Stripe		5.5	2.2	1.5	-	1.2	1.0	1.0	-
3	Leaf		-	-	-	-	-	-	-	-
4	Leaf		-	0.5	-	-	-	-	-	-
5	Stem		-	0.5	-	-	0.5	-	-	-
6	Stem		-	-	-	-	-	-	-	-
Tiritea	Stripe		9.0	5.0	5.7	0.5	8.0	4.0	4.0	-
Otane	None		-	1.0	-	-	1.2	-	-	-
Karamu	Leaf/stem		-	-	-	-	-	-	-	-
Oroua	Stripe		3.0	3.2	1.2	-	1.7	1.0	-	-
		Leaf								
1			1.0	0.5	-	-	1.2	-	-	-
2			0.5	1.7	1.5	0.5	1.3	-	1.0	-
3			6.0	5.5	3.5	3.0	5.0	2.0	2.0	-
4			7.2	6.7	4.2	3.7	5.0	3.0	3.0	0.5
5			-	-	-	-	0.5	-	-	-
6			-	-	-	-	-	-	-	-
Tiritea			-	-	-	-	-	-	-	-
Otane			-	-	-	-	-	-	-	-
Karamu			6.7	5.7	3.2	2.5	5.5	3.0	3.0	0.5
Oroua			-	-	-	-	-	-	-	-
		Stem[1]								

[1]Only lines 5 and 6 slightly infected in 84/85 E; no lines infected in 84/85 L.

Table 4. Relative yields for the overall effect of the four spraying treatments and two sowing dates in the 1983/84 and 1984/85 trials.

Spraying treatments	Yield, relative to Treatment 1 (comparison within columns) 83/84 E	83/84 L	84/85 E	84/85 L
1	100(2117)[1]	100(1828)	100(1370)	100(1669)
2	104	107	114	108
3	103	108	118	109
4	102	113	124	112
LSD 0.05	NS	4	4	5
CV	7.4	8.1	7.1	8.8
Sowing date mean effect				
	100 (2168)	90	100 (1565)	114
LSD 0.05	3		3	
CV	9.7		8.3	

[1]Yield g/plot.

Table 5. Summary of mean monthly temperature and rainfall data during the growing seasons in 1983/84 and 1984/85.

	1983/84		1984/85	
	Mean temp. (°C)	Total rainfall (mm)	Mean temp. (°C)	Total rainfall (mm)
September	15.2	113.4 (21)[1]	15.3	51.9 (10)
October	17.1	48.1 (16)	16.3	57.2 (12)
November	18.6	37.9 (9)	19.8	85.8 (10)
December	19.7	81.5 (16)	22.7	78.7 (13)
January	21.1	25.1 (10)	23.6	170.8 (14)
February	22.3	54.9 (9)	23.1	43.7 (5)
March	22.4	113.4 (12)	21.1	37.6 (8)

[1]Total number of rain days.

Table 6. Relative yields for the spraying treatments within genotypes in the 1983/84 trials.

Line	Rust susceptibility	83/84 E Yield, relative to genotype x Treatment 1 (comparison within rows) Spraying treatments 1	2	3	4	LSD 0.05
1	Stripe	100(2009)[1]	112	105	105	10
2	Stripe	100(2105)	111	98	102	9
3	Leaf	100(2239)	103	102	106	9
4	Leaf	100(2405)	99	107	101	8
5	Stem	100(1667)	108	96	102	12
6	Stem	100(1754)	116	116	112	11
7	None	100(2331)	93	101	101	8
8	None	100(2084)	97	107	102	9
Karamu	Leaf/stem	100(2418)	103	98	97	8
Oroua	None	100(2157)	105	100	98	9
				83/84 L		
1		100(1428)	134	130	137	12
2		100(1704)	102	113	128	10
3		100(1989)	94	110	106	8
4		100(1919)	101	103	106	9
5		100(2064)	98	97	106	8
6		100(1976)	102	116	102	8
7		100(1895)	118	112	111	9
8		100(1941)	106	101	110	9
Karamu		100(1627)	121	108	124	10
Oroua		100(1752)	109	100	113	10

[1]Yield g/plot.

stripe rust race) gave moderate responses. Of the leaf rust susceptible lines (3, 4, and Karamu), only Karamu gave a significant response, possibly due to an interaction with the stem rust that was also present in this cultivar. This result supports the suggestion of Burnett and McEwan (1982) that control of both leaf and stem rust might be possible by timing spraying on appearance of leaf rust. The reduction in leaf rust observed between Treatments 1, 2, and 3 for these lines was not clearly reflected by their yields, probably because the second spray of Treatment 3 was so late. Close (1980) only recommends spraying for leaf rust if the disease is present at flowering (GS 65), but in these trials it did not appear until well into milk development. The other stem rust susceptible lines (5 and 6) showed no clear responses.

Table 7 gives the results for the 1984/85 trials. As in 1983/84, the responses are larger in the lower yielding trial, except that for this season this was the early trial. In the early trial all four stripe rust susceptible lines (1, 2, Tiritea, and Oroua) gave large responses and in general followed the pattern (4 3 = 2 1) predicted by the rust scored. The huge response by Tiritea, even to a single spray, indicates the potential destructiveness of this disease when highly susceptible material is grown. In the late trial the responses by these lines were reduced, with clear differences showing

Table 7. Relative yields for the spraying treatments within genotypes in the 1984/85 trials.

Line	Rust susceptibility	84/85 E Yield, relative to genotype x Treatment 1 (comparison within rows) Spraying treatments 1	2	3	4	LSD 0.05
1	Stripe	100(1301)	121	128	135	9
2	Stripe	100(1514)	114	111	118	8
3	Leaf	100(1570)	104	111	115	8
4	Leaf	100(1468)	105	112	103	8
5	Stem	100(956)	116	121	117	13
6	Stem	100(1732)	103	105	109	7
Tiritea	Stripe	100(571)	246	240	305	22
Otane	None	100(1682)	100	106	111	7
Karamu	Leaf/stem	100(1523)	103	109	113	8
Oroua	Stripe	100(1382)	118	121	131	9
				84/85 L		
1		100(1931)	102	98	101	6
2		100(1614)	105	101	116	8
3		100(1835)	102	107	109	7
4		100(1777)	104	104	108	7
5		100(1462)	101	105	102	8
6		100(1724)	105	113	115	7
Tiritea		100(1407)	144	137	145	9
Otane		100(1648)	100	111	109	7
Karamu		100(1668)	114	112	118	7
Oroua		100(1621)	111	108	108	7

[1]Yield g/plot.

up between the genotypes. Line 1 gave no response at all, Line 2 responded only to Treatment 4, whereas Tiritea and Oroua responded equally well to all three sprayings. These different responses were not clearly indicated by the levels of stripe rust observed, and demonstrate the interaction of genotype possible on the effects of the rust. Similar levels of disease in different genotypes may cause different amounts of damage and only a large number of results will allow such tolerances to be clearly defined.

The leaf rust susceptible lines (3, 4, and Karamu) in the early trial all responded well to the sprayings, although not as strongly as for stripe rust. Apart from the unexpectedly low yield of Line 4, Treatment 4, all the other means followed the general pattern (4 3 2 1) predicted by the levels of leaf rust observed, although not all these differences were significent. Unlike the previous season, there was a difference between treatments 1, 2, and 3, showing that a late post flowering infection may still cause significant damage. No stem rust was observed in Karamu, so all three susceptible lines responded similarly. The responses are not as straight forward in the late trial, but there were still significant increases in yield after spraying, particularly in Treatments 3 and 4. The higher response by Karamu in this trial suggests that stem rust was present, although it was not recorded in the plots.

The responses of the two stem rust susceptible lines were unclear. A little rust was observed in the early trial, yet Line 5 showed a response which was large and similar over all three sprayings. In the late trial no rust was observed, yet Line 6 gave a good response to Treatments 3 and 4. Otane, which is only moderately resistant to stem rust, also responded to Treatments 3 and 4, despite there being no recorded disease. These results contrast with the 1983/84 late trial where quite heavy infection was observed, but no clear yield responses were measured. They again demonstrate the difficulty of reconciling levels of disease incidence with the measured yield losses over seasons and genotypes.

CONCLUSIONS

Very large yield losses can be caused by stripe rust and significant losses by leaf rust in susceptible wheats grown in the Manawatu. Significant losses were also measured in stem rust susceptible lines, although this was not predicted by observed rust incidence.

Spraying responses were dependent upon environment and genotype. For stripe rust susceptible lines a single spray at first sign usually produced a significant response. Although leaf rust appeared very late in all trials, it did affect yields and in one trial spraying at this time also produced a significant response.

The largest responses to spraying were in the lowest yielding trial and the smallest responses in the highest yielding trial. This was only partially explained by rust levels with the trials.

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