TRENDS IN STRIPE RUST RESISTANCE IN NEW ZEALAND WHEAT CULTIVARS

M.G. CROMEY

DSIR Plant Protection, Private Bag, Christchurch

SUMMARY

Since stripe rust of wheat was first found in New Zealand in 1980, the number of races identified has risen from one to nine. As a result, several cultivars which relied on single gene, seedling resistance to stripe rust have become highly susceptible to the changing pathogen population. Attention has shifted to the use of adult plant resistance, which operates at post-seedling growth stages and is more likely to prove durable. The stage of onset of adult plant resistance has been investigated in New Zealand wheat cultivars in the field. Cultivars differed in both their stage of onset and level of adult plant resistance to stripe rust. Results have been used in the development of disease control strategies tailored to specific cultivars.

INTRODUCTION

Stripe rust of wheat (*Triticum aestivum* L.), caused by *Puccinia striiformis* Westend. f. sp. *tritici* Erikss., was first detected in New Zealand in November 1980, approximately 1 year after it first appeared in Australia (Beresford 1982). Most of the wheat area in New Zealand at that time was sown in susceptible cultivars and, in replicated field trials, yield losses of up to 60% were recorded (Beresford 1982). As well as infecting leaves, stripe rust can attack wheat spikes, resulting in significant yield losses (Cromey 1989a).

Since the appearance of the disease, incorporation of stripe rust resistance into improved cultivars has been a major aim in New Zealand wheat breeding programmes, and a number of cultivars with improved resistance have been released. Resistant cultivars fall into two categories: those which are resistant as seedlings and at all subsequent growth stages, and those which, although susceptible as seedlings, develop resistance at post-seedling growth stages in the field. This latter form of resistance is often termed "adult plant resistance".

This paper reports on the use of seedling resistance and adult plant resistance in New Zealand wheat cultivars and associated changes in the stripe rust population in New Zealand.

MATERIALS AND METHODS

Seedling resistance and stripe rust races

Each year, since 1980, wheat crops in Canterbury, Manawatu, Wairarapa, and Southland were surveyed for the presence of the disease. Bulk samples of approximately 20 infected leaves per crop were taken at random. Samples were also collected from variety trials, especially where stripe rust was seen on cultivars which, from previous tests, were expected to be resistant.

Some race typing was carried out by the author, but most samples were sent to the Plant Breeding Institute, Castle Hill, Sydney. To characterise isolates according to race, rust spores were inoculated onto seedlings of an internationally recognised standard set of differential cultivars grown in the glasshouse (Johnson *et al* 1972). Cultivar reactions (resistant or susceptible) were recorded after the latent period, and a race designation given.

To identify the presence of seedling resistance genes in New Zealand wheat cultivars, inoculations were made on seedlings in the glasshouse.

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Onset of adult plant resistance

The resistance to stripe rust on each leaf of plants of eight New Zealand wheat cultivars was followed on tagged main tillers in autumn-sown field trials in 1987/88, 1988/89 and 1989/90 and a spring-sown trial in 1989/90. Five main tillers were tagged in each of four replicate plots of each cultivar. Assessments of percent leaf area affected by stripe rust were made at weekly intervals on all leaves of the tagged tillers. Leaves were numbered from one (primary leaf) to the flag leaf. The number of leaves produced (usually 10 or 11) varied between trials with Otane consistently producing one less leaf than the other cultivars.

RESULTS AND DISCUSSION**Seedling resistance and stripe rust races**

Results are from reports and personal communications by C.R. Wellings, Plant Breeding Institute, University of Sydney as well as from limited race characterisations here. A single race (104E137A-) was initially identified in New Zealand (Table 1), but in 1982, a variant (106E139A-) with virulence on the gene Yr7 was found on the previously resistant cultivar Oroua. Four New Zealand cultivars (Oroua, Brock, Hotspur and Newbury) contain the gene Yr7. Because of selection pressure on the stripe rust population due to the popularity of the cultivar Oroua in the mid-1980's, this second race rapidly became the most common race in New Zealand. In the 1986/87 season, two new races were identified in New Zealand. One of these, 108E141A+, was first found in South Canterbury in November 1986, and is virulent on Karamu. This race was the most common race in Australia at the time and it is likely that it was introduced from Australia. The other new race, 109E141A-, was new to Australasia, and is virulent on Pegasus. This race was first found in Canterbury, but has since been identified in Southland. In the 1987/88 season, three further races were identified, and the original race (104E137A-) was not identified at all.

In the 1988/89 season, one further race was identified. This new race, 111E143A+ is the most virulent race so far recorded in New Zealand, combining all the specific

TABLE 1: Stripe rust races identified and resistance status of wheat cultivars in New Zealand.

Year first found	Designation	Additional virulence over 104E137A – Genes	Cultivars affected
1980	104E137A –	—	—
1982	106E139A –	Yr7	Oroua, Brock, Newbury, Hotspur
1986	108E141A +	Yr6, YrA	Karamu
1986	109E141A –	Yr1, Yr6	Pegasus, Bounty, Kokart, Lancer, Sapphire
1987	110E143A –	Yr6, Yr7	Oroua, Brock, Newbury, Hotspur
1987	110E143A +	Yr6, Yr7, YrA	Oroua, Brock, Newbury, Hotspur, Karamu
1987	109E141A +	Yr1, Yr6, YrA	Pegasus, Karamu
1988	111E143A +	Yr1, Yr6, Yr7, YrA	Oroua, Brock, Newbury, Hotspur, Karamu, Pegasus, Bounty, Kokart, Lancer, Sapphire
Cultivars with seedling resistance to all the above races:			Abele, Batten, Crossbow, Tara.
Cultivars lacking seedling resistance to all the above races:			Advantage, Briscard, Domino, Konini, Kotare, Nimbus, Norseman, Otane, Rongotea, Ruapuna, Takahe, Tancred, Tiritea, Tui, Weka

virulences found in previously identified races in New Zealand. It can therefore infect all the cultivars overcome individually by previous races. There is no evidence, however, that this race is any more aggressive than other races on cultivars lacking seedling resistance genes.

The Oroua race (106E139A-) has continued to be the most common race in New Zealand. This reflects the relatively small acreage of cultivars with seedling resistance genes other than Yr7. Occurrence of these new races, coupled with the decline in occurrence of the original race, indicates that selection pressure towards races with increased virulence has been strong.

Most wheat cultivars used in New Zealand lack effective seedling resistance to some or all of the races of stripe rust identified in New Zealand (Table 1). With the rapid appearance of new races of stripe rust, use of seedling resistance genes in wheat cultivars has frequently been unsuccessful.

Onset of adult plant resistance

All cultivars in the field trials were susceptible as seedlings to stripe rust but differed in level of adult plant resistance. Three cultivars (Rongotea, Oroua, and Tiritea) were susceptible at all growth stages and five cultivars (Otane, Kotare, Weka, Tui, and Ruapuna) showed some resistance as adult plants. Results of the 1987/88 trial (in which symptoms appeared earlier than in the other three trials) are presented in Fig. 1. Stripe rust was first observed on leaf 1 and was severe on leaf 2 of all cultivars. Resistance developed progressively from the emergence of leaf 3 to leaf 6, with time of onset varying between cultivars. Only the mean figures for the two groups of cultivars (susceptible and resistant) are presented here. The three susceptible cultivars had a mean

Fig. 1: Mean stripe rust disease progress curves for separate leaves (L1 to L10) of wheat cultivars that were susceptible (A) or possessed adult plant resistance (B) to the disease.

severity on leaf 6 of 66%, compared with 11% for the five resistant cultivars. Similar results were obtained in the following two seasons, but since stripe rust appeared later, the early leaves did not always become infected.

The area under the disease progress curve (AUDPC) was calculated for the epidemic on each leaf number of each cultivar for each of the trials: mean AUDPCs for each leaf number of each cultivar across all four trials were expressed as percentages of combined mean values for the three susceptible cultivars (Table 2). Where less than 11 leaves were produced, missing values were arbitrarily assigned. The three susceptible cultivars (Tiritea, Rongotea, Oroua) supported severe epidemics on all leaves once stripe rust became established. Of the five cultivars with adult plant resistance, Weka was the most susceptible in seedling growth stages, having epidemics more severe than the mean of those on the susceptible cultivars on three of the first four leaves. Other cultivars had identifiable resistance even at early growth stages, although resistance was greatest on the flag leaf for all five cultivars.

TABLE 2: Relative "area under the disease progress curves" for stripe rust infection of eight wheat cultivars (mean of 4 trials over 3 years)*.

	Leaf number										
	1	2	3	4	5	6	7	8	9	10	11
Tiritea	116	88	109	147	135	102	138	136	140	142	132
Rongotea	124	95	121	74	89	80	81	94	86	81	76
Oroua	74	113	75	90	87	94	81	70	76	77	90
mean	100	100	100	100	100	100	100	100	100	100	100
Weka	109	142	96	134	51	48	63	39	35	16	10
Otane	86	72	71	68	15	11	11	12	—	9	8
Kotare	37	54	67	25	20	12	15	8	8	5	4
Ruapuna	45	65	69	83	14	20	18	13	8	8	3
Tui	54	112	28	21	2	3	3	2	10	8	5
mean	66	89	66	66	20	19	22	15	12	9	6

*expressed as the percentage of the mean of the susceptible cultivars Tiritea, Rongotea and Oroua.

Because the stage of onset of adult plant resistance varied between cultivars, disease management strategies must be cultivar-specific to take account of this. For instance crops of Weka must be treated as susceptible through much of their growth period. On the other hand, Otane is an early maturing cultivar, producing one less leaf than most cultivars. The usual spring sowing of this cultivar and development of adult plant resistance, means that an early fungicide spray will probably only be required if stripe rust becomes established early in the season. However, Otane has been shown to be susceptible to stripe rust in the spike (Cromey 1989b), and if conditions (cool, damp weather) around the time of ear emergence are particularly suitable for disease development, then a late spray (between ear emergence and flowering) may be warranted. In view of the differences between cultivars, stage of onset of resistance should be taken into account in cultivar selection.

Resistance to stripe rust in the future

Since most seedling resistance genes have proved ineffective, cultivars must rely on adult plant resistance to stripe rust. The challenge is to ensure that future wheat cultivars have resistance which develops early and to a high degree. Care must be taken on the sources of resistance used, since some forms of adult plant resistance have been overcome by new stripe rust races overseas (Priestley 1978). Recent work (Cromey, unpublished) suggests that such races may already be present in New Zealand. Studies to determine the genetic nature of stripe rust resistance in new cultivars will be necessary in order to ensure that diversity of resistance is maintained.

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