RESISTANCE OF NEW ZEALAND BARLEY CULTIVARS TO SCALD, CAUSED BY *RHYNCHOSPORIUM SECALIS*

M.G. CROMEY, R. HANSON and K.I. SINCLAIR

*New Zealand Institute for Crop & Food Research Limited,
Private Bag 4704, Christchurch*

ABSTRACT

The resistance of New Zealand barley cultivars to leaf scald, caused by *Rhynchosporium secalis*, was assessed under conditions of high disease pressure in two autumn-sown disease nurseries. Assessments of disease severity were made at several growth stages and area under the disease progress curves calculated. Cultivars ranged from highly resistant to highly susceptible, with several cultivars showing intermediate levels of resistance. Relative disease levels between cultivars were largely consistent between assessment dates. Subsets of these cultivars were spring-sown in three trials situated within commercial crops, where disease pressures ranged from low to high. Two trials, one in Canterbury and one in the Wanganui district, consisted of four cultivars, with or without fungicide treatments. The other trial, in Southland, consisted of eight cultivars. Scald severity differed between cultivars. Partial resistance to scald, such as that found in Regatta, is likely to be more affected by environment than high level resistance. Such cultivars will probably require fungicide control of scald when inoculum pressure is high.

Keywords: partial resistance, durable resistance, physiological specialisation.

INTRODUCTION

Scald, caused by *Rhynchosporium secalis* (Oud.) J.J. Davis, is a common disease of barley (*Hordeum vulgare* L.) in New Zealand. In a survey, Arnst and Fenwick (1973) found 30% of New Zealand barley crops were infected with *R. secalis*. In the Wairarapa district of the North Island this figure has reached 90% (Cromey *et al.* 1980), with individual crop yield losses estimated as high as 44% (Sheridan and Grbavac 1977).

Disease resistance can provide a cost-effective means of control of diseases such as scald, but resistance is often race-specific, and therefore may become ineffective in a short time. For instance, Cromey (1987) identified four races of *R. secalis* in New Zealand, which overcame the resistance of several local cultivars. The pathogenic variation of *R. secalis* in New Zealand presents a risk to the use of single gene resistances in barley cultivars. Smaller, quantitative, levels of resistance have been shown to significantly reduce yield losses caused by *R. secalis* (Rowling and Jones 1976). Such resistance can also be race-specific (Habgood 1976), but does provide an additional strategy in breeding for potentially durable resistance to *R. secalis*.

The research presented here sought to determine the variation in resistance between New Zealand barley cultivars, in particular whether partial resistance was present.

MATERIALS AND METHODS

Field disease nursery

The resistance of 135 commercial New Zealand barley cultivars and advanced breeding lines was compared in a disease nursery in 1998/99 at Lincoln, Canterbury. The trial was sown on 1/7/98. Test plots consisted of two 1 m-long rows and were replicated three times (12 commercial cultivars were replicated twice in each block) in a randomised block design. Each plot was adjacent to a scald spreader row, which

consisted of a highly susceptible cultivar. Infection relied on natural inoculum. Assessments of disease severity (percent leaf area affected on all leaves capable of expressing disease) were made on five dates, between growth stages 30 and 77 (Zadoks *et al.* 1974). The area under the disease progress curve (AUDPC) was calculated for each plot (Viljanen-Rollinson and Cromey 1998). Results were analysed using analysis of variance. Calculations of AUDPC were also made for commercial cultivars in a similar disease nursery in 1997/98 which was sown on 23/7/97.

Field trials

The resistance of four cultivars to scald was further examined in three field trials situated within spring barley crops in Canterbury, Wanganui and Southland. Plots in the Canterbury and Wanganui trials received an early application of epoxiconazole (125 g/ha as Opus), or were untreated. Treatments were replicated six times in a randomised split plot design, with fungicide treatment as the main plot. The Wanganui trial was sown on 19/10/98, with the fungicide applied on 18/11/98 at early stem elongation. The Canterbury trial was sown on 2/9/98, with the fungicide applied on 23/10/98 during tillering. A later application was made to some plots in each trial (results not presented). The Canterbury trial was assessed for scald severity (% leaf area affected) three times (30/11/98, 21/12/98 and 6/1/99) and the Wanganui trial twice (15/12/98 and 19/1/99). The Southland trial consisted of eight cultivars with four replicates (results of the six commercial cultivars are presented) and was assessed on 3/2/99. No fungicides were applied. Results for the three trials were analysed using analysis of variance.

RESULTS

Disease nurseries

Seven of the 12 commercial cultivars in the 1998/99 nursery, were classed as resistant (R) or moderately resistant (MR) (Table 1). There was a clear distinction in scald severity (mean of 4% versus 26%) and AUDPC (mean of 105 versus 837) between the R and MR categories, but not between the MR and moderately susceptible (MS) or between MS and susceptible (S) categories. Two of the cultivars were classified as S and one as highly susceptible (HS). The HS cultivar Optic had much higher scald severity and AUDPC than the S cultivars.

Disease severity was much lower in the 1997/98 nursery than in 1998/99. The ranking of cultivars in the resistant and susceptible (S and HS) categories was consistent between the two seasons. There were no differences ($P>0.05$) between the four MR and MS cultivars present in both seasons.

TABLE 1: Scald resistance rating, maximum scald disease severity, and total area under the disease progress curve (AUDPC) for New Zealand barley cultivars in two field trials.

	Rating	1998/99 trial		1997/98 trial	
		Max. % leaf area affected	AUDPC	Max. % leaf area affected	AUDPC
Dash	R	1	31	1	22
NFC94-5	R	3	50	-	-
Sherwood	R	3	65	2	42
Cask	R	7	274	2	52
Nugget	MR	26	770	8	305
Valetta	MR	29	868	5	140
H90014-85	MR	23	873	12	424
Regatta	MS	36	1224	3	170
92215	MS	45	1433	-	-
Fleet	S	42	1639	13	460
Liberty	S	49	1648	12	565
Optic	HS	60	2109	18	715
LSD ($P<0.05$)			478		378

Twenty three (17%) of the commercial cultivars and advanced breeding lines screened in the 1998/99 nursery were resistant to scald (Table 2), while 31 (23%) were susceptible (S or HS); the remaining 81 being MR to MS. The cultivars designated as MR were approximately evenly spread across the 501 - 1000 range of AUDPC, while many MS cultivars tended towards the higher end of the MS range (1001 - 1500). Only two cultivars (one was Optic) fitted the HS category, with an AUDPC over 2000. Thirteen of the 29 S cultivars were in the 1801 - 2000 range.

Maximum disease severities (the mean for cultivars in each range) showed a discontinuity between the R cultivars (mean maximum of 4% leaf area affected) and the other categories, which ranged from 25% to 60% leaf area affected. The difference in maximum disease severity was slight between the S and HS categories, with HS cultivars characterised by a rapid increase in disease severity early in the season.

TABLE 2: Distribution of New Zealand barley cultivars and advanced breeding lines according to scald resistance in a disease nursery in 1998/99.

Rating	AUDPC range	Mean percent leaf area affected ¹	Number in category
R	0 - 500	25	23
MR	501 - 1000	39	31
MS	1001 - 1500	56	50
S	1501 - 2000	60	29
HS	2001+	4	2

¹mean of cultivars in category on the assessment date where disease severity was highest.

Field trials

The Canterbury trial was assessed three times, the Wanganui trial twice and the Southland trial once. Results for a single assessment date for each trial are presented in Table 3. Other assessment dates gave similar differences between cultivars.

Scald severity at early grain fill (15/12/98 at Wanganui and 21/12/98 at Canterbury) fell into three categories. Dash and Sherwood were virtually free of scald at both sites, while the disease was relatively severe on Optic in untreated plots (12% and 26% leaf area affected at Canterbury and Wanganui respectively). Severity on Regatta was intermediate, but was only 12 - 30% of that of Optic. Treatment with foliar fungicides almost eliminated scald in Regatta and reduced the severity of the disease in Optic by 60 - 80%.

Six commercial cultivars were examined in the Southland trial. Two cultivars (Fleet and Optic) had severe scald, two (Dash and New Grange) had very low levels and the remaining two (Regatta and Cask) had intermediate disease levels.

TABLE 3: Scald severity (percent leaf area affected) of four barley cultivars untreated or treated with fungicide in trials in Canterbury, Wanganui and Southland.

	Canterbury		Wanganui		Southland
	Untreated	Fungicide	Untreated	Fungicide	Untreated
Dash	0.0	0.0	0.0	0.2	2
Optic	12.5	5.0	26.3	4.3	60
Regatta	3.5	0.8	3.0	0.5	18
Sherwood	0.0	0.0	0.0	0.0	-
Fleet	-	-	-	-	80
Cask	-	-	-	-	18
New Grange	-	-	-	-	4
LSD (P<0.05)	2.0		2.1		9

DISCUSSION

Scald disease pressure was high in the 1998 autumn-sown disease nursery. Highly resistant (R) cultivars stood out in the nursery, with their high proportions of green leaf area at all growth stages. Partial resistance was identified in the nursery using both severity and cumulative AUDPC data. Differences between the MR, MS, S and HS categories were more easily distinguished using cumulative AUDPC than severity data at any particular date. There were few statistically significant differences between cultivars in the MR and MS categories, and ranking was not consistent between seasons. This suggests that more precise measures to distinguish between cultivars with partial resistance are needed. Distribution of cultivars in the MR to HS categories was a continuum, suggesting that several minor genes are likely to contribute to partial resistance to scald.

While the dry conditions experienced in the 1998/99 growing season were not particularly conducive to scald development in the spring-sown trials within commercial crops, moderate to high disease severities were recorded in Optic. The extreme susceptibility of Optic suggests fungicide control in this cultivar is likely to be worthwhile in most situations. However, data presented here also suggest that it is more difficult to control scald in highly susceptible cultivars such as Optic, than in partially resistant cultivars.

Regatta demonstrated a moderate to good degree of resistance to scald in all trials. Partial resistance, such as that found in Regatta, is likely to be more affected by environment than high level resistance. Such cultivars will probably require fungicide control of scald where inoculum pressure is high. Because of variability in disease levels, it is important to test cultivars over several seasons and disease pressures, to accurately determine their level of partial resistance to *R. secalis*.

The susceptible (S and HS) cultivars were susceptible in both seasons, and are therefore susceptible to at least the predominant races of *R. secalis* in New Zealand. If they contain major resistance genes, these will be overcome by matching virulence in the pathogen population. This was observed in the cultivar Magnum, which was susceptible in New Zealand despite being resistant to three of the four races identified (Cromey 1987).

Some cultivars were highly resistant (R) in both seasons. The discontinuity observed between the R category and other categories suggests that this high level resistance is conditioned by single major gene resistance. While R cultivars are unlikely to require fungicides for scald control at present, they are at risk from new races, which could spread rapidly. It is possible that some such races are already present in New Zealand, and would be selected from the *R. secalis* population if the cultivars were to be widely used. For instance, the cultivar Koru was resistant in most locations when it was released, but a race with matching virulence was soon identified (Cromey 1987).

Crop loss assessment would provide useful extra information on the level of resistance required under New Zealand growing conditions. Avoidance of HS cultivars will allow for effective fungicide control of scald. Infected host residue is the principal source of primary inoculum of *R. secalis* (Davis and Fitt 1992). Therefore, second and subsequent barley crops will usually have much higher inoculum levels than first crops. In New Zealand, severe scald infection in spring barley crops is usually restricted to second or later crops. The Wanganui trial was in a fifth year barley crop. Integrated scald control should combine cultivar resistance to scald with appropriate crop rotations and fungicide applications where necessary. Highly susceptible cultivars such as Optic should especially be avoided where second year barley crops are sown, since fungicide control may be inadequate in such situations.

ACKNOWLEDGEMENTS

Funding was provided by the New Zealand Foundation for Research, Science and Technology (FRST) and the Foundation for Arable Research (FAR). We thank Mr A. Taylor, Mr J. Wright and G. and R. Collins for providing the land on which the field trials were sown. Cathy Munro, Stewart Armstrong and Anna Moorhead provided technical assistance.

REFERENCES

- Arnst, B.J. and Fenwick, J.E., 1973. A survey of barley disease in New Zealand. *Proc. 26th N. Z. Weed and Pest Control Conf.*: 157 - 160.
- Cromey, M.G., 1987. Pathogenic variation in *Rhynchosporium secalis* on barley in New Zealand. *N.Z. J. Ag. Res.* 30: 95-99.
- Cromey, M.G., Grbavac, N. and Sheridan, J.E., 1980. Diseases and pests of cereals in the Wairarapa - a six year study. *Proc. 33rd N.Z. Weed and Pest Control Conf.*: 254 - 257.
- Davis, H. and Fitt, B.D.L., 1992. Seasonal changes in primary and secondary inoculum during epidemics of leaf blotch (*Rhynchosporium secalis*) on winter barley. *Ann. App. Biol.* 121: 39 - 49.
- Habgood, R.M., 1976. Differential aggressiveness of *Rhynchosporium secalis* isolates towards specified barley genotypes. *Trans. Brit. Mycol. Soc.* 66: 201 - 204.
- Rowling, R.H.D. and Jones, D.G., 1976. The reaction of three spring barley varieties exposed to epidemics of *Rhynchosporium secalis* of varying intensity and duration. *J. Agric. Sci.* 87: 643 - 657.
- Sheridan, J.E. and Grbavac, N., 1977. Cereal diseases 1976-77. Disease survey in the Wairarapa, yield losses and control. Mycol. and Pl. Path. Rep. 9. Botany Dept, Victoria University of Wellington, N.Z.
- Viljanen-Rollinson, S.L.J. and Cromey, M.G., 1998. The effectiveness of stripe rust resistance gene *Yr18* in wheat cultivars. *Proc. 51st N.Z. Plant Prot. Conf.*: 71 - 75.
- Zadoks, J.C., Chang, T.T. and Konzak, C.F., 1974. A decimal code for the growth stages of cereals. *Weed Res.* 14: 415 - 421.