Paper 8
PROTECTING THE BARLEY CROP

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INTRODUCTION

For barley growing to be profitable there must be low inputs with relatively high outputs in the form of harvested grain. With foresight and good management the cost of protecting the crop from the yield-reducing effects of weeds, insects and diseases, can be kept low. Decisions on the overall plant protection programme for barley can be made some time before sowing, at sowing, during crop growth, and after harvest. Methods for protecting the barley crop are outlined, some specific problems are discussed, and a key to barley diseases is provided.

TABLE 1: Resistance of barley cultivars to some leaf diseases

Cultivar	Powdery Mildew	Leaf Rust	Scald
Ark Royal	MR	MS	R
Claret	R	MR	MR
Georgie	MS	MR	S
Goldmarker	MR	MS	MR
Goldspear	R	MR	MR
Gwylan	MR	MR	S
Hassan	MR	MS	S
Julia	MR	MR	MR
Kaniere	S	S	MR
Koru	MS	MR	MR
Kym	MR	MR	S
Magnum	R	MR	S
Makareta	R	R	S
Manapou	S	S	MS
Mata	S	S	MS
Triumph	R	R	S
Zephyr	S	S	S

S — susceptible
MS — moderate susceptibility
MR — moderate resistance
R — resistant

CULTIVARS

There are many barley cultivars now available and most have resistance to one or more diseases. Thus resistance must be considered when selecting a cultivar, as well as potential yield, grain size and end use.

Table 1 lists the main cultivars and their reaction to powdery mildew, leaf rust and scald. These reactions have been derived from data in Anon. (1983), Thaine and Malcolm (1981), and supplied by the companies concerned. A brief description and key for these and other diseases is contained in the Appendix — a modification of that produced by Sanderson (1973).

SEED TREATMENT

Grain for sowing can be saved from your own crop or can be obtained as one of three grades of certified seed from agricultural merchants. All seed barley should be treated with a fungicide. Seed from merchants will be treated. Farm-saved seed may be sent to merchants for treatment, or be treated by mobile operators, or the farmer. Some farmers have used untreated seed saved from a crop grown the previous year from certified seed. This certainly should not be done more than once with any line of seed.

Three seed treatment chemicals are available. Dithane M45 SD (80% mancozeb) will control covered smut and protect the plant against some soil-borne disease organisms. Vitaflo 200 (containing 20% carboxin and 20% thiram) and Baytan F17 (15% triadimenol and 2% fuberidazole) will do the same, but also control loose smut, an infection that can be present in the seed. Baytan F17 also controls some leaf diseases (Moore *et al.*, 1979) such as powdery mildew and leaf rust, when these are present in young crops arising from late-sowing (November-December). Table 2 sets out the spectrum of activity of the three products.

It should be noted from Table 2 that the two seed-borne diseases, net blotch and spot blotch, are kept in check by these products though often the effectiveness varies in relation to the climate and the cultivar (Sheridan *et al.*, 1982; Sheridan and Grbavac, 1983). Fungazil (containing imazadil) is now registered for control of net and spot

TABLE 2: Seed treatments for control of barley diseases.

	Dithane M45 SD	Vitaflo 200	Baytan F17
Covered Smut	+	+	+
Loose Smut	–	+	+
Net Blotch	+	+	+*
Spot Blotch	+	+	+*
Powdery Mildew	–	–	+
Leaf Rust	–	–	+

*effective only on some cultivars

blotches, but not smut diseases. However, net blotch can be present also on the stubble and air-borne spores from stubble can spread into new-sown crops. In many cases, however, the seed-borne inoculum is more important and must be totally eradicated. Hence research continues in order to obtain cheap but highly effective chemicals for control of this and other diseases. The life cycle of net blotch is shown in Fig. 1.

ROTATIONS

Many of the disease-causing organisms (pathogens) can survive on barley stubble and volunteer (self-sown) barley (see Table 3).

There is therefore a strong recommendation to burn the stubble, and to avoid growing barley after barley wherever possible. Even where a good burn is obtained, disease inoculum may persist in the headlands, where diseased straw has been ploughed in to form a firebreak. It is possible to grow two barley crops in succession or wheat then barley but there can be an increase in amount of take-all and eyespot leading to some yield losses in second and subsequent cereal crops. The break between barley crops in a rotation should be at least two years without wheat or barley, because take-all and eyespot also survive on wheat residue. Barley is less severely affected than wheat by these diseases. Many farms are becoming more and more crop-oriented, so an adequate break is difficult to achieve. Take-all can also survive on couch (or twitch), and areas with severe couch problems should be avoided for barley cropping. Killing the couch by spraying just before sowing does not solve the problem, as take-all can survive on dead couch roots for some 6 to 12 months.

VOLUNTEER BARLEY

Self-sown plants may grow from seed that has shaken from the ears or fallen from the header and then been incorporated into the soil during the cultivation for early autumn-sown pastures or crops. Table 3 shows that these plants can be an important source of powdery mildew and leaf rust spores, as well as of other diseases and of aphids.

TABLE 3: Barley stubble and volunteer (self-sown) barley as a source of many diseases.

	Barley Stubble	Volunteer Barley
Take-all	+	–
Eyespot	+	–
Fusarium Foot-rot	+	–
Net Blotch	+	+
Spot Blotch	+	+
Scald	+	+
Leaf Rust	–	+
Powdery Mildew	+	+

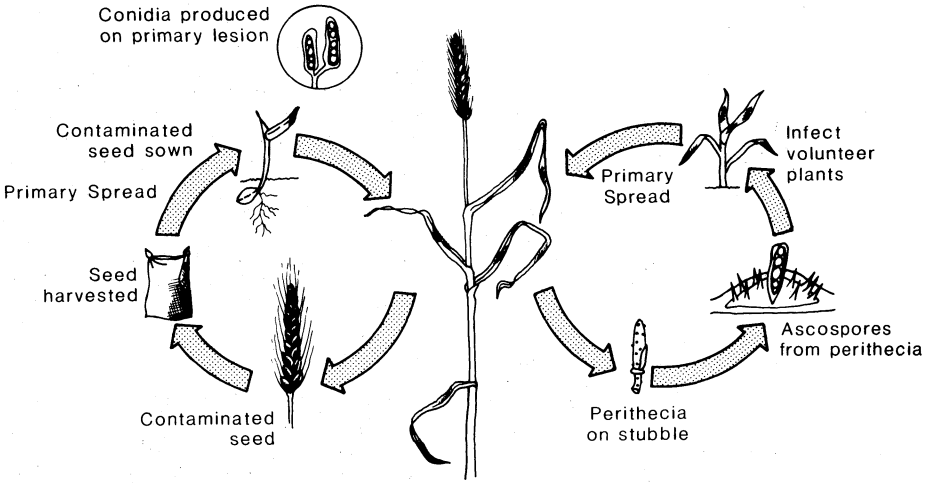

Figure 1: Life cycle of Net Blotch: Primary spread into spring-sown barley by infected seed to seedlings or spores from infected stubble and volunteer barley. Spread within crops (secondary spread) is by spores produced on the surface of infected leaves.

Thus these plants allow many barley diseases to survive, over the winter, from one cropping season to the next. Before emergence of spring-sown crops, all volunteer barley plants should be removed by grazing.

TIME OF SOWING

Most barley crops are sown in September or October. If sown in November or December there is a greater risk from infection by diseases such as leaf rust and powdery mildew, with spores coming from earlier-sown crops.

There has been some discussion about winter barley. Overseas experience indicates that growing winter barley leads to an increase in leaf diseases in spring barley. The winter barley crops, like volunteer barley, provide an excellent overwintering source of many diseases. Thus the more winter barley is grown, the more disease will increase in spring barley, incurring greater costs in protecting those crops.

DISEASE PROBLEMS

Barley Yellow Dwarf Virus

In spring-sown crops yellow (infected) plants may be seen scattered through crops but in the South Island the disease generally does not cause severe damage. There have been some reports (Close, 1969) of yield responses arising from treatments for control of cereal aphids and virus. The overall crop losses from the virus may be about 5%. The best prospects for control lie in the development of resistant cultivars. All present cultivars are more or less susceptible but lines of barley with good resistance are included in the North Island barley breeding programme of the DSIR.

Barley stripe mosaic virus also has been found infecting barley (Burnett and Ashby, 1978). It is a virus disease that does not appear to be of economic importance.

Leaf Rust

As many new cultivars have good resistance to leaf diseases (Table 1), cultivar selection can minimize the yield-reducing effects. Differences between cultivars, as a result of resistance, are shown by the disease severity data of Lim and Gaunt (1981) with respect to the effects of powdery mildew and leaf rust on Georgie, Hassan, Manapou and Zephyr.

The pathogen that causes leaf rust of barley does not infect other cereals and grasses.

When severe leaf rust infection of the upper leaves and leaf sheaths occurs, this can affect grain filling, reducing grain size and total yield (Table 4). The infected plants are weaker as a result of the rust attack, and may break down (lodge) prior to harvest.

Leaf rust is generally more severe in late-sown crops, those sown from early November to mid-December (Table 4). Hence it is these crops that could need spraying with Bayleton, Tilt or other effective chemicals.

It is difficult to set threshold levels for action on diseases. As a guide, sprays could be applied when 50% of the leaves at the leaf 2 position (one below the flag or top leaf) are found to be infected with leaf rust.

TABLE 4: Effects of leaf rust on yield and size of grain from crops sown at four times during spring and early summer, 1976 (data from Teng and Close, 1977).

Trial Sown	Leaf Rust (%)*		Yield (t/ha)	
	Untreated	Sprayed	Untreated	Sprayed
22 Oct.	2	0	3.8 (44)**	3.8 (45)
5 Nov.	30	1	3.7 (43)	4.4 (47)
2 Dec.	51	0	1.6 (38)	3.1 (43)
15 Dec.	97	0	1.1 (29)	3.2 (40)

* At growth stage 11.1 on leaf 2

** Figures in brackets are the 1000 grain weights (in grams)

Powdery Mildew

This can survive on stubble as well as on volunteer barley. The wheat and barley powdery mildews are distinct strains, thus they do not cross-infect.

Control is achieved largely through burning stubble, by destroying volunteer barley and by the use of resistant cultivars. Fungicide sprays put on late-sown crops for leaf rust will also control powdery mildew.

For powdery mildew, sprays could be applied when 5% of the leaf area of the oldest fully-green leaf is infected with this disease. With late-sown crops, mildew may be found to be more severe in early crop growth than late in crop development. On the other hand, mildew may not be present in some late crops.

Net Blotch

This disease is of importance in the North Island and in the higher rainfall areas of the South Island. As can be seen from Fig. 1, the disease can reach crops from two sources: from infected seed and from barley stubble. Once infection is in a crop, spread within the crop can occur by spores produced on the surface of the dark-brown flecks and stripes on the leaves. In severe infections, yield losses of 11-42% have been reported (Sheridan *et al.*, 1983).

Control must be by destroying stubble before sowing new crops in the spring and by eradicating the seed-borne infection by the use of effective seed treatments. Even with these measures, infection still seems to develop in North Island crops and further research is required on the value of new systemic chemical sprays for control. Although most barley cultivars seem to be susceptible to net blotch, there appears to be scope for further work on selection for resistance.

Spot Blotch

This disease is common in North Island barley crops and can cause yield losses if not adequately controlled (Hampton, 1979). Destruction of stubble, rotation of crops, and effective seed treatments are required.

Scald

Severe epidemics of scald can occur in barley greenfeed crops sown in autumn or early winter. In spring-sown crops this disease is not generally important.

Physiological Leaf Blotch

Common in many cultivars but especially Triumph. Small (3 to 5 mm) brown spots but also occurs as larger brown oval blotches (up to 2 cm long). Not considered to be of economic importance.

INSECT, NEMATODE AND WEED PROBLEMS

Insects

The following insects can occur on barley: cereal aphids, grain aphids, rose grain aphids, armyworms, wireworms, Hessian fly, wheat sheath miner, and Argentine stem weevil (this one can be controlled by fallowing the area for six weeks). In general, insects are not a problem in barley, though sometimes cereal aphids can be important because of their ability to spread barley yellow dwarf virus.

Nematodes

Cereal cyst nematode has been recorded on barley. This nematode is limited in its distribution within New Zealand and is not expected to be a significant problem.

Weeds

Because spring-sown barley is fast-growing, it is a crop which generally can suppress the growth of many annual weeds. If annual weeds do appear to be a problem, then they can be readily controlled by the use of a number of herbicides (applied at the correct time of application for maximum weed kill and to avoid damage to barley).

Wild oats can be a problem, but less so in barley than in wheat. Inspect the crop for wild oats and use a specific herbicide at the right time of application.

Perennial weeds (such as couch) need to be controlled well in advance of drilling, preferably in the previous summer-autumn period.

PROTECTION STRATEGIES FOR SPRING-SOWN CROPS

Cultural

1. Immediately after harvest burn or plough under stubble.
2. Destroy volunteer (self-sown) barley by grazing, especially in late winter (before sowing any spring barley). Do not grow winter barley if intending to grow spring barley, or else only grow winter barley cultivars resistant to the main leaf diseases.
3. Preferably use cultivars with resistance to leaf diseases.

Chemical

For crops sown September-October

— use any one of the four seed treatments, but check its effectiveness on net blotch on the cultivar to be grown.

— chemical sprays should **not** be required on these crops.

For crops sown November-December

— use Baytan F17 as seed treatment on cultivars susceptible to leaf rust otherwise use products effective against net blotch.

— spray when leaf rust and powdery mildew are present with Bayleton, Tilt or other effective fungicides.

REFERENCES

Anon. 1983. Use of fungicides and insecticides on cereals 1983. Ministry of Agriculture, Fisheries and Food ADAS Booklet 2257, pp 120.

Burnett, P.A., Ashby, J.W. 1978. Barley stripe mosaic virus in New Zealand. *N.Z. Journal of Agricultural Research 21:* 143-145.

Close, R.C. 1969. Summary of trials for the control of barley yellow dwarf virus. *Proceedings 22nd N.Z. Weed and Pest Control Conference:* 214-226.

Hampton, J.G. 1979. The presence and effects of seed-borne and soil-borne *Drechslera sorokiniana* on barley in New Zealand.
I. Occurence of the pathogen. *N.Z. Journal Experimental Agriculture 7:* 383-386.
II. Effect on barley seed germination, emergence and seedling vigour. *Ibid:* 387-390.
III. Effect on grain yield. *Ibid:* 391-393.
IV. Chemical control and cultivar susceptibility. *Ibid:* 395-398.

Lim, L.G., Gaunt, R.E. 1981. The timing of spray applications against powdery mildew and leaf rust in barley. *Proceedings 34th N.Z. Weed and Pest Control Conference:* 195-198.

Moore, M.S., Close, R.C., Lai, R. 1979. Control of seed-borne and foliar diseases of barley with new systemic fungicides triadimenol and triadimefon. *Proceedings 32nd Weed and Pest Control Conference:* 261-271.

Sanderson, F.R. 1973. Description and key of barley diseases in New Zealand. *Proceedings 26th N.Z. Weed and Pest Control Conference:* 152-156.

Sheridan, J.E., Dawson, M.V., Grbavac, N. 1982. New seed treatments and foliar sprays for control of spot blotch of barley. *Proceedings 35th N.Z. Weed and Pest Control Conference:* 237-241.

Sheridan, J.E., Grbavac, N. 1983. Seed treatments for control of net blotch of barley. *Proceedings 36th N.Z. Weed and Pest Control Conference:* 237-241.

Sheridan, J.E., Grbavac, N., Ballard, L. 1983. Strategies for controlling net blotch in barley. *Proceedings* 36th N.Z. Weed and Pest Control Conference: 242-246.

Teng, P.S., Close, R.C. 1977. A preliminary comparison of benodanil and MEB 6447 for control of leaf rust of barley. *Australian Plant Pathology Society Newsletter 6:* 55-57.

Thaine, P., Malcolm, J.P. 1981. Barley cultivars. Recommended list for 1981. *N.Z.M.A.F. Aglink* FPP 162.

APPENDIX

Description and Key of Barley Diseases In New Zealand
(after Sanderson, 1973)

LEAF DISEASES

1. Small superficial lesions of white, grey or buff mycelium scattered over the top surface of the leaf ..... Powdery Mildew (*Erysiphe graminis* DC)
2. i. Numerous scattered small (1-2mm) orange-yellow pustules occasionally in concentric rings. Associated with black pustules on the leaf sheath at maturity of the plant. More severe in late-sown barley crops ..... Leaf Rust (*Puccinia hordei* Otth.)
   ii. Numerous small yellow pustules arranged in blotches or distinct stripes on the leaves. May occur on seedling plants ..... Stripe Rust (*Puccinia striiformis* West)
3. Water-soaked areas soon becoming lens-shaped in outline, greyish green with distinct brown margins. Old lesions assume a bleached straw colour while retaining the distinct brown margin ..... Scald (*Rhynchosporium secalis* [Oudem] J.J. Davis)
4. Striping of the leaves and leaf sheaths. Initially yellow though soon turning brown. Not common, can be present on plants derived from imported seed. ..... Leaf Stripe (*Pyrenophora graminea* [Died] Ito. & Kurib., conidial state *Drechslera (Helminthosporium) graminea* Rabh. ex Schlecht.).
5. Lesions exhibiting characteristic network effect produced by numerous longitudinal, transverse, and oblique, dark-brown lines. Common in crops, more severe in North Island crops. ..... Net Blotch (*Pyrenophora teres* [Died] Drechsler, conidial state *Drechslera (Helminthosporium) teres* Sacc.).
6. Lesions occur at heading — dark-brown in centre fading into green tissue, 0.5-3 mm wide by 3-20 mm long. Fungus present on glumes and seed. Seedlings may show distortion, stunting and basal browning. ..... Spot blotch and common root rot. (*Cochliobolus sativus* (Ito & Kurib) Dastur, conidial state *Drechslera sorokiniana* (Sacc.) Subram. and Jain).
7. Lesions, small (3-8 mm) round with buff centre and dark-brown margins, often with chlorotic halos. Mostly on upper leaves but can occur on glumes. Black fruiting bodies develop within lesions. Not common. ..... Halo spot (*Selenophoma donacis*) (Pass.) Sprague & Johnson.
8. Lesions, 1-2 cm long, oval or lens-shaped, brown to red-brown in colour, with fruiting bodies (pycnidia) within the lesion ..... Glume blotch (*Stagonospora (Septoria)* state of *Leptosphaeria nodorum* Muller)
9. Brown leaf blotches of variable size (2 to 20 mm) and shape (circular to oval) ... Physiological leaf blotch (no pathogen involved)
10. Brown stripe forming an inverted 'V' or 'W' on the leaves, with a mosaic pattern of chlorosis within the 'V' or 'W'. Leaf area on the back of the leaf remaining green. Not common, above symptoms only in susceptible cultivars ..... Barley Stripe Mosaic Virus
11. Basal leaves a distinct golden-yellow with yellowing of leaves extending up the plant. In general only scattered infected plants seen within field, but sometimes many plants show symptoms. ..... Barley Yellow Dwarf Virus

STEM DISEASES

A. Leaf Sheath Infection

1. Small superficial lesions of powdery white mycelium later fusing and containing numerous black fruiting bodies (cleistocarps) ..... Powdery Mildew (*Erysiphe graminis*)
2. Scattered brown or yellow rust pustules turning black with maturation of the plant.
   i. Small (1 to 2 mm) circular orange-yellow pustules. ..... Leaf Rust (*Puccinia hordei*)
   ii. Elongated red-brown pustules, partially covered by epidermal flakes. Not common. .. Stem Rust (*Puccinia graminis* Pers.)
3. Water soaked areas soon becoming lens shaped in outline greyish-green with distinct brown margins. Old lesions assume a bleached straw colour while still retaining the distinct brown margin ..... Scald (*Rhynchosporium secalis*)

B. Stem Base

4. Lens-shaped areas of bleached tissue surrounded by darker margins. Often associated with grey mycelium in the internal cavity of the stem. Stem weakened and some lodging. Common in areas like Southland, especially in second cereal crops ..... Eyespot (*Pseudocercosporella herpotrichoides*) (Fron) Deighton
5. General browning of the stem base.
   i. Rapid bleaching of the whole plant at maturation. Infected plants often occur in patches. Mat of coarse, dark-brown mycelium around the stem base, and over main roots. ..... Take-all (*Gaeumannomyces graminis*) [Sacc] v Arx & Olivier) (syn. *Ophiobolus graminis*)
   ii. No coarse dark brown hyphae. Scattered small brown lesions on the roots, usually near the stem base. Pink spore masses sometimes present. ..... Fusarium Foot-Rot (*Fusarium avenaceum* [Fr.] Sacc.; *F. culmorum* [W.E. Sm.] Sacc.; *F. graminearum* Schw.; *F. nivale* [Fr.] Ces.)

HEAD DISEASES

1. White-heads
   i. Browning of stem base associated with dark-brown mycelium ..... Take-all (*Gaeumannomyces graminis*)
   ii. Browning of stem base. No dark-brown mycelium ..... Fusarium Foot-Rot (*Fusarium* spp.)
   iii. Associated with eyespot lesions at the base of the plant ..... Eyespot (*Pseudocercosporella herpotrichoides*)
   iv. No discoloration of the stem base ..... Severe drought.
2. Head Blight
   i. Bleached to grey lesions on the flag leaf sheath, later infecting the head where cottony white to pink mycelium may be seen together with powdery pink spore masses ..... Fusarium Head Blight (*Fusarium culmorum* (W.E. Small) Sacc.)
   ii. Light brown lesions on glume .... Glume blotch (*Stagonospora (Septoria) nodorum*)
   iii. Light brown lesions on glumes but with dark-brown margins ..... Scald (*Rhynchosporium secalis*)
3. Black spore masses replacing the floral parts. Most conspicuous at flowering.
   i. Spore masses retained inside an outer membrane. Awns usually remain attached and erect. Spread occurs during harvest when smut spores contaminate healthy grain. ..... Covered Smut (*Ustilago hordei* [Pers.] lagerh.)
   ii. Black powdery spore mass at flowering, not retained within an outer membrane. Awns become lost ..... Loose Smut (*Ustilago nuda* [Jens.] Rostr.)