Keeping ahead of powdery mildew in barley

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Powdery mildew is one of the world's most significant barley diseases. In Australia, and more particularly Western Australia, its importance has been under-rated, and only recently has interest in this disease emerged.

Powdery mildew was widespread throughout Western Australia's southern cereal growing areas in 1983. Only a prolonged dry period in August and early September of that year prevented possible large-scale crop losses. Similar outbreaks occurred in 1984.

While some barley varieties are resistant to infection, the use of fungicides, particularly seed dressings, can minimise further infection.

### Symptoms

Powdery mildew is caused by a fungus *Erysiphe graminis f.sp. hordei* which is specific to barley. The symptoms of infection are pure white fluffy superficial growths or lesions on the leaf. These lesions enlarge rapidly and coalesce with others, giving the leaf a powdery appearance. Infection leads to premature yellowing and later death of the entire leaf.

### Infection and carry-over

The fungus produces two types of spores which can cause new infection.

Many asexual spores called conidia are formed on the white lesions and make up the powdery mass.

Conidia are wind-blown, singly or in clumps. Most of the spores are carried short distances before landing but some can be carried over very long distances at considerable height. Under favourable conditions, this disease can spread quickly over a wide area.

Infection occurs when conidia settle on the leaf. They germinate within two hours of settling by producing a delicate tube or haustoria which enters the plant tissue to absorb nutrients. From this point, the fungus grows rapidly and within about five days a new generation of conidia is produced.

Leaf wetness is believed to discourage infection by washing spores off and by inhibiting spore germination. However humidity must be high enough to prevent the delicate tube drying out. This may explain why powdery mildew develops more regularly in south coastal areas receiving over 325 mm of rain.

The white lesions darken to a buff colour with age. Later in the season small black bodies called cleistothecia appear which contain the sexual spores or ascospores. These black bodies can survive on plant debris over summer to release sexual spores when wetted. Research at the University of Western Australia has confirmed that autumn rain encourages ascospore production and the infection of self-sown barley.
The relative importance of both types of spores to fungus survival over summer is not known. The fungus may survive as asexual spores on self-sown barley plants around Esperance and south-west coastal areas when summer rain falls. In the rest of the cereal growing area, the sexual spores may survive on stubble. The significance of these spores in mildew epidemics here needs further investigation.

Effect on the crop
In Western Australia powdery mildew infection is highly unlikely to severely damage barley crops, but it could significantly reduce yield and quality. Early infection may restrict root development and reduce the number of grain bearing heads, number of grains per head and general growth of the plant. Late infection may reduce grain weight and cause smaller grains. Overseas work and our observations suggest that early infection by powdery mildew is the most damaging to the crop. The State's barley crops show most mildew during the early growth stages, but the disease usually disappears later in the season when the weather is drier and adult plant resistance is higher, although tiller number may already have been reduced.

Overseas results show that powdery mildew infection may also reduce the quality of the grain for malting.

Control
Variety resistance
The initial development of resistant barley varieties was seriously frustrated by the breakdown of resistance within a few years of their release.

The powdery mildew fungus consists of numerous strains, as does rust. More than 100 strains have been identified overseas and there is evidence of similar variability here. Strains capable of attacking new resistant varieties quickly evolve, multiply and render resistance ineffective. As a result breeders have had to use additional strategies to exploit the benefits of genetic resistance.

One scheme which operated in the United Kingdom for some time was the Cultivar Diversification Scheme. Farmers were advised to grow two or more barley varieties, each carrying a different genetic basis for powdery mildew resistance. Tables were provided which showed which varieties should be grown together and which combinations to avoid. It was hoped that this would slow the mildew epidemic within a season and discourage dramatic changes in the mildew strains which occur when a single resistant variety is grown over large areas.

The scheme is being replaced by one in which a mixture of varieties is planted, each with a different source of genetic resistance. The mixtures appear to have more stable resistance to mildew and out-yield the sum of the resistance of component varieties. This approach is achieving some acceptance in Europe. However, it would create major difficulties in the malting barley trade in Australia and does not appear practical here.

In Western Australia there is little information available on the resistance of currently recommended barley varieties. Field observations for 1982-83 are shown in Table 1.

Fungicides
A number of systemic fungicides highly effective against powdery mildew are available. They can be applied as seed dressings as well as foliar sprays. In Europe, where barley yields are very high, fungicides are now an important part of the total control strategy.

Fungicides such as Milstem® and Calixin® are only effective against mildew. Others such as Benlate®, Bayleton® and Tilt® are also effective against many other diseases.

The effect of fungicidal seed dressing and spraying was examined in South Australia and some significant increases in yield were recorded with seed dressing. Grain yield increased by up to 41 per cent when powdery mildew was controlled throughout the growing season.

In Western Australia at Esperance Downs Research Station in 1983, yields of Dampier increased by 30 per cent in one trial after spraying with a fungicide. Yield was up 20 per cent when the seed was treated with Erex® seed dressing.

In trials on farmers' properties at Esperance in 1983, yield responses to a single fungicidal spray on Dampier varied from nil to 16 per cent and from 3 to 21 per cent with two sprays. If the...
Table 1. Powdery mildew resistance of barley varieties.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Western Australian varieties</th>
<th>Some Eastern States varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moderately resistant</td>
<td>* Forrest</td>
</tr>
<tr>
<td></td>
<td>Moderate susceptible</td>
<td>* O'Connor</td>
</tr>
<tr>
<td></td>
<td>Susceptible</td>
<td>* Stirling</td>
</tr>
<tr>
<td></td>
<td>Very susceptible</td>
<td>* Clipper</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shannon (Tas)</td>
<td></td>
<td>* Forrest</td>
</tr>
<tr>
<td>Galleon (SA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grimmett (Qld)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schooner (SA)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Currently recommended
† Widely grown

Table 2. Effect of powdery mildew control on yield of three barley varieties to nitrogenous fertiliser (kg/ha).

<table>
<thead>
<tr>
<th>Variety</th>
<th>No nitrogen fungicide</th>
<th>Fungicide</th>
<th>20 units nitrogen fungicide</th>
<th>Fungicide</th>
<th>40 units nitrogen fungicide</th>
<th>Fungicide</th>
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</thead>
<tbody>
<tr>
<td>1982</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stirling</td>
<td>2859</td>
<td>3192</td>
<td>2666</td>
<td>3269</td>
<td>2795</td>
<td>3564</td>
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<tr>
<td>Forrest</td>
<td>2808</td>
<td>2680</td>
<td>2756</td>
<td>2910</td>
<td>2885</td>
<td>2756</td>
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<td>1983</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dampier</td>
<td>1600</td>
<td>1676</td>
<td>1679</td>
<td>1908</td>
<td>1592</td>
<td>1917</td>
</tr>
<tr>
<td>Forrest</td>
<td>1711</td>
<td>1833</td>
<td>1711</td>
<td>1536</td>
<td>1712</td>
<td>1714</td>
</tr>
</tbody>
</table>

Prospects for Western Australia

In view of overseas experience it is unlikely that a major effort to breed resistant varieties for Western Australia will be fruitful in the long term. For example, Clipper barley was released as a resistant variety in 1972 but is now affected by mildew in many areas. The resistance of recommended varieties will be carefully monitored and advanced breeding lines will be screened for resistance. Even small amounts of resistance can reduce mildew infection significantly when combined with fungicidal seed dressing.

The use of variety mixtures to control mildew is practical for feed barley only. If mixtures are to be used, a large number of high yielding varieties with a variable genetic basis of resistance would be needed. New mildew strains would have to be constantly monitored and the seed industry would have to consider selling seed mixtures.

Until the full potential of mildew to reduce crop yields is understood and the potential gain is well established, it is unlikely that the Department of Agriculture's limited resources will be directed to such an extensive breeding programme.

The use of fungicides, particularly seed dressings, may minimise the mildew problem. An assessment of the resistance of recommended varieties, their response to seed dressing, and if necessary to spraying, could form a suitable programme for minimising yield losses due to mildew.

An understanding of the role of stubble, and the effect of nitrogenous fertilisers and other cultural practices on mildew epidemics in different barley varieties, will help to maintain and maximise yields in mildew-prone areas of the south coast.

Single spray had been applied earlier in the season, yield responses would probably have been greater.

Seed dressing would protect plants against infection from emergence to the start of tillering. A combination of a seed dressing plus a single spray could be an economical choice in a potentially high yielding crop.

Cultural practices

Much information on cultural methods that could reduce crop losses from powdery mildew has been reported from Europe. Some of these methods are not relevant to Western Australian conditions, others need to be tested. High rates of nitrogenous fertilisers have been reported to increase mildew infection, and crops on manganese deficient soils are more susceptible. Stubble burning and ploughing in self-sown barley plants have been recommended in the United Kingdom.

In trials at Esperance Downs Research Station in 1982 and 1983, high nitrogen applications increased the levels of mildew infection. However yield losses due to mildew depended on variety. Forrest, which at the time showed some resistance to mildew, showed almost no response to applied nitrogen or mildew control in both years (Table 2).

The susceptible varieties Stirling and Dampier only responded to applied nitrogen when mildew was controlled. Stirling yielded more than 3.5 tonnes per hectare in 1982 as a result of high nitrogen applications and mildew control. Dampier with similar treatments yielded almost 2 t/ha in 1983.

The 1983 yield results are high for a season when the very dry spring depressed overall barley yields. They indicate a need for powdery mildew control in variety comparisons and in agronomic trials. The roles of stubble and sowing dates also need careful consideration and studies of these started in 1984.