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Coping with brown spot
and root rots of lupins

By Mark Sweetingham, Plant Pathologist, South Perth

There is increasing concern that brown spot and root diseases may limit the long term viability of lupin cultivation in close rotations in the agricultural areas of Western Australia.

Research has found several useful strategies to reduce the impact of brown spot and Pleiochaeta root rot so that losses can be kept to a minimum.

Rhizoctonia has proved more difficult to combat. Although less widespread than Pleiochaeta, it has caused severe losses and appears to be increasing in incidence, particularly in the northern wheatbelt.

Research has vastly expanded our knowledge of the strains of Rhizoctonia present in our soils and the diseases they cause. Because we can now identify the strains involved, we are better able to examine the impact of management techniques on disease severity and to start screening lupins for resistance to the various strains.

PLEIOCHAETA DISEASES

The fungus Pleiochaeta setosa has been known as the cause of the disease brown spot of lupins in Western Australia since 1940. In 1983, it was discovered that the same fungus also causes a damaging root rot of seedling lupins.

Research has unravelled the life cycle of this organism. Of crucial importance are the large quantities of spores produced on fallen diseased leaves under the crop canopy. These spores can survive for several years in the soil, carrying over the major source of root and leaf infection for subsequent lupin crops.

The severity of brown spot as a leaf disease varies dramatically with seasonal conditions. Yield is affected most if disease is severe within the first few weeks after sowing, when seedlings can be drastically set back or killed by complete defoliation and infection of the growing point. In many situations disease is confined to spotting and defoliation of the lower leaves with little if any effect on yield. However, such infections still significantly add to the spore population in the soil.
Stems are often flecked and spotted and occasionally, in severe cases, large cankers develop which can girdle the plant and kill it above the infection point.

Pods also may develop lesions, particularly those set closer to the ground. Occasionally the fungus can grow through the pod wall to infect and discolour seed. Such seed is usually not viable and therefore does not contribute much to disease carry-over.

By contrast, the severity of Pleiochaeta root rot varies less from season to season, depending mostly on the soil spore population and the method of establishing the crop. However, it is more severe where the surface soil dries out shortly after seeding. When the disease is severe, the tap root of young seedlings rots off and the plant dies, reducing stand densities and thus yield potential. Less severe disease, resulting in the partial rottin of the tap and lateral roots, reduces seedling vigour, which can depress yields.

**Disease risk**

An understanding of the risk of severe brown spot and Pleiochaeta root rot in a particular paddock is important if farmers are to make the appropriate management decisions to combat these diseases.

Climate and soil type strongly influence the risk of brown spot. In the northern wheatbelt, because of higher winter temperatures, lupins grow rapidly out of the susceptible seedling stage and develop tall dense stands which reduce rain splash of spores from the soil onto the plant.

In colder areas, growth rates are slower and plants remain small with prolonged exposure to rain splash at the most susceptible 0 to 4-leaf stage. They also take longer to grow away from disease on the lower leaves.

In the lower rainfall areas, crops are less able to compensate for early setbacks in vigour because of the shorter growing season and so early brown spot can have a greater impact on grain yield (Figure 1 and map).

Narrow-leafed lupins are best adapted to slightly acidic deep loamy sands. They are progressively less suited to growing on the more acidic yellow earths, leached grey and white sands, duplex and heavier soil types. On less favourable soils growth rates are reduced,
keeping plants shorter and exposed to rain splash for longer. Also, crops do not finish as well on these soils, providing less opportunity to compensate for earlier disease.

Pleiochaeta root rot is less influenced by climate and soil type than is brown spot, and can be severe throughout the wheatbelt.

The spore population in the soil is the major determinant of the risk of Pleiochaeta root rot in a paddock. The higher the spore population the more severe the disease. Brown spot risk is also increased with higher spore populations, but not to the same extent.

Spores in the soil are produced initially on the carpet of fallen leaves under previous lupin crops. It was originally thought that spores were only produced on the brown spot-infected leaves that drop prematurely from the plant. It now seems likely that the fungus can grow and produce spores on healthy leaves after they senesce and fall onto the ground. So not only severely diseased, but relatively healthy lupin crops can contribute large increases to the soil spore population, but not to the same extent.

There is some experimental evidence that very dense crops (more than 50 plants per sq. metre) may contribute to high spore populations because of earlier leaf drop but this effect needs further investigation.

Brown spot can develop on land cropped to lupins for the first time from small numbers of spores that may accompany the seed or be wind-blown from nearby paddocks. If the weather is favorable, more spores can be produced on the fallen diseased leaves to reinfect the plant that season. However, first time lupin paddocks usually have low levels of brown spot and do not have spores distributed through the soil profile to cause Pleiochaeta root rot.

Management strategies to minimize losses

Rotation

The population of P. setosa spores in soil declines by about half every 12 months. So the longer the break between lupin crops the lower will be the spore numbers and the disease risk.

P. setosa is a specific pathogen. It attacks all Lupinus species but does not attack cereals or common pasture and weed species that grow in the agricultural areas with two possible exceptions. Serradella (Ornithopus spp.) can get a brown spot infection associated with Pleiochaeta, but recent evidence suggests that it is a different species or strain of Pleiochaeta which is not very damaging to lupins. Similarly, the lupin-attacking Pleiochaeta appears less virulent to serradella. Very occasionally P. setosa infects peas and other legumes which have been damaged by sand blasting. However, in such instances where infection is slight, increases in spore population of the soil would be negligible.

Cereals are the preferred break crop because of their improved yields after lupins and the opportunity they provide to control broadleaf weeds in the rotation.

The number of years needed between lupin crops to reduce disease to an acceptable level will depend on the disease risk (imposed by climate and soil type) and a farmer’s ability to comply with the other management options to be discussed later.

Generally, a one-year break is sufficient under most circumstances on good yellow sandplain in the northern wheatbelt; whereas a three-year break may be necessary on a wodjil soil type in the eastern wheatbelt. The results of two rotation trials, one on the East Chapman Research Station and the other at Korbel (15 km south-west of Merredin), support this idea (Table 1).

The climatic risk of yield loss in lupins from brown spot. Note: The severity of Pleiochaeta root rot is much less influenced by climate than is brown spot.
Table 1. The effect of rotation on brown spot, Pleiochaeta root rot and yield in two contrasting environments

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Brown spot defoliation</th>
<th>Grain yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W W W W L</td>
<td>6.3</td>
<td>0.82</td>
</tr>
<tr>
<td>L W W W L</td>
<td>7.6</td>
<td>0.58</td>
</tr>
<tr>
<td>- L L L L L</td>
<td>8.0</td>
<td>0.12</td>
</tr>
<tr>
<td>W R W L &lt;2</td>
<td>12.0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Korbel (gravely yellow earth, pH 5.6)
- W L W W L | <2                    | 1.35             |
- W L L L L | <2                    | 1.26             |
- W L L L L | <2                    | 1.23             |

East Chapman ('Eradu' yellow loamy sand, pH 6.5)

*: Number of primary leaves on the main stem defoliated at the 12-leaf stage
W = wheat; R = rape; L = lupins.

Sowing date
Early sowing is always recommended for maximum yields of lupins. However, it is critically important in the high disease risk areas, where sowing in the last week of April or early May enables seedlings to develop beyond the most susceptible 0 to 4-leaf stage before the onset of colder and wetter weather in June or July.

Stubble mulching
Lupins sown into cereal stubble suffer less brown spot than those sown on bare ground. The stubble needs to be on the soil surface (not buried) after the seeding operation. As the amount of stubble on the soil surface increases brown spot infection continues to decrease.

The stubble mulch appears to reduce the rain splash of soil particles containing the P. setosa spores on to the leaves and stems of the plant. Stubble may also increase seedling vigour and reduce disease susceptibility by reducing surface wind velocity and injury from sand-blasting.

Sowing depth
Spores of P. setosa are most concentrated in the top 2 cm of soil, rapidly declining to zero at about 10 to 12 cm depth. Pleiochaeta root rot is more severe with shallow sowing depths because the tap root has to grow through the band of concentrated spores (Figures 2 and 3).

A sowing depth of 5 cm appears to be best for lupin establishment at sites with a high concentration of Pleiochaeta spores. This depth also ensures rapid imbibition and germination of seed. Shallow-sown seed may fail to germinate until a later rain because the surface few centimetres of soil can dry out so rapidly, particularly in early May. On the other hand, sowing deeper than 7 cm causes plant densities to decrease.

Seeding machinery
Several trials have compared the establishment of lupin crops with different seeding systems.

Depth control is much inferior with cultitrash discs compared with a tined seeder. Regardless of the depth the discs are set to cut, a typical cultitrash arrangement will sow most seed relatively shallow (depths ranging from 0 to 4 cm). As a consequence root rot is more severe and establishment often poorer with a cultitrash than a tined seeder which can more accurately place the seed below the concentrated band of spores in the soil.
Lupins were sown 2 cm deep (left plot) and 5 cm deep in these marked plots on Wongan Hills Research Station. Trial results have consistently shown that sowing 5 cm deep improves yield where Pleiochaeta root rot is severe and where surface soil moisture is marginal.

However, trials in 1989 indicated that depth control with a cultitrash could be improved by directing the seed tubes behind the back discs. This modification reduced root rot and improved establishment and yield.

The use of a disc plough to incorporate topdressed seed also results in severe root rot (see tillage).

Tillage

Using a disc plough to control weeds, reduce stubble or incorporate simazine before seeding lupins can dramatically increase root rot. The disc plough inverts the soil and buries the band of concentrated spores deeper into the soil profile where they can more readily infect roots.

Scarifying with a tined cultivator causes much less spore burial and accompanying root rot.

Direct drilling is the best choice as lupins rarely show a growth response to cultivation and Pleiochaeta root rot infection is kept to a minimum.

Recent results have shown that spores buried by disc ploughing before the previous season’s wheat crop will survive at depth and cause more root rot in the following lupin crop compared to direct drilling the wheat. Scarifying or deep ripping the previous wheat crop has no deleterious effects on subsequent lupins (Figure 4).
Fungicides

Two dicarboximide fungicides Rovral® and Sumisclex® consistently reduce brown spot in seedling lupins when used as a seed dressing. Results of many trials over several seasons show that fungicide seed treatment increases yields the most in crops that get severe brown spot in the first three weeks after sowing.

Where brown spot is mild or epidemics build up later in the season, there may be little if any yield increase from seed dressing.

However, in moderate and high risk situations, seed treatment is worthwhile insurance against seedling wipeouts as large yield losses can be avoided.

Research is continuing to see if early indications of the effectiveness of lower rates of these fungicides is consistent over more sites and seasons. The Department of Agriculture should be contacted for further advice.

The ability of seed treatments to control Pleiochaeta root rot has been more variable. In some trials root rot was suppressed whereas in others it was not.

Phosphorus nutrition

Rahman and Gladstones (1974) were the first to note that lupin crops severely deficient in phosphorus suffer more from brown spot than those with adequate phosphorus.

Recent research has investigated whether marginally deficient crops are more susceptible to disease, and whether increasing the level of nutrition beyond that recommended for maximum profit (under disease-free conditions) would reduce brown spot and Pleiochaeta root rot.

Results of field trials have indicated that the interaction between disease severity and phosphorus nutrition varies with the season and the nature of the brown spot epidemic. Higher levels of phosphorus nutrition (whether from higher concentrations of phosphorus in the seed or from drilled or deep-placed fertilizer) seem to have little effect on the severity of brown spot epidemics in seedlings. However, better phosphorus nutrition may reduce brown spot when epidemics continue into August by increasing canopy development, so protecting upper leaves from infection by rain-splashed spores.

The direct effect of seed phosphorus concentration and fertilizer phosphorus on Pleiochaeta root rot appears small and inconsistent. However, root rot may reduce the plant’s ability to take up phosphorus through ‘root pruning’.

In only one of seven trials comparing phosphorus rates at different disease pressures was the optimum rate higher in the more diseased treatment. In the other six, the optimum rate was the same for all disease pressures. What may prove to be of greater importance is the recent research showing the substantial benefits of deep placement of superphosphate as opposed to drilling or topdressing (Jarvis, 1989).

Seeding rate

Stand density has little any effect on brown spot epidemics in seedlings. However, thin stands (less than 20 plants per sq. m) are shorter and tend to close their canopy slower, which may extend the period of susceptibility to rain splash.

Stands greater than 50 plants per sq. m may increase P. setosa spore populations by encouraging earlier drop of the older leaves. The optimum stand density in most situations is 40 to 45 plants per sq. m.

Seeding rates can be increased to compensate for losses caused by high levels of root rot which might be anticipated if seeding with a cultittrash or into a disc-ploughed paddock.
RHIZOCTONIA ROOT AND HYPOCOTYL ROTS

The root rotting fungus Rhizoctonia occurs worldwide in cultivated and virgin soils. Many species and strains of this fungus exist and they vary dramatically in their virulence and host range.

Recently a polyacrylamide gel electrophoresis (PAGE) system was adapted to rapidly ‘finger­print’ strains of Rhizoctonia (Sweetingham et al., 1986). With the aid of this technique, 10 distinct strains of Rhizoctonia solani and five of other Rhizoctonia species have been identified from diseased roots of crop and pasture plants from the State’s agricultural areas.

The virulence and host range of these strains has been tested in glasshouse experiments. From these tests the 15 strains can be assigned to four main groups.

The bare patch group (R. solani ZG 1-1, ZG 1-4 and ZG 2)

This group causes the disease known as Rhizoctonia bare patch which has been known in southern Australia for more than 50 years and was confirmed in Western Australia in 1981 (MacNish 1983).

Rhizoctonia bare patch occurs in cereals, lupins and pastures, illustrating the wide host range of these strains. The disease is characterized by its occurrence in abrupt-edged patches which are usually roughly circular and range from 0.3 to 5 m in diameter. In lupins both tap and lateral roots become pinched off by a brown rot to produce ‘spear tips’, similar in appearance to Pleiochaeta root rot. (However, Pleiochaeta root rot does not occur in distinct, abrupt-edged patches.)

In Western Australia Rhizoctonia bare patch has been most widespread on the calcareous mallee soils around Salmon Gums and on the Esperance sandplain. However, it occurs in scattered pockets throughout the wheatbelt.

The ZG 1-1 strain is by far the most common.

The legume-attacking group (R. solani) ZG 3, ZG 4 and ZG 6)

The strains in this group are most virulent on legume species such as lupins, peas, subterranean clover and medic, although they cause minor infections of cereals and other species. In cereals they rot the coleoptile of young seedlings which can lead to some emergence problems in deeper sown crops, but they do not infect the roots.

Strains ZG 3 and ZG 4 attack the hypocotyl (the below ground stem) causing distinct reddish-brown lesions and rarely infect the tap root. They can also rot lupin seed before it emerges or kill a seedling between the 2 to 6-leaf stage when lesions rot completely through the hypocotyl, cutting off the root system.

If plants with hypocotyl lesions survive beyond the 8-leaf stage they usually remain somewhat stunted; lateral roots initiated from the lesioned portion of the hypocotyl can become infected and pinched off. In some instances mature plants can die suddenly when the fungus has effectively ring-barked the plant just below ground level.

Until recently, hypocotyl rot caused by the ZG 3 and ZG 4 strains has been observed as a randomly scattered disease. However, when severe, it seems it may occur in distinct patches similar in above ground appearance to Rhizoctonia bare patch.

The ZG 3 strain has been recorded in the northern and central wheatbelt mainly on white, grey and pale yellow sandy surface soils. The ZG 4 strain appears slightly less common, but has been found over a wider area of the State, particularly on white and grey sands including the south coastal strip.
The ZG 6 strain causes severe root and hypocotyl rot of seedling lupins. The hypocotyl lesions are indistinguishable from those caused by ZG 3 and ZG 4. The root lesions are often more reddish-brown than those caused by the bare patch strains or *Pleiochaeta*. Pinched off roots are characteristically stubby and not spear-tipped like those caused by the bare patch strains.

As with the other strains in the group it has also been found almost exclusively on white, grey and pale yellow sands. It has been recorded throughout the wheabelt. Its distribution within a paddock is scattered or in small clumps rather than as abrupt-edged patches.

Recently, the PAGE system identified another strain (ZG 10). It causes root and hypocotyl lesions on lupins very similar to those of ZG 6. It causes minimal damage to wheat, although its full host range has not yet been determined. It is less common than the other strains, only being recorded so far from Manjimup and Esperance.

Sometimes all the legume strains can occur together in a single paddock. Usually, however, one strain is dominant.

The crucifer attacking group (*R. solani*) ZG 5 and ZG 9

The ZG 5 and ZG 9 strains cause insignificant amounts of damage to cereals and legumes but can cause serious hypocotyl rot of rapeseed and other crucifers.

The weak or non-pathogenic group (Binucleate Rhizoctonia species)

All the *R. solani* strains are multinucleate (have more than two nuclei per cell). There are other *Rhizoctonia* species that are binucleate (have only two nuclei per cell). Several strains of the binucleate type (CZG 1, 2, 3, 4 and 5) have been isolated from cereal and legume roots throughout the agricultural south-west of Western Australia. They appear to cause little or no disease on wheat or lupins.

Management to minimize losses due to Rhizoctonia

There are fewer options for controlling *Rhizoctonia* diseases compared to *Pleiochaeta*; and the strategies differ for the various strains.

*Rhizoctonia* bare patch (ZG 1-1, ZG 1-4, ZG 2)

*Rhizoctonia* bare patch is most severe in direct drilled crops and cultivation reduces its severity (MacNish 1985; Rovira 1986).

Jarvis and Brennan (1986) found that the timing of cultivation or the implement used was not critical, but that disease control increased with depth of cultivation. They demonstrated a large reduction in disease with a modified combine that cultivated a slot 8 to 10 cm below the seed while seeding at normal depth in a single pass operation. An important advantage of this system is the reduced risk of soil erosion.

Crop rotation does not control Rhizoctonia bare patch because of the wide host range of the strains involved. Fungicide seed treatments and depth of sowing also seem to have little effect.

*Rhizoctonia* hypocotyl rot (ZG 3 and ZG 4)

Cultivation does not control hypocotyl rot. It can make it worse as there is a tendency to accidentally sow deeper into the resulting softer seedbed. Severe outbreaks of hypocotyl rot are often associated with sowing deeper than 6 cm. Shallower sowing (2 to 3 cm) exposes less hypocotyl tissue to infection.

The ZG 3 and ZG 4 strains appear to survive well in the soil in the absence of their preferred legume hosts and one or two cereal crops seem to have little effect on disease. However, severe outbreaks have often been seen in crops following a long pasture phase, suggesting a gradual build up in population under subterranean clover or annual medic.

Fungicide seed treatment offers some promise for suppression of hypocotyl rot. In field trials, Rovral and some experimental fungicides have suppressed disease. However, these trials have always been at sites which developed only low levels of hypocotyl rot, and so no conclusions could be drawn on control under high disease pressure where potential for an economic return from seed treatment might exist.

At sites with a history of severe hypocotyl rot, increasing the seeding rate to compensate for expected losses in stand density is recommended.

Early sowing may possibly increase the disease risk as in several instances lupins resown immediately into paddocks wiped out from hypocotyl rot have escaped serious infection.

*Rhizoctonia* root and hypocotyl rot (ZG 6)

Where strain ZG 6 is dominant neither cultivation nor sowing depth reduce the severity of the disease. Shallow sowing increases root infection and sowing deeper increases hypocotyl infection with no overall benefit.
A limited number of fungicide trials have indicated that hypocotyl infection, but not root infection, may be suppressed by seed treatment. More trials are needed. Increasing seeding rates may be appropriate in paddocks with a history of severe disease.

PUTTING TOGETHER A LUPIN DISEASE MANAGEMENT SYSTEM

For successful management growers need to know the pathogens and the disease risk in each paddock. The information in this article on distribution and risk by climate and soil type can be used as a guide, but confirmation from the Department of Agriculture on specific disease problems is advisable.

A common difficulty arises in trying to achieve an accurate sowing depth while retaining stubble. Available seeding machinery has deficiencies in one or other of these areas.

The two extreme choices are to cultittrash straight into the standing stubble (good stubble retention but poor depth control); or to burn the stubble and sow with a combine or airseeder (no stubble but good depth control).

Better solutions include cutting straw shorter and spreading it more evenly at harvest, or reducing large stubbles by raking and cold burning to assist seeding with tined implements. (If seeding with tines, rolling prickle chain harrows can greatly improve incorporation of simazine).

Alternatively the depth control of a cultittrash may be improved by modifying seed tube placement or disc angles.

These decisions have to be made on an individual paddock basis, considering the disease risk, erosion risk, weed burden and yield potential; as well as your budget, existing machinery and other management constraints.

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References and further reading


