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primefact

Reducing the risk of lupinosis and the incidence of phomopsis

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Introduction

The two main species of lupins grown in Australia are Narrow-leaf lupin (*Lupinus angustifolius*) and Broad-leaf or White lupin (*L. albus*).

There are two ways lupins are used in livestock production: [1] grain is fed specifically to livestock as a supplement to maintain or increase liveweight and [2] stubble is grazed after harvest.

Lupin seed is high in protein and metabolisable energy while being low in starch. It is relatively safe to feed to ruminants and is often used in feedlot rations as a cost effective protein source.

A potential issue with grazing lupin stubble or in some cases feeding lupin seed is the risk of lupinosis, a disease that primarily damages the liver and causes loss of appetite, poor production and sometimes death.

Lupinosis is caused by a toxin that is produced by the fungus *Diaporthe toxica*, formerly known as *Phomopsis leptostromiformis*.

The fungus can infect all plant parts but is more commonly seen on dry stems at maturity and on pods and in some cases seed. It is commonly referred to as phomopsis stem and pod blight, or simply phomopsis.

Some lupin varieties are resistant to infection by *Diaporthe*, which means lower risk of lupinosis for livestock in normal years. With careful grazing management the risk is small and the benefits are great.

In years with late season rain or hail, the risk of lupinosis increases. Sowing lupins close to the previous year's stubble also increases the risk.

Phomopsis infected lupin grain is unsuitable for sowing due to poor germination. Also, sowing affected seed may spread the pathogen.

This Primefact looks at managing the risk to livestock from lupinosis as well reducing the incidence of phomopsis infection on lupin crops.

Benefits to livestock grazing lupin stubble

Lupin stubbles are reasonably nutritious and can achieve daily weight gains up to 200 and 500 grams per head in lambs and young cattle respectively. Lupin seed is very nutritious and can produce rapid weight gains.

Livestock performance is mainly driven by the quantity of available seed and any green material in the paddock. Broad-leaf lupin grain is nearly three times larger than narrow leaf and thus easier for livestock to find, causing increased daily intakes and production.

Different parts of the lupin plant vary greatly in quality. Table 1 lists the differences between leaf, stem, grain and pod for narrow-leaf lupins.

Seed pods can maintain liveweight as long as protein is available from other parts of the diet such as seed.

Livestock performance is better if higher value components of the stubble are available. The more stubble there is, the greater the likely availability of these components.

Table 1. Feed quality of the components of narrow leaf lupin stubble before and after grazing.

	Crude Protein (%)		Dry Organic Matter Digestibility (%)	
	3 Dec	24 Mar	3 Dec	24 Mar
Stem	3.7	3.9	31.68	17.46
Leaf	19.6	10.9	29.61	31.59
Pods	3.1	3.3	51.66	23.31
Seed	33.2	32.5	78.93	80.73

May, Barker and Ferguson (1990) Performance of weaner steers grazing stubbles of Narrow Leafed Lupin and Wheat stubbles. Proceedings Australian Society of Animal Production, Vol 18 Page 288-291

Risks for livestock grazing infected lupin stubble or grain

Sheep and cattle grazing lupin stubbles or fed lupin seed infected with Phomopsis may develop lupinosis. See Table 2.

Grazing lupin stems with high levels of toxin usually results in livestock getting lupinosis within a couple of days, while at low levels the disease develops over a number of weeks.

In relatively wet years the risk increases as conditions favour fungal growth (even in resistant varieties) which can often spread to seed and pods. Under these conditions livestock are much more likely to consume toxic fungus from stems, pods or seed.

If pycnidia (leopard spotting - Figure 1 - B) are seen on stem material, pod and seed are probably also infected, and the risk of lupinosis is too great to allow grazing of the stubble.

The upside of wetter than average conditions is other feed being available due to increased growth of pasture and green weeds in cereal stubbles.

Impacts of lupinosis on sheep

Lupinosis and associated liver damage can happen quickly if animals consume a lot of toxin, usually following wet humid conditions or in remnant stubble in the year following the crop.

Gradual liver damage is most probably due to lower exposure to toxin following normal rainfall and low levels of spilt grain.

In the worst cases lupinosis can cause deaths but commonly results in weight loss as sheep lose their appetite. In late pregnant ewes this may result in pregnancy toxaemia. Wool growth and staple strength may also be reduced while twinning and conception rates may be significantly reduced.

Figure 1: Effect of phomopsis on Albus lupins. A. Contrasting a resistant variety on right with a susceptible variety on the left. B. Characteristic pycnidia ("leopard" spotting) on *L. albus* stubble. Stems such as these will contain the toxins causing lupinosis. Infected stems look similar in both lupin species. C. Heavily infected pods and seeds from field grown plants after late season rain. D. An infected lupin plant prior to harvest following late season rain.

Table 2. Summary of lupinosis risk.

Low risk	High risk
Grazing stubbles in years with normal rainfall	Grazing stubbles following late season rain or stubbles that have suffered from hail damage
Grazing stubbles that contain more than 50kg/Ha of grain for sheep and 100kg/Ha for cattle	Grazing stubbles containing less than 50 and 100kg of grain per hectare for sheep and cattle respectively
Grazing stubbles soon after harvest	Delayed grazing of stubbles after harvest especially in wet humid conditions
Grazing sheep in mobs smaller than 600 head and stocked at less than 10 per hectare	Grazing sheep in mobs larger than 600 head and stocked at greater than 10 head per hectare
Grazing stubbles that do not have pycnidia (leopard spotting)	Grazing stubble that contains pycnidia (leopard spotting)
Grazing stubbles that do not contain discoloured seed	Grazing pasture or cropping paddocks containing lupin stubbles from the previous year's crop
Grazing paddocks sown with clean seed, with a minimum of a four year crop rotation	Grazing stubbles or feed lupin grain containing discoloured seed
Feeding less than 10% infected seed as part of mixed ration	Crops sown with greater than 10% infected seed or sown adjacent to previous years lupin stubble

Weaners are more susceptible to lupinosis possibly because they feed less selectively and likely to consume more stem material compared to adults.

Weaners suffering from mild lupinosis may also suffer impaired selenium and vitamin E metabolism resulting in symptoms similar to white muscle disease.

Impacts of lupinosis on cattle

Cows in late pregnancy and early lactation are affected differently by lupinosis compared to other cattle. They are more likely to suffer from 'fatty liver' syndrome. Liver cells of affected animals contain a lot of fat resulting in enlarged and soft-looking livers.

The effects of fatty liver syndrome are similar to those of starvation ketosis (pregnancy toxaemia) and affected cows usually die suddenly while still grazing the stubble.

Other classes of cattle are more likely to have 'cirrhotic' livers which, unlike 'fatty livers', are small and firm due to scar tissue or 'fibrosis'.

Animals suffering these effects of lupinosis are likely to perform poorly or have photosensitisation for some weeks after grazing lupin stubbles. Some die as liver damage progresses.

Figure 2. A; Phomopsis infected Narrow-leaf lupin seed. Note the golden-tan colour, see Figure 5 for Albus lupin. B; The range in seed mottling between different varieties of Narrow-leaf lupin can make it difficult to detect Phomopsis infected seed. Bar = 10mm.

Grazing management of stubble to reduce the risk of lupinosis

The key to lowering the risk of lupinosis if the infection status of stubbles is unknown is to reduce the need for livestock to graze lupin stems as they are likely to contain higher levels of toxin.

To achieve this ensure that there is sufficient lupin grain and green weeds available. Livestock naturally select this higher quality feed and when it runs out they are then forced to eat lower quality portions such as pods and stem material.

Graze lupin stubbles as soon as possible after harvest, as fungal growth and the toxin tend to increase once the plant dies and losses its resistance.

The longer grazing is delayed the greater the risk that rain will promote fungal growth. In long hot dry summers the risk is much lower and grazing can be delayed to take advantage of the ability of grain to hold its quality later into the season.

Avoid moving hungry livestock onto lupin stubbles. Wait until mid morning after animals have had a chance to graze.

Length of grazing

The length of grazing time depends a lot on the amount of seed/stubble per hectare, the size of the paddock and the stocking rate.

After harvest, there can be between 50 and 400 kg per hectare of grain remaining on the ground.

As a guide sheep should be removed from stubble paddocks when the amount of seed falls to around 50kg per hectare (100kg/ha for cattle) and before the green weeds run out.

Removal of livestock at this time will not only reduce the risk of lupinosis if stubble is infected, it will also benefit livestock production and help protect ground cover and soil.

Careful monitoring of how much seed is available and grazing habits allows removal of animals before they are forced to consume stem material.

Stocking rate and mob size

Grazing lupins stubbles at low stocking rates allows animals to freely select spilt grain and green weeds. Stocking rates at or below 10 sheep or two cattle per hectare are advisable.

Large mob sizes can make observation of livestock and early detection of lupinosis difficult.

Also larger mobs often ‘eat out’ areas faster than expected which may result in larger amounts of stem material being consumed earlier than anticipated.

Grazing last year’s lupin stubble

Lupin stubble can remain toxic for over 12 months and the risk is high that last year’s stubbles will be infected. Avoid sowing grazing crops into lupin stubbles as livestock often seek roughage when grazing lush crops. Take special care if livestock are to graze these paddocks. Carefully inspect paddocks to ensure there are no signs of pycnidia or ‘leopard spotting’, particularly if a dry season follows the lupin crop.

Table 3. Method for calculating amount of grain remaining in a field following harvest

Steps	Process	Example
Step 1	Measure width of header windrow in relation to width of header cut ▪ Calculate ratio of counts both within and outside the windrow	▪ Cut is 10 m ▪ Windrow is 3 m ▪ Take one third of the counts within the windrow and two thirds outside the windrow
Step 2	Use 50 × 50 cm quadrant ▪ Collect all the grain within the quadrant from random locations across paddock. ▪ Ensure one third of samples are taken within the windrow and two thirds outside. ▪ Weigh total grain collected	▪ 21 quadrant samples of grain were collected ▪ Total weight: 24 grams
Step 3	▪ Calculate average weight of grain per quadrant	▪ 24grams / 21 quadrants ▪ = 1.14 grams of grain per quadrant
Step 4	▪ Calculate the amount of grain per hectare (A 50×50 cm quadrant = ¼ of a square meter)	▪ 1.14grams X 4 = 4.56 grams per square meter ▪ There is 10,000 square meters in one hectare (ha) ▪ 10,000m x 4.56 grams = 45,600 grams per ha ▪ = 45.6 kg of grain per ha
Step 5	▪ Determine if grazing should cease ▪ Guideline: allow grazing if ○ Sheep >50 kg grain / ha ○ Cattle >100kg grain / ha	▪ In this example there is insufficient grain: the benefit of grazing does not outweigh the risk of lupinosis or damage to ground cover

Estimating the amount of grain present

Estimating the amount of grain present at the start and throughout the grazing period is crucial when deciding to graze or continue to graze stubble paddocks.

To accurately assess the amount of seed available for grazing, it is important to collect a number of samples while walking across the header windrows.

The header windrows probably contain more seed so ensure the samples are taken both within and between windrows.

Estimate the width of the windrow in relation to the width of the header cut. If the windrow is one third the width of the header cut, make sure the number of counts taken within a windrow is one third of the total number of counts taken.

Table 3 shows how to estimate the amount of grain present on the ground following harvest.

Feeding infected lupin seed

Feeding infected lupin seed to livestock can result in lupinosis if enough toxin is consumed.

Discolouration is a good indication that the seed may be infected. Such seed often weighs less than healthy white seed and can usually be removed through seed cleaning. Figures 2 and 5 show what infected seed may look like.

When assessing the risk of lupinosis, both the percentage of infected seed in the diet and the toxicity of the infected seed has to be considered.

To estimate the percentage of infected seed collect a representative sample. Mix the sample and take a 200gram sub-sample.

Use the photo in Figures 2 and 5 to help sort the sub sample into infected and non infected seed. Weigh the infected sample and calculate what proportion of the 200g sample is infected.

The amount of toxin in samples can be assessed by testing at Agrifood Technology (tel. 03 9742 0555).

Armed with this information multiply the amount of seed fed per head per day, the percentage of infected seed and the amount of toxin per kg of infected seed.

For example:

- 500g/head/day x 10% infected = 50g (i.e.0.05kg) infected seed/hd/day
- 0.05kg x 355µg toxin/kg of infected seed
- = 17.75µg of toxin consumed/hd/day

There are no clear guidelines as to 'safe' levels of toxin for different livestock, but sheep have been fed 12.5*µ*g toxin /kg bodyweight per day, i.e. 625*µ*g of toxin for a 50 kg animal, with minor effects.

It has been suggested that if there is less than 10% of discoloured seed in the sample the risk of livestock suffering from lupinosis is small when the lupins are fed as part of a balanced ration.

As the level of discoloured seed increases, the proportion of lupins fed as part of the diet should decrease.

Symptoms/observation

It is vital to observe livestock daily by moving them a short distance, checking for stragglers, weak or hollow looking animals and any animals with a yellowing of the eyes and mouth (jaundice).

Livestock suffering from moderate levels of lupinosis will also eat less as appetite declines.

As there is no cure for lupinosis, if any sheep show signs of the disease, remove the entire mob from the paddock immediately (if grazing lupin stubble) or immediately cease feeding the grain.

Daily inspection identifies the few animals that begin to graze stems or other infected material before the rest of the mob. In doing so the impact of the toxin can be minimised and more widespread intoxication prevented.

Areas where livestock appear to be grazing more intensely may indicate a higher risk of stem consumption. Careful observation is required; if in doubt it is better to remove livestock. Infected stem material is a potential health risk and provides little nutritional value.

Where mild levels of toxin are suspected, remove livestock from lupin stubbles at least a week before slaughter to reduce the chance of animals being rejected due to jaundice.

Treating affected animals

If lupinosis is suspected in a mob, remove all sheep from the paddock or cease feeding infected grain immediately. Contact your local veterinarian for a diagnosis and treatment options.

Affected animals are likely to have liver damage and **should not** be fed high protein diets for six weeks until their livers have recovered. Sheep and cattle with liver damage cannot tolerate the levels of ammonia resulting from high protein diets.

Separate affected animals from the main mob and feed good quality mature pasture or hay for a number of weeks until they begin to recover. Low protein grains can be introduced gradually if required.

If livestock show signs of photosensitisation either during or after grazing lupin stubbles, it suggests they have liver damage. Signs of photosensitisation include sensitivity to sunlight, red skin around the face, and swollen, droopy or crusty ears.

Animals showing these signs need to be moved into a dark area away from sunlight. Darkened shearing sheds are commonly used or heavily timbered paddocks or yards. Do not feed licks or blocks containing urea or copper as they can be toxic to the liver.

Phomopsis-infected lupins

Biology

Phomopsis stem and pod blight occurs in all areas of NSW but is more common in medium to high rainfall areas.

Historically, phomopsis stem blight in *Lupinus albus* crops has been rare. However, since 2004 outbreaks of this disease occurred in southern NSW. This represented a potential threat to the Australian lupin industry and mixed farming systems.

Modern narrow-leaf lupin varieties have resistance to phomopsis, although there is evidence that this resistance is breaking down in southern NSW.

There are two sources of infection in lupin crops

1. Spores dispersed from neighbouring crops or stubbles
2. Pathogen spread by sowing infected seed.

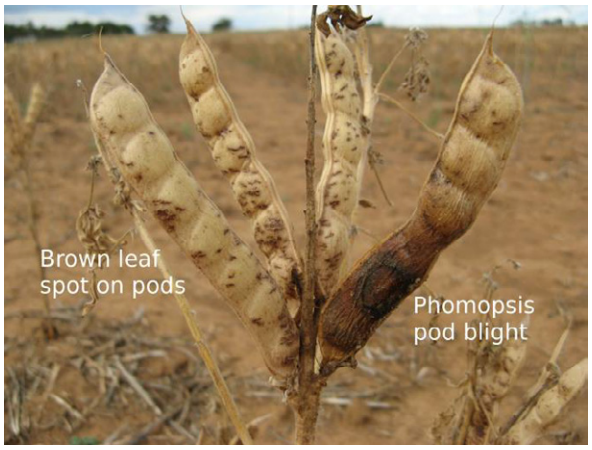
What to look for

Typically phomopsis infection occurs early in the growing season, but is not visible in the plants until maturity. Figure 1 illustrates signs of phomopsis infection in *L. albus* plants at maturity on whole plants, stems, and pods. Signs of infection of narrow-leaf lupin are similar.

Lupin stubble commonly contains mould or other fungal diseases that are not phomopsis. Often these moulds can be rubbed off while phomopsis fungus cannot.

Stubble infected with phomopsis will develop characteristic pycnidia, which are raised, dark coloured and more or less circular in shape. This is commonly called ‘leopard spotting’ (Figure 1B).

Figure 3: Phomopsis pod blight symptoms on Lupinus albus on right. This plant was photographed in a drought year that had late season rain. Due to stunted growth, the plant was more susceptible to rain-splash enabling Brown leaf spot (caused by Pleiocheata setosa) to develop on left.



Pod infection is seen as blackened, shrivelled pods (Figure 1). Pods infected with phomopsis often have a sugary appearance as plant sap is exuded and dries on the pod (Figure 3).

If pod infection occurs early in pod development the pod will abort and not produce any seed. Late infection and favourable weather conditions can result in significant seed infection that is harvested.

Seed infected with phomopsis is often a golden-tan to brown colour (Figure 5). White fungal hyphae can be detected on infected seed. In narrow-leaf lupin the signs are similar although harder to see in some of the darker seeded varieties (Figure 2). Within a pod there may be varying levels of infection.

Risk of fungus infection

Location

Phomopsis occurs in all lupin growing areas in Australia. Different isolates of the fungus preferentially infect either lupin species. Narrow-leaf lupin isolates are widespread in NSW. A study of commercial broad-leaf lupin seed-lots produced in NSW in 2004-2006 detected phomopsis infected seed in 15% of the seed lots inspected. Most of these were in southern NSW.

Previous crop history, paddock selection and rotation

Short lupin rotations favour the development of phomopsis. A minimum four year rotation is advised for both broad and narrow leaf lupins.

Variety selection

Growing resistance varieties of lupins is the best strategy for reducing the risk of phomopsis infection and lupinosis. Selection for resistance is

the first priority followed by other important agronomic considerations specific for your location.

Since 1988 new narrow-leaf lupin varieties have been bred with improved levels of resistance. Refer to the Crop Sowing Guide available at www.dpi.nsw.gov.au/pubs/winter-sowing-guide. Resistant varieties have much less phomopsis stem blight on mature, dry stems compared to susceptible varieties. The risk of lupinosis is reduced when resistant varieties are grown.

There are currently no broad-leaf lupin varieties that have been bred specifically for improved phomopsis resistance. However, the variety Ultra has useful resistance and Rosetta has moderate resistance, particularly in pods and seeds.

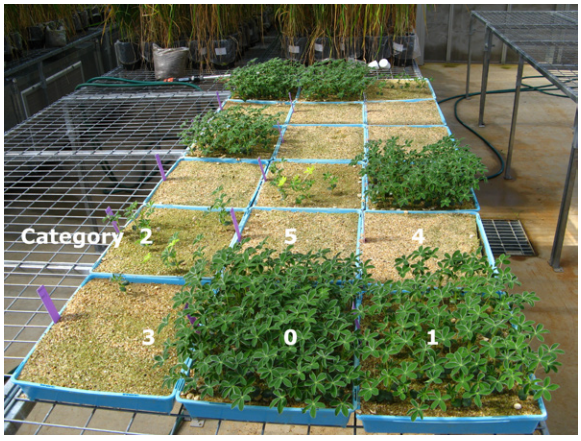
Sowing seed

Inspect seed to be used for sowing prior to sowing the crop. Figure 5 shows the varying discolouration seen in phomopsis-infected seed. If infected seed is sown the risk of phomopsis establishing within the crop increases, heightening the risk of lupinosis.

Infected seed weighs less than normal seed and may be graded off using an air-table. The current receival and export standard for phomopsis-infected lupin seed is 3%.

Seed-borne phomopsis will reduce germination in both narrow-leaf and broad-leaf lupins. Heavily infected seed does not germinate (Figure 4). Only clean or lightly infected seed germinates well. Avoid sowing infected seed.

Figure 4: The effect of phomopsis infection on germination. Only seed from categories 0 and 1 germinated.



Environmental conditions

The fungus may spread rapidly through the crop if there is high humidity around the time of harvest maturity.

Although the fungus is capable of penetrating undamaged pods and stem tissue, anything causing wounding can result in rapid fungal spread and development in a crop. Wounding can be caused by insects or hail. If pod infection occurs late as a result of wounding, more infected seed will be harvested.

Time of harvest and un-harvested Lupins

Delayed harvest may increase phomopsis infection if weather conditions are suitable. In years with dry summers lupins that are not harvested can generally be grazed safely, provided they have been inspected for signs of infection. In wet summers however, the risk of lupinosis occurring is greater.

Figure 5: Phomopsis-infected broad-leaf lupin seed sorted into categories based on degree of discolouration. Seed was sorted into these categories (0 on left, 5 on right) and sown in a germination experiment

Stubble management

Practices that encourage rapid breakdown of infected stubble will reduce the potential risk of lupinosis. Infected stubble should be burnt or incorporated into the soil to aid rapid breakdown. In no-till situations, inspect stubble for pycnidia development before grazing is allowed. In seasons with summer rain, stubble must be inspected frequently.

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